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ORIGINAL ARTICLE

Feasibility of perinatal mood screening and text messaging on patients' personal smartphones

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Abstract

Screens and adjunctive treatments for perinatal mood are available, but barriers prevent many women from receiving them. Mobile technology may help bypass barriers. The purpose of this study was to evaluate the feasibility of screening and texting perinatal women via their personal smartphones. This prospective cohort study enrolled 203 pregnant and postpartum women receiving obstetric care at a Midwestern US academic medical center. Participants received one electronic mood screen and three text messages per week for two weeks. Texts were based on the Mothers and Babies Course, a CBT-based preventative program that addresses limited social support, lack of pleasant activities, and harmful thought patterns. Feasibility was defined as the ability to take the mood screen and receive texts without technical difficulties. Demographic variables were paired with results. Insurance type (private or public) was used as a proxy for socioeconomic status. Pearson chi-squared tests were used to analyze the data. A text-based satisfaction survey was also administered. The sample was 72% privately insured and 28% publicly insured. Sixty-seven percent completed electronic screening. Screen completion was significantly associated with private insurance (OR = 3.8, 95% CI 2.00–7.30) and "married" status (OR = 1.93, 95% CI 1.01–3.70). Most survey respondents (92%) found it easy to receive the texts, and 76% responded with very favorable comments about the texts. Smartphone mood screening and supportive texting were technically feasible. Screen completion was lower among single women with public insurance.

Keyword Screening · Depression · Smartphone · Mobile health · Text

Introduction

Despite the efficacy of perinatal mood screening, barriers such as competing clinical activities or time constraints prevent high rates of adoption (Kim et al. 2009). While the American Congress of Obstetricians and Gynecologists (ACOG 2018) and the US Preventative Task Force (Siu et al. 2016) endorse perinatal mood screening, best practices for implementation have not been sufficiently studied (Gjerdingen and Yawn 2007). Similarly, barriers lower treatment uptake. They include a lack of insurance, time, child care (Kim et al. 2010; Gjerdingen and Yawn 2007), the cost of in-person mental health services, and the paucity of outpatient mental health resources (Byatt et al. 2012).

Novel technology may improve the uptake of screening and adjunctive treatment. Unlike paper screening, electronic screening offers immediate notification of positive results and the use of computerized adaptive tests that address a spectrum of psychiatric symptoms (Velikova et al. 1999; Drummond et al. 1995). In adaptive testing, such as Computerized Adaptive Test-Mental Health (CAT-MH™) used in this study (Gibbons et al. 2012, 2013, 2014), questions are based on the test taker's previous answer and impairment level (Weiss 1985). The result is increased measurement precision for mental health constructs such as depression, anxiety, mania, and suicide (Gibbons et al. 2012, 2013, 2014). CAT-MH™ is based on item response theory (Revicki and Cella 1997).

Another possible advantage of electronic screening is patient preference. In a recent study of screening delivery

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methods (Graham et al. 2019), participants preferred the CAT-MH™ (53%) most often, followed by interview, and PHQ-2/PHQ-9/GAD-7. There was no association between preferred screening method and age, gender, education, income, self-reported depression or anxiety, or SCID-diagnosed depression or anxiety. In another randomized study of 636 pregnant women, electronic screening with the Edinburgh Postnatal Depression Scale (EPDS) versus paper was found to be feasible and acceptable to pregnant women (Kingston et al. 2017).

According to Pew Research Center (2018), 77% of Americans own a smartphone. In areas that lack mental health resources, smartphone applications and text messaging could potentially make adjunctive treatment accessible and affordable (Lopez et al. 2011). Mobile health technologies, such as Text4Baby, have been successfully implemented and show feasibility and acceptance among perinatal women (Gazmararian et al. 2014; Broom et al. 2015) and require less time from overburdened medical staff (Marsch and Gustafson 2013). Smartphone applications bypass the childcare barrier by allowing women to engage at their convenience.

Technology is not without limitations. Possible issues with smartphone-based initiatives include disruptions in mobile service, unwanted costs associated with patients using data or receiving texts, and data security concerns. We evaluated the feasibility of computerized adaptive screening and supportive texting via personal smartphones of pregnant and postpartum women and examined demographic factors associated with screening uptake and texting feedback. We hypothesized that (a) electronic screening and texting would be technically feasible for most subjects and that (b) fewer postpartum women would complete screening compared with pregnant women and that (c) most women would respond favorably to the timing, frequency, and content of the texts.

