Development and design of an intervention to improve physical activity in pregnant women using Text4baby

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Abstract

Text4baby is a free, mobile health information service for pregnant and post-partum women. This study aims to understand preferences of physical activity text messages (SMS), sequentially develop prototype SMS, and determine preferred dose of SMS to inform a future study utilizing Text4baby. This study had a user-centered design with three phases: (1) literature review and interviews with pregnant women for development of prototype SMS, (2) interviews with health care professionals and pregnant women for prototype SMS feedback, and (3) survey to determine preferred dose of SMS. Data from interviews identified knowledge and support as major themes. Prototypes were developed ($N=14$) and informed 168 SMS. Pregnant women ($N=326$) thought three SMS/week were about right (50.2 %) and preferred three SMS/week throughout pregnancy (71.9 %). There is a need for opportunities for behavioral scientists to incorporate evidence-based practices within scalable interventions. As such, this research will inform utilization of Text4baby to potentially improve physical activity participation.

Keywords

Pregnancy, Mobile health, Technology, SMS, Text messaging

INTRODUCTION

Regular physical activity during pregnancy has many health benefits for both mother and fetus [1–3]. For the mother, benefits may include weight control [4] and reduced risk of early delivery and gestational diabetes [2, 3, 5–7], and for the fetus, benefits may include improved stress tolerance and a decrease in resting fetal heart rate [8–12]. Despite these benefits, only 15.8 % of pregnant women (as compared to 26 % of non-pregnant women) achieve recommendations for physical activity [6, 13, 14] (i.e., meeting physical activity recommendations of 150 min of moderate intensity activity per week) [15–17].

Pregnancy may be an opportune time to promote the adoption of physical activity, as women may be more likely to adopt health behaviors because they are concerned with the healthy development of their baby and/or a quick return to pre-pregnancy body composition [18–21]. However, women may not be

Implications

Practice: To use an already existing, free, mobile health service, Text4baby, as an opportunity to disseminate physical activity messages to pregnant and post-partum women.

Policy: Health care providers could easily, with little resources (i.e., time, money) use Text4baby to refer patients to evidence-based information about physical activity during and after pregnancy.

Research: Research to determine the optimal dose of physical activity text messages within the Text4baby curriculum to improve physical activity participation in pregnant women is needed.

receiving information they need from trusted sources such as physicians to make changes in their health behaviors (i.e., physical activity) [20, 22]. For example, research suggests that women may not receive adequate information about physical activity during physician visits because physicians are constrained by time and may lack knowledge about proper recommendations [20, 22–25]. In our formative work, women reported using the internet for pregnancy-related information (94 % of respondents) and did this to add to the information their health care provider gave them (88 %) or wanted to find out more information on their own (99 % of those that responded). Approximately 44 % of women used the internet for information related specifically to physical activity/exercise. Interestingly, women in our study were concerned about the accuracy of the information they were accessing online (~65 % felt that they had been to a site that was wrong or misleading). Pregnant women have specifically requested current evidence-based recommendations for physical activity to help them to be more active [22]. However, studies have suggested that women may not know how to evaluate the accuracy of the information they receive and do not consistently check the source of information [26, 27]. Recent theories posit that improving the quality and precision of information about physical activity may be insufficient to change this behavior; the timing and

dose of information over time may be important moderators of the specificity of information [28].

Of late, mHealth interventions (i.e., the use of mobile and wireless devices to improve health outcomes, health care services, and health research) have become increasingly popular as a means to motivate individuals for physical activity participation [29–36]. Specifically, mobile phone text messaging (SMS) has been used to provide timely access to health advice, prompt self-monitoring, and educate individuals about preventive health [37]. SMS may be an effective channel to provide pregnant women with evidence-based information about physical activity and improve their physical activity participation during pregnancy. SMS interventions may be particularly useful because over 90 % of women in the USA own a mobile phone, 80 % of these send/receive text messages, and 60 % access the internet from their mobile phone [38].

Text4baby is a free, nationwide, mobile health information service that delivers health-related SMS to pregnant women and during the first year postpartum. Text4baby has been shown to be acceptable by low-income underserved pregnant women and new mothers with the potential to change health behavior [39, 40]. A prospective cohort study evaluating Text4baby reported that 88 % of their participants ($n=209$) planned to continue using Text4baby (after an intervention) [39]. In one pilot study, Text4baby users were three times ($OR=2.73$, $p=.042$) more likely to believe that they were prepared to be a new mother compared to the no exposure control group ($N=123$) [40]. The standard Text4baby SMS set includes 267 messages addressing a wide range of maternal and child health topics (i.e., safety, nutrition, support, symptoms, screening, development) throughout pregnancy and up until the baby's first birthday [41]. Currently, the standard Text4baby SMS set has limited (only two) content related to physical activity participation. The purpose of the current study was to (1) conduct formative research to understand SMS acceptable to pregnant women, (2) develop a pool of prototype physical activity text messages that include referrals to evidence-based physical activity websites, and (3) determine by survey the preferred dose (number per day or week) and timing of text messages (time of day, number per trimester). Information gathered from this study will inform the design of a larger randomized control trial [42, 43].

METHODS

This study included three phases and was based upon user center and an iterative design process. User-centered design considers the people who will ultimately be impacted by the intervention (i.e., the user) as the center of the intervention design process [44]. In phase 1, we used qualitative research methods (i.e., interviews) and the literature to understand the needs and opinions of the potential users of the intervention (i.e., pregnant women) to develop prototype text messages ($N=14$). In phase 2, we gained insight about

the prototype text messages using additional qualitative research methods (i.e., interviews) with health care professionals (e.g., physicians, midwives) and the target user group and then developed 168 additional text messages. Finally, in phase 3, we conducted a survey to determine the users preferred dose of text messages to inform the design of our intervention (currently being implemented). The following sections detail each phase of the process, and the final intervention design is also briefly described. An Institutional Review Board at a University in the Southwestern United States approved this study, and all participants consented to participate in the study.

Phase 1: interviews and prototype development

During phase 1, we conducted a literature review and interviews in active pregnant women (i.e., meeting physical activity recommendations of 150 min of moderate intensity activity per week) [15–17] to identify potential themes for the text message prototypes (i.e., barriers, strategies). We interviewed active pregnant women due to their potential insight on overcoming barriers to physical activity during this time in addition to the limited research about facilitators to physical activity adherence in active pregnant women [45, 46]. Women were recruited for the interviews from local community physician clinics via fliers, social media (e.g., Facebook), and word of mouth. Physically active women were invited to participate in the interviews if they were (1) pregnant or had ever been pregnant, (2) ages 18 years and older, (3) able to speak English, (4) participated in at least 30 min of moderate activity 5 days week (more than 150 min) in the last week (self-reported), and (5) willing to participate in an interview for 30–60 min. Interested participants contacted the research team to volunteer to participate in the study. The research team confirmed eligibility (over the phone) and then scheduled a time for an interview. Interviews were conducted ($N=15$) over the phone at a time convenient to the participant. Participants were provided a \$25 incentive to participate. All interviews were audio recorded and transcribed verbatim. Interviews lasted less than 30 min and included questions about how active pregnant women fit in physical activity during their day, symptoms and/or fears related to being active during pregnancy and how they overcame those in order to remain active, reasons they chose to be active during pregnancy, strategies they used to be active (e.g., support, resources), and how they thought inactive pregnant women should be prompted to be active. Example interview questions are included in Table 1.

Interviews were analyzed using a case study approach in QSR NVivo10 (Cambridge, MA, 2010). A case study approach allows the investigator to study multiple bounded systems (cases), through detailed, in-depth data collection involving interviews and reports a case description and case-based themes [47, 48]. Two coders, trained in qualitative data analysis (master's and doctoral level training) coded the data and then