Materials and methods

This prospective cohort study enrolled pregnant and postpartum women receiving obstetric care through an academic integrated health system that annually delivers 5000 women at two hospital campuses in Midwestern USA. Data were collected between March 2016 and September 2016. The study protocol was approved by the Institutional Review Board of NorthShore University HealthSystem. All procedures in this study were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all participants in the study. Eligible women were defined as English-speaking, currently pregnant or postpartum, and owners of a smartphone with internet access. Patients were approached about the study at routine obstetric care visits. No incentives for participation were provided so that the endpoint of patient acceptability would not be confounded.

Women who consented to participate in the study received a securely transmitted text message within 72 h of enrollment that contained a unique link to a secure website, www.cat-mh.com, where they could complete CAT-MH™ on their smartphones. The link took the subject directly to her own individual survey. No application download was required and no user ID or password entry was needed. CAT-MH™ accommodates varying literacy levels with questions at a sixth-grade reading level and reading questions aloud to the test taker. A Spanish version is also available but was not offered in this study. English-speaking Latinas were enrolled. Figure 1 shows a screen shot of a typical question as seen on a patient's smartphone.

In a prior study, we calibrated the CAT-MH™ for the perinatal population in a sample of over 400 pregnant and postpartum test takers (Kim et al. 2016). Convergent validity was assessed between the CAT-MH and EPDS. The correlations were $r = 0.82$ for depression, $r = 0.79$ for anxiety, and $r = 0.31$ for mania. Concordance between suicidal ideation as assessed by EPDS item 10 and the Columbia-Suicide Severity Rating Scale items embedded in CAT-MH™ was 96%.

In addition to the CAT-MH™, participants received six securely transmitted text messages. Texts were sent three

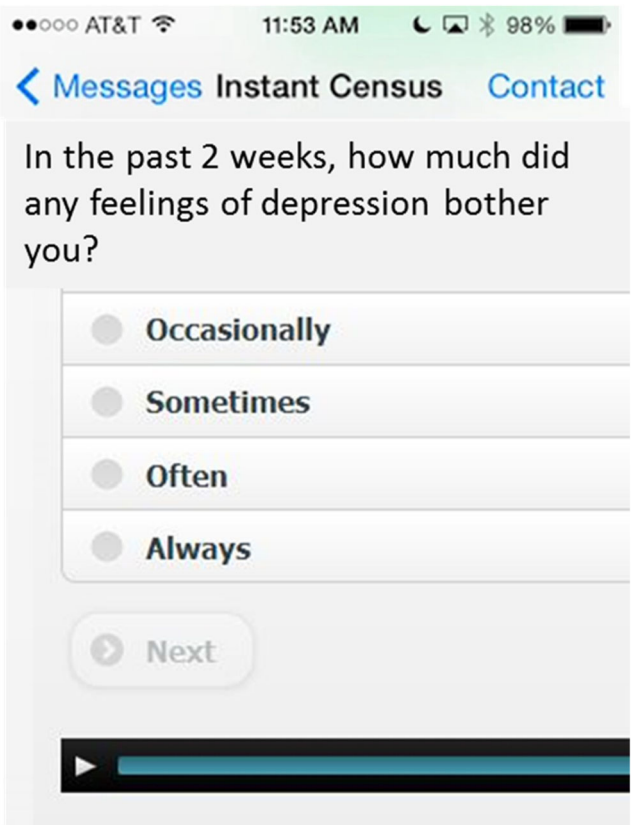

Fig. 1 Screenshot of a sample CAT-MH™ question on a subject's smartphone

times per week for 2 weeks. The first text was sent within a week of consent. All study-related text messages were transmitted via a secure, HIPAA-compliant SMS platform (Instant Census; Zagorsky). Participants could receive these text messages without having to download an application. There was no way to verify that texts were read. NorthShore's health information technology team scrutinized the data privacy and storage policies of the screening and texting vendors and informed the IRB of their approval.

The content of the texts was derived from a preventative intervention, the Mothers and Babies Course (Muñoz et al. 2007). The course is based on principles of cognitive behavioral therapy and was designed to teach participants to recognize which thoughts, behaviors, and social contacts influence their mood. Two randomized controlled trials have demonstrated efficacy (Le et al. 2011; Tandon et al. 2011). The texts were supportive and educational in nature. For example, "Pleasant activities make us feel better. They can be anything, even eating a favorite food. Do something for yourself today." Thus, the small subset of selected texts should not be considered equivalent to the intervention.

After all data were de-identified, demographic variables such as insurance type (private or public as a proxy for socioeconomic level), marital status, ethnicity, and race were extracted from the electronic medical record and paired with CAT-MH™ results. Group comparisons were conducted using SAS 9.2 (SAS Institute, Cary, NC). Pearson chi-squared tests were used to analyze the data and odds ratios with confidence intervals were calculated.

Feasibility and patient acceptance were assessed by a satisfaction survey. The survey questions were administered within a week after the last supportive text was sent. Ten satisfaction survey questions were sent via text. Instant Census survey logic sent a text that contained a single survey question and then waited for an answer from the recipient. When the recipient texted back an answer, Instant Census parsed the answer and sent the next question. If women did not respond with an answer, they did not receive the next question. Feasibility was defined as the ability to complete the screen and receive texts via smartphone without technical difficulties. Patient acceptance was defined as affirmative answers to satisfaction survey questions about content, timing, and reaction to the texts.

Because technical feasibility and patient acceptance were the goals for this study rather than clinical performance of CAT-MH, all subjects were also screened with the paper version of Edinburgh Postnatal Depression Scale (Cox et al. 1987) at the time of enrollment. This paper screening process has been in place at NorthShore since 2003. EPDS with scores ≥ 12 or any response other than "never" to thoughts of self-harm was considered positive (Murray and Carothers 1990; Kim et al. 2008). Nurses in obstetric practices confidentially e-faxed paper screens. The faxes came to a confidential email that was monitored hourly by administrative staff. Positive screens were sent to social work for immediate patient telephone evaluation and mental health referral (Gordon et al. 2006). This risk protocol was followed based on positive EPDS. CAT-MH results were not used clinically in this study. Phone calls usually occurred on the same day patients completed the screen. During the call, women were informed of a 24/7 crisis hotline developed by our program and administered in collaboration with the Illinois Department of Health and Human Services. No other demographic information was collected.

Results

Of the 256 women approached, 210 consented to participate (82%). Among the 46 women who declined to participate, only three (7%) cited a smartphone barrier. Two did not own a smartphone and the third used her smartphone infrequently. Seven of the 210 enrolled subjects withdrew from the study by texting "STOP" as instructed for ending study participation. The remaining 203 subjects completed the study and their demographic characteristics are shown in Table 1.

Screening

Subjects completed CAT-MH™ tests of depression, anxiety, mania, and suicide. Sixty-seven percent (137/203) of subjects completed CAT-MH™. Fifty-eight percent (117/203)

Table 1 Demographic characteristics of the study sample

Demographic	Frequency	Percent (%)
Race		
Asian	32	16
Black	32	16
Multiracial	5	2
Other	9	4
White	125	62
Ethnicity		
Hispanic	31	15
Non-Hispanic	172	85
Screening timeframe		
Antepartum	168	83
Postpartum	35	17
Insurance type		
Private	147	72
Public	56	28
Marital status		
Partnered	151	74
Single	52	26

completed it in response to the initial text request. An additional 9% completed after one or two text reminders sent 7 and 14 days after study activation. Twenty-five percent (51/203) of subjects did not attempt to complete CAT-MH™ at all. The remaining 8% (16 subjects) started but did not finish CAT-MH™. The entire sample completed the paper EPDS at the time of study enrollment. On average, CAT-MH was completed with answers to 40–48 questions covering depression, anxiety, mania, and suicidality. Average time to completion was 7.5 min and ranged from 2.6 to 44.7. Median time to completion was 5.8 min. Eight-five percent (115/136) of women completed in less than 10 min, and 94% (128/136) completed in less than 15 min. Twelve women scored positive on the paper EPDS. Social workers reached each of those 12 women.