Table 1 | Sample survey and interview questions

Survey questions	
Do you participate in any text message-based services (for example: Skweez, Text4Baby, or Knowledge Generation Bureau)?	<ul style="list-style-type: none"> •Yes. Which ones? •No
Is there a time of day you prefer to receive/send text messages?	<ul style="list-style-type: none"> •Yes. What time of day? •No
In your past pregnancies, when do you think it would have been most helpful for you to receive information about weight gain?	<ul style="list-style-type: none"> • First trimester •Second trimester •Third trimester •Could have used the information during the entire pregnancy
If you got three text messages a week from a text messaging service about your health, do you think this would be:	<ul style="list-style-type: none"> • Too many •About right •Too little
Would you prefer these three text messages per week during the:	<ul style="list-style-type: none"> • First trimester •Second trimester •Third trimester •Similar amount of text messages throughout the pregnancy
Did you (or do you currently) monitor your physical activity/exercise during your pregnancy?	<ul style="list-style-type: none"> •Yes •No
How did you do so?	<ul style="list-style-type: none"> •Journal/log •Pedometer •Calendar •Fitbit/Jawbone Up or similar •Other _____
How acceptable would you find information about physical activity/exercise delivered by text message during pregnancy?	<ul style="list-style-type: none"> • Very unacceptable •Unacceptable •Neutral •Acceptable •Very acceptable
Interview questions	
Were you active prior to finding out you were pregnant? How has pregnancy impacted your current activity level?	
Please tell me a story about your typical day, from waking up to going to bed. In particular, please help me understand where you fit physical activity into your busy day.	
Please tell me about the symptoms you are experiencing while pregnant. How do they impact your physical activity on a day to day basis? Can you tell me a story about when you overcame your symptoms of pregnancy and exercised anyway? What happened?	
Why have you chosen to participate in physical activity during your pregnancy?	
How do you think physical activity should be promoted to pregnant women that are inactive?	
What role do you think text messaging could play in your physical activity participation during your pregnancy?	

met to discuss themes. Themes were then re-established, and the coders recoded data together, according to those themes. Discussion occurred until all conflicts were agreed upon related to themes and codes. Validation was conducted similar to peer debriefing to assure that the coders considered all aspects of inquiry for interpretation and evaluation of the data [49, 50]. Themes were developed based on the major topics of the interview questions [49]. Themes that emerged from the interviews were used to develop categories ($N=7$) for text message prototype development.

Phase 2: prototype assessment with key informants to inform text message content

In phase 2, prototype text messages were developed. Two prototype text messages were developed for each

of the seven categories identified in phase 1 ($N=14$). Prototypes were limited to 160 characters or less and included a mobile-friendly link to a Health on the Net Code of Conduct (HON Code) [51] certified website (i.e., an ethical, reliable online source for health information). To be HON Code certified, a website must provide the qualifications of authors, cite all sources of information, ensure privacy, complement information provided by physicians, ensure privacy, provide accurate contact information, disclose financial conflicts, and has appropriate advertising [51].

Once the prototype text messages were developed, informal interviews were conducted to determine the feasibility (perceived acceptability and demand) and the appropriateness (culturally and linguistically) of the material. Interviews were conducted with a convenient sample of physicians ($N=7$), nurses/midwives ($N=5$), and inactive (i.e., not meeting physical

Fig 1 | Example prototype

activity recommendations of 150 min of moderate intensity per week) pregnant women ($N=5$). Participants for interviews were recruited through physician clinics and word of mouth and were included if they were (1) a physician, nurse/midwife, or pregnant patient at a local physician clinic, (2) able to read and speak English, (3) willing to participate in a 60-min interview, and (4) at least 18 years of age. All interviews took place in person at a place convenient for the participant (i.e., physician office, coffee shop) and were provided \$25 for their participation. Participants were provided the two prototype text messages in each of the seven categories on a PowerPoint slide. The interviewer read the text messages to the participant and then asked the following questions: (1) “Could you please give us your gut reaction about these text messages?”, (2) “Do you think these would help women with their physical activity?”, (3) “How might we improve these messages?”, and (4) “Which one of these do you prefer and why?”. Figure 1 illustrates an example prototype provided in the interviews.

Phase 3: appropriate dose and informing of design

We conducted a survey to determine the acceptable dose (frequency and intensity) of messages and to inform the design of the intervention. Women were invited to participate if they were (1) pregnant or had ever been pregnant, (2) at least 18 years of age, (3) able to read and speak English, (4) and willing to complete a 5-min survey. A convenience sample of pregnant women ($N=326$) was recruited from throughout the USA using word of mouth, fliers placed in places where pregnant women may be present (e.g., baby stores, maternity stores, physician clinics, WIC clinics), using email listservs (e.g., partnership with Text4baby and foundations related to pregnancy), and social media (e.g., Facebook, Twitter). Additionally, investigators recruited women from a WIC clinic in the Midwest to ensure participation from a diverse sample of women. The survey was free, voluntary, and available online and on hardcopy. There was no incentive to complete the survey. Women who chose to

complete the survey clicked on an internet link provided on all recruitment materials. The survey was hosted by Qualtrics (Provo, Utah). Women recruited from the WIC clinics who did not have access to a computer completed the survey on paper, and research team members entered their survey online ($N=120$).

The survey had 45 questions and assessed how often during the pregnancy (e.g., daily or weekly) and when during the pregnancy (e.g., time of day; first, second, third trimester, and/or throughout) women would want to receive text messages about physical activity participation. The survey also asked questions about the use of other automated services for health information via text or email and the frequency and intensity of those services. Example survey questions are listed in Table 1.

Survey data was downloaded from Qualtrics and analyzed using Statistical Package for the Social Sciences (SPSS) software version 21 [52]. Data was reviewed for errors, missing values, and outliers. Frequencies were run to determine the distribution of variables. Age and current and pre-pregnancy BMIs were calculated to determine the mean and standard deviation of the sample.

RESULTS

Phase 1: interviews

Demographic information for interviews with active pregnant women ($N=15$) are presented in Table 2. Knowledge and support were the two major themes identified in the interviews. Categories and subcategories were then derived from the main themes. Knowledge included basic education and information (e.g., dispelling myths, activity ideas (i.e., modifications, lifestyle-based activity)), time (e.g., strategies to make time), safety, and benefits/consequences of activity. Related to knowledge, one woman said educating women would help them stay active during pregnancy, “...I think just even being educated on even the simplest things are going to help people better understand

Table 2 | Demographic information of active pregnant women

	Participants (<i>N</i> =15) M (SD)
Age (years)	30.87 (4.1)
BMI before pregnancy	21.37 (1.6)
BMI during pregnancy	24.37 (2.3)
	M (%)
Race	
Caucasian	14 (93.3)
Did not wish to respond	1 (6.7)
Education	
Some college	1 (6.7)
Associates/2-year degree	1 (6.7)
Bachelor's degree	5 (33.3)
Graduate school or above	8 (53.3)
Income (per year)	
Less than \$20,000	1 (6.7)
\$21,000–\$41,000	1 (6.7)
\$61,000 and above	12 (80.0)
Did not wish to respond	1 (6.7)
Marital status	
Single	1 (6.7)
Partnered/in a relationship	1 (6.7)
Married	13 (86.7)
Current week in pregnancy	
5–12 weeks	0 0
13–28 weeks	7 (46.7)
29–40 weeks	8 (53.3)

like how it will help and how important it is,” and another said that she liked to receive information, “I think a mixture of motivational and informative...I like information, I like little tips.”

Related to safety, a woman shared that she felt safe and overcame any fear about activity by modifying, “Modify, and do something that I am more comfortable doing.” Related to the benefits, one woman shared that she felt that helping inactive pregnant women understand the benefits of physical activity would encourage them to be active. “Helping women understand the benefits of being active, and it might be different for every woman, so I think highlighting the array of benefits. So maybe it's that your labor is easier or maybe that you feel better while you are pregnant, but I think a lot of women are motivated by looking good...if you stay active during your pregnancy, it will be easier to lose the weight after you gift birth.” Another said, “...this is imperative for your child.”

Support included motivators (e.g., resources to help with motivation, accountability), social environments (e.g., activity with other pregnant women/moms), and praise (e.g., how to encourage activity). Women reported using the gym and group fitness classes and relying on instructors and significant others to motivate them. “...my husband is very supportive. He is not one for physical activity ...but he is really good if I say, “will you walk with me”...and we will go for a walk together.” Another shared, “I do have a friend that we like to work out together. And I think that's key

when you have, like for yoga. When you have paid for something and you need to be there, that's a good motivator.”

Sample text messages according to their respective themes and categories are presented in Table 3.