The majority of participants (83%) were enrolled during pregnancy. There were no differences in the CAT-MH™ completion rate between pregnant and postpartum women. Screen completion rates did not vary by race or ethnicity. However, privately insured women were significantly more likely to complete CAT-MH™ than publicly insured women (OR = 3.823, 95% CI 2.002–7.303, $p = 0.001$) based on Pearson's chi-squared tests. Married subjects were significantly more likely (OR = 1.929, 95% CI 1.007–3.695, $p = 0.046$) to complete screening than unpartnered women.

Text messaging

Table 2 shows the specific text messages that were sent to all subjects. The first was an introductory text message that oriented subjects to the study. It offered a way to end participation in the study, provided the MOMS Hotline number, and instructed subjects to dial 911 for psychiatric emergencies. The clinical texts were sent on weekdays at 10:30 am to avoid early or late texting and to give women the rest of the day to respond to the screen. Three were sent in the first week. The remaining three texts were sent the second week.

Table 2 Text messages sent to study participants' personal smartphones

Welcome to Text MOMS! Within a few days, we will send you supportive text messages regardless of your mood. We want to see if these texts are useful. If you need emotional support, call 866-364-6667. For emergencies, dial 911. We are unable to respond immediately to texts. Text 'STOP' to end messages at any time.
Pleasant activities make us feel better. They can be anything, even eating a favorite food. Do something for yourself today.
Practice giving yourself credit for the positive things that happened this week. Positive thoughts create positive feelings.
If you feel pressure to be a perfect mother, you are not alone. A better goal is to be a "good enough" mother.
During stressful times, ask yourself if is there a step you can take to address the problem today. If yes, do it. If not, take some deep breaths.
Sometimes we criticize ourselves more than we would others. When you feel bad about yourself, imagine what you would say to a friend. Then say it to yourself.
People can put us in a good or bad mood. Think of who can help you feel better when you are having a hard day. For support now, call 1-866–364-6667 (MOMS).

Satisfaction survey

Table 3 shows text-delivered satisfaction survey questions and answers about the supportive text messages. The number of respondents varied by question. All 203 women received the first question. Sixty-seven percent (136/203) answered the first question. Responses waned with each subsequent question. Between 47 and 67% of the total sample (96 to 136 women out of 203 total) answered one or more survey questions.

Most subjects reported they read the texts (85%) and rated them easy to receive (92%). Although most respondents did not screen positive for depression, anxiety, mania, or suicide, nearly half of respondents reported they followed the advice in the texts and affirmed that the texts taught them how to improve their mood. Among respondents, most (85% or 103/121) thought three texts per week was an adequate number to receive.

Most respondents (61% or 67/110) would not change anything about the texts, "I loved receiving them. They made my day better" and "Texts were extremely easy and accessible - I liked receiving uplifting messages this way and I could go back and look at them later." The remaining respondents offered a variety of suggestions. Five respondents felt their mood was stable so the texts were irrelevant, "Some of the texts didn't apply to how I was feeling....while they were good advice, they did not impact me." Several wanted more enhanced content, "more personal" or "maybe links to articles." Three respondents felt negatively toward the text about the "good enough" mother. Only one respondent worried about privacy, "I wish there were a private way to receive them. When they arrive, they show on the face of my phone."

Most respondents (75% or 75/102) replied positively to what they liked best about the texts. The most frequently cited benefit ($N = 25$) was the positive nature of the texts, "The positive messages and feeling like someone cares about how I feel" and "I felt positive after reading them, prompted self-reflection." Four of the respondents scored positive on the EPDS and offered these comments, "Gave me something different to think about besides what was already in my mind. Sent my mind in a different direction," "good thoughts," "mood booster," and "They were a pleasant surprise, like someone reaching out when I felt alone."

Finally, 76% of privately insured (111/147) and 45% (25/56) publicly insured women answered at least one survey question. Most respondents had unlimited texting plans—63% (10/16) of publicly insured subjects and 70% (56/80) of privately insured subjects. Among women who did not have unlimited texting, similar numbers responded that they strongly agreed (9%) and strongly disagreed (8%) that the texts were worth paying for.