Phase 2: text message content

Demographic information of the 17 participants who completed prototype interviews are presented in Table 4. Content for the SMS curriculum (168 texts) was guided by the most preferred prototype (of the two presented during prototype interviews) for each category (i.e., educational, benefits/consequences, time scheduling, motivational, social, safety, and praise). The preferred prototype also guided the linguistics for the content of the other text messages in that category. Additionally, reasons that the prototype was preferred (i.e., “like the way it sounds,” “it explains stuff”) were used to further inform content. Example of the text message revision process and two sample final text messages (in the benefits/consequences and safety categories) are illustrated in Table 5.

Phase 3: dose for intervention and final design

Descriptive characteristics for women who completed the survey are presented in Table 6. A total of 326 women (mean age 30.51 ± 5.83) completed the survey. Seventy percent were Caucasian, and 17 % were African American. Approximately 73 % were married or living with a partner, and a third of the women had an income of less than \$20,000 a year. A little over 30 % were currently pregnant, and 61 % reported regular engagement in physical activity. Almost all women (94 %) used text messaging with 45 % receiving 0–10 text messages per day. Almost half of the women had/were currently participated in a text message-based service (e.g., Text4baby, Babycenter, Whattoexpect). Most women (86.5 %) read the text messages, and 84 % found them somewhat valued or highly valued. Participants thought that three texts per week, each week, for an automated service were about right (50.2 %) or too many (47.3 %). When asked about preference for the time during pregnancy (i.e., trimester) to receive three text messages per week, 71.9 % preferred a similar number throughout their pregnancy. Fifty percent of women reported that they could use physical activity messages during pregnancy (past or current) and felt that this information would be acceptable (39.4 %) or very acceptable (21.3 %). Results from the pregnancy text message survey questions are presented in Table 6.

DISCUSSION

There is a need for SMS interventions that not only include evidence-based recommendations but are also designed appropriately for the target users to ensure the messages are both useful and usable (i.e., fit into a person's life) [20]. This study used a mixed methods

Table 3 | Sample text messages

Category	Theme	Sample text message
Motivators (<i>n</i> =29)	Support	Don't let a "bump" in the road keep you from your workout! Get inspired by reading these tips to staying active: bit.ly/t4bbump
Social (<i>n</i> =14)	Support	Do you have an exercise "buddy?" Enlisting a friend makes exercise fun and provides accountability. Learn more here: bit.ly/t4bcancel
Time (<i>n</i> =21)	Knowledge	Take the stairs! Choosing an active route to your destination helps squeeze in activity during pregnancy. bit.ly/t4broute
Education (<i>n</i> =30)	Knowledge	Exercise benefits mom and baby! It can reduce risk of preterm birth, improve oxygen supply for baby & ease labor. bit.ly/t4bhealthpreg
Praise (<i>n</i> =14)	Support	Don't feel pressured to hit the gym. Pregnancy is a time to start small & take it easy. Work your way up to 30 min. of daily walking. bit.ly/t4bsmall
Safety (<i>n</i> =31)	Knowledge	Low-impact aerobics classes are a great option for expecting moms. Learn how to adapt your routine throughout your pregnancy here: bit.ly/t4badapt
Benefits/consequences (<i>n</i> =29)	Knowledge	Yoga during pregnancy can improve circulation, muscle tone & flexibility. Learn about the many benefits & how to get started here: bit.ly/t4bcalm

approach that utilized a team of experts in a variety of disciplines (e.g., physical activity, psychology, epidemiology, public health) and incorporated interviews,

Table 4 | Demographic information of prototype interview participants

	Participants (<i>N</i> =17) M (SD)
Age (years) (<i>n</i> =17)	42.7 (13.1)
Gender	Female (%)
Physicians (<i>n</i> =7)	4 (57.1)
Nurses/midwives (<i>n</i> =5)	5 (100.0)
Inactive pregnant women (<i>n</i> =5)	5 (100.0)
Physically active	
Physicians (<i>n</i> =7)	5 (71.4)
Nurses/midwives (<i>n</i> =5)	1 (20.0)
Years of experience	Physicians (<i>n</i> =7)
0–5 years	2 (28.6)
11–15 years	2 (28.6)
20+ years	3 (42.8)
	Nurses/Midwives (<i>n</i> =5)
0–5 years	1 (20.0)
11–15 years	2 (40.0)
20+ years	2 (40.0)
Inactive pregnant women (<i>n</i> =5)	
Race	
Caucasian	2 (40.0)
African American	2 (40.0)
Other	1 (20.0)
Education	
Less than high school	2 (40.0)
High school diploma	1 (20.0)
Bachelor's degree	2 (40.0)
Income (per year)	
Less than \$20,000	3 (60.0)
\$41,000–\$60,000	2 (40.0)
Marital status	
Single	3 (60.0)
Married	2 (40.0)

iterative prototyping, and surveys among key stakeholders (e.g., pregnant women, physicians) to glean insights about how physical activity messages could be incorporated into Text4baby in the future.

The research presented in this paper adds to the emerging literature supporting the need for formative research to design mHealth interventions and the opportunities for behavioral scientists to incorporate evidence-based practices within scalable interventions. Specifically, the intervention designed from the formative research reported here can be used to inform how physical activity messaging is incorporated into Text4baby in the future. The current Text4baby curriculum has limited SMS about physical activity, and because the evidence supporting participation in physical activity as part of a healthy pregnancy is ample [1–12], there is a need to modify standard Text4baby physical activity SMS in light of these findings.

During phase 1, our review of the literature and interviews in active pregnant women were essential to identify the areas of focus for SMS content that may help women overcome challenges to regular physical activity participation during pregnancy. Notably, women need education about physical activity benefits, ways in which to be safe and modify physical activity participation (i.e., intensity), and resources for support to help them be successful at physical activity participation [53]. Especially because some of these factors have been linked to increased physical activity participation in pregnant women [45].

During phase 2, we were able to gather feedback about our prototype SMS from key informants such as physicians and nurses in obstetrics and gynecology, in addition to our target population for the feasibility intervention (inactive pregnant women). Other formative work suggests that involving the target population and key informants can provide important information to help guide the development of program and messaging for interventions [54, 55]. This information helped guide the development of the physical activity curriculum SMS that will be tested in our feasibility intervention as well as what could be incorporated into

Table 5 | Example of text message revision process and sample final text messages

	Original message	Interviewer feedback	Final message
Prototype A	Wanna have a healthy pregnancy? Walk, swim, bike, practice yoga or weight train. Pick what you enjoy and go! Bit.ly/t4bhealthypreg	“Too casual and of course everyone wants to have a healthy pregnancy and whether they are concerned about it or not they should know that exercise is recommended.” (Physician)	Exercise benefits mom and baby! It can reduce risk of preterm birth, improve oxygen supplies for baby & ease labor. Bit.ly/t4bhealthypreg
Prototype B	Exercise means healthy mom and baby. Walk, swim, bike, practice yoga or weight train daily for a healthy pregnancy. Bit.ly/t4bhealthypreg	“This one sounds a little more non directive. This is more informational to me and A is more confrontational.” (Midwife/nurse)	
Prototype A	Belly getting in your way? Don't skip activity, modify with these month by month guidelines. Bit.ly/t4b2modify	“I am a true believer of #2. But I think for the great majority of people, 1 would be better... we are not accustomed to listening to our bodies. This one would be better for our patients.” (Physician)	Not sure if it's safe to exercise during your pregnancy? Check out this list and consult your doctor. Bit.ly/t4b2modify
Prototype B	Belly getting in your way? Don't skip activity, modify by lowering your intensity and listening to your body. Bit.ly/t4b2modify	“You know there are different ways to say it. Like instead of saying ‘belly getting in your way’ belly in your way is probably really going to hit patients where their thinking. I would probably have said it differently I would probably say, ‘Feel you are too far along in your pregnancy for activity? Don't skip.... Whatever.’ That's what I would tend to say but maybe belly getting in your way is what patients... really think.” (Physician)	

Text4baby in the future. Satisfaction of the SMS content will also be explored in our next study.

Finally, phase 3 was particularly useful for informing the dose of our feasibility intervention. SMS frequency has been shown to moderate intervention effectiveness [56]. Specifically, interventions that allow participants to set their own schedule or those in which the frequency decreases over the course of the study may be more effective than those that have fixed frequency (e.g., once per month). The current Text4baby curriculum is provided 3 days per week (M, W, F) at noon. However, the dose of the Text4baby curriculum has had limited evaluation in relation to its acceptance (i.e., satisfaction) and/or its effectiveness in changing health behaviors (i.e., physical activity). We used phase 3 to not only determine if the SMS would be accepted

3 days a week but also if it would be accepted 7 days a week and/or if there are higher or lower dropout rates based on the frequency of text messages. Specifically, this phase contributes to the knowledge gap about balancing pragmatic requirements of usability/acceptability with the likely dosage necessary to achieve changes in physical activity behavior in pregnant women [56, 57].

There are still many questions about whether SMS for physical activity will increase physical activity participation during pregnancy. Further, it is not known whether the low dosage of messaging will be effective. However, based on information from all three phases, the research team finalized the design for the Text4baby study and this larger ongoing study (currently being conducted) will test the impact of various doses and timings of physical activity-based text messages. The study has a quasi-experimental design with four groups: (1) standard Text4baby approach (three Text4baby general curriculum text messages per week (M, W, F) at noon), (2) intervention (three text messages (one physical activity and two Text4baby) per week (M, W, F) at noon), (3) intervention +1 (seven text messages (six physical activity, one Text4baby) per week (Su-Sa) at noon), and (4) intervention +2 (seven text messages (six physical activity, one Text4baby) per week (Su-Sa) at the time of day they choose). Outcomes being assessed are feasibility, satisfaction, and physical activity levels.

Although this study adds to the literature, there were some limitations. All of the women that were interviewed in phase 1 were Caucasian, limiting the information we obtained from a more diverse sample to guide the themes and categories for the SMS curriculum content. However, phase 2 helped to guide the specific language for the text messages and three of the five women who were interviewed in this phase classified themselves as African American or other. Additionally, the physicians and nurses that were interviewed have a diverse sample of patients in which they provide care. We also had challenges recruiting racial/ethnic minorities to participate in the survey in phase 3. However, research team members actively recruited participants from a WIC clinic in the Midwest to help further engage low income and minority women who

Table 6 | Descriptive characteristics and survey responses

	Surveys (N=326) M±SD
Age	30.51±5.83
Hispanic	(n=14)
Race	
Caucasian	230 (70.6)
African America	55 (16.9)
Asian	1 (0.3)
American Indian	8 (2.5)
Alaska Native/Pacific Islander	0 (0.0)
Other	22 (6.7)
Missing	10 (3.1)
Income	
<\$20,000	102 (31.3)
\$21,000–40,000	56 (17.2)
\$41,000–60,000	57 (17.5)
\$61,000+	95 (29.1)
Missing	16 (4.9)
Education level	
<High school	22 (6.7)
High school diploma	50 (15.3)
Some college	49 (15.0)
Associates degree	18 (5.5)
Bachelors degree	89 (27.3)
Graduate school+	87 (26.7)
Missing	11 (3.4)
Marital status	
Single	67 (20.6)
Partnered	32 (9.8)
Married	206 (63.2)
Separated	3 (0.9)
Divorced	5 (1.5)
Widowed	0 (0.0)
Missing	13 (4.0)
Currently pregnant	
Yes	102 (31.3)
No	224 (68.7)
How many weeks pregnant are you? (n=93)	
5–12 weeks	25 (26.88)
13–26 weeks	29 (31.18)
27–40 weeks	39 (41.94)
How many other children do you have? (n=309)	
0	33 (10.7)
1	126 (40.8)
2	86 (27.9)
3	28 (8.6)
4	20 (6.5)
5	11 (3.6)
6	2 (0.6)
7	3 (1.0)
Age of youngest child	
>0 and ≤1	121
>1 and <2	38
≥2 and ≤5	85
>5 and ≤10	20
≥11 and <19	7
N/A	17
Regular engagement in PA (n=311)	
Yes	200 (64.3)

No	111 (35.7)
Currently text (n=312)	
Yes	293 (93.9)
No	19 (6.1)
Average number of texts received a day (n=293)	
0–10	132 (45.1)
11–20	88 (30.0)
21–30	30 (10.2)
31+	43 (14.7)
Average number of texts sent a day (n=294)	
0–10	140 (47.6)
11–20	86 (29.3)
21–30	25 (8.5)
31+	43 (14.6)
Ever signed up for an automated service (n=295)	
Yes	168 (56.9)
No	127 (43.1)
What types of services were they? (n=167)	
Text	23 (13.8)
Email	86 (51.5)
Email and text	58 (34.7)
How often did you receive automated text messages? (n=91)	
Never	4 (4.4)
Less than once a month	2 (2.2)
Once a month	13 (14.3)
2–3 times a month	23 (25.3)
Once a week	23 (25.3)
2–3 times a week	17 (18.7)
Daily	9 (9.9)
Read automated texts (n=89)	
Yes	77 (86.5)
No	12 (13.5)
Value received from the text messages (n=87)	
Highly valued	26 (29.9)
Somewhat valued	48 (55.2)
Neither	8 (9.2)
Somewhat not valued	5 (5.7)
Highly not valued	0 (0.0)
Did the value received change over time? (n=88)	
Yes	28 (31.8)
No	60 (68.2)
How long before the text messages no longer seemed relevant (Example responses)	
Almost immediately	8
1–6 months	11
6 months to child's 1st birthday	6
Still relevant	10
I don't know	8
Do you participate in any text-message based services? (n=90)	
Yes. Which ones?	41 (45.6)
No	49 (54.4)
Example responses: Babycenter, Text4Baby, Whattoexpect	
Is there a time of day you prefer to receive/send text messages? (n=90)	
Yes	33 (36.7)
No	57 (63.3)
Is there a time of day you do NOT prefer to receive/send text messages? (n=90)	
Yes	35 (38.9)
No	55 (61.1)

Is this your first pregnancy? (n=298)	
Yes	78 (26.2)
No	220 (73.8)
Is there a time in your pregnancy (past or current) that you think you could have had some information via text message about physical activity/exercise that would have been most helpful to you?	
Yes	162 (58.3)
No	116 (41.7)
If yes- how often would you like to receive them?	
Example responses:	
Often	
Bi-weekly	
If you got 3 text messages a week from a text messaging service about your health, do you think this would be: (n=279)	
Too many	132 (47.3)
About right	140 (50.2)
Too little	7 (2.5)
Preferred trimester to receive 3 weekly texts (n=267)	
First	40 (15.0)
Second	24 (9.0)
Third	11 (4.1)
Similar amount throughout pregnancy	192 (71.9)
Did or do you monitor your PA during pregnancy? (n=274)	
Yes	152 (55.5)
No	122 (44.5)
How did you monitor? (n=161)	
Journal/log	56 (34.8)
Pedometer	7 (4.3)
Calendar	41 (25.5)
Fitbit/Jawbone Up or similar	13 (8.1)
Other	44 (27.3)
How acceptable would you find PA info sent via text during pregnancy (n=277)	
Very acceptable	59 (21.3)
Acceptable	109 (39.4)
Neutral	76 (27.4)
Unacceptable	16 (5.8)
Very unacceptable	17 (6.1)
How acceptable would your partner find PA info sent via text during pregnancy (n=271)	
Very acceptable	31 (11.4)
Acceptable	74 (27.3)
Neutral	120 (44.3)
Unacceptable	27 (10.0)
Very unacceptable	19 (7.0)

may not be normally interested or able (e.g., no internet access, no home computer) to participate in the survey. The survey was provided to these women in a hardcopy form, and the research team members later entered the data into Qualtrics. As a result, in the phase 3 survey, approximately 26 % of the women were non-White and 31 % had a household income below \$20,000.

The formative study conducted here contributes to our knowledge about SMS for physical activity among pregnant women and helps to inform future research. The physical activity SMS curriculum can be added to an already existing service (i.e., Text4baby) and then examined for feasibility and initial effectiveness for

significantly improving physical activity behavior during pregnancy. More importantly, the physical activity SMS has the potential to reach a large number of women across many socio-demographics. Future research should explore the effectiveness of Text4baby to improve health behaviors during pregnancy, namely physical activity. Additionally, minimal dose necessary to improve behaviors needs to be explored. Finally, targeting messages within special population groups (i.e., those with history of miscarriage, overweight/obese women) and the dose necessary to change behaviors in these groups specifically would significantly add to the literature. More research using Text4baby is warranted.

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