Table 3 Satisfaction survey questions and answers on feasibility and acceptance of supportive texts

Survey question	Number of respondents	Number of respondents who received the question	% respondents who answered the given question	% respondents of total $N = 203$ sample	Answers among respondents % (N)					
					Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	
It was easy to receive the texts. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree)	136	203	67%	67%	7% (10)	1% (1)	0% (0)	10% (14)	82% (111)	
I read the texts. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree)	132	136	97%	65%	6% (8)	2% (2)	7% (9)	14% (19)	71% (94)	
I followed the advice in the texts. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree)	126	132	95%	62%	4% (5)	13% (17)	34% (43)	25% (31)	24% (30)	
The texts taught me how to improve my mood. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree)	123	126	98%	61%	6% (7)	14% (17)	29% (36)	24% (30)	27% (33)	
					Too many	**Too few**	**Just right**			
You received 3 texts per week. Was that too many, too few, or just right?	121	123	98%	60%	12% (15)	2% (3)	85% (103)			
What would you change about the texts?	110	122	90%	54%	Various. See Results section.					
What was the best thing about receiving the texts?	102	110	93%	50%						
Did you take the mood survey? If not, why not?	100	102	98%	49%						
					NA	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
It was easy to take the mood survey. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree, or 0 = not applicable)	97	100	97%	48%	9% (9)	7% (7)	3% (3)	13% (13)	15% (15)	52% (50)
I do not have unlimited texts, but paying for them myself was worth it. (On a scale from 1-5 with 1 = strongly disagree and 5 = strongly agree, or 0 = not applicable)	96	97	99%	47%	69% (66)	8% (8)	5% (5)	6% (6)	2% (2)	9% (9)

As for screening, 67% (65/97) reported they thought it was easy to complete CAT-MH™. Twelve subjects reported why they did not complete the screen. Of those, six encountered technical difficulties with either the link or their internet connection, while the rest either forgot to take the screen, had insufficient time, or lost the text message containing the link.

Discussion and conclusions

Mood screening via personal smartphone was feasible and acceptable for most pregnant and postpartum participants in our study. We undertook this feasibility study after 15 years of experience with pen-and-paper perinatal mood screening because of several shortcomings. These included the need for in-person administration, competing demands within an obstetric appointment, and the inability to screen women beyond the 6-week postpartum obstetric visit when mood conditions may develop. Thus, smartphone-based screening may result in the ability to screen more women, more frequently, conveniently, and with greater precision because of computerized adaptive testing described here. Before transitioning to smartphone-based screening, however, potential barriers should be addressed.

A minority of women (3%) experienced technical difficulties in attempting to complete CAT-MH™. Publicly insured and unpartnered women were significantly less likely to complete mood screening via smartphone. These women may be more likely to face interrupted phone service or sharing a smartphone with another household member. Any deployment of smartphone-based screening must take these realities into account and ensure these women are screened. Strategies may include using tablets in office so patients can complete the screen at the time of their visit if they were unable to by smartphone. This would also ensure that women who do not own smartphones would have the opportunity to be screened with the same test as their peers since the CAT-MH™ is available on tablets.

We hypothesized that postpartum women may be too busy to complete the screen. However, there was no difference in completion rates between pregnant and postpartum women. As for symptomatic women, in this study, only 6% (12/203) scored positive on the EPDS. Additional study of smartphone-based screening and texting with a larger, screen-positive sample is warranted.

Strengths of this study include its naturalistic setting and reliance on a patient's own technology and internet access to assess the feasibility and limitations of smartphone-based screening. In addition, CAT-MH™ is an innovative tool that shows promise to improve detection of perinatal depression, anxiety, mania, and suicide. For this study, the expense of the screening tool was negotiated at a reduced rate and waived for texting software. Future studies should address the legitimate concern that mobile health technology may be costly to develop and to use (Steinhubl et al. 2015).

Limitations of the study include missing survey data. Comparing survey responses between publicly and privately insured women could not be accomplished due to the relatively smaller sample of publicly insured respondents. Another limitation is the lack of verification that texts were read. Additionally, the satisfaction survey software did not provide all questions up front. Future texting initiatives could employ software that notifies the sender whether a text was read and deliver satisfaction questions contemporaneously.

Mobile health technology raises ethical and liability concerns (Lal and Adair 2014). Health professionals may be reluctant to adopt technology due to perceived privacy issues and uncertainty surrounding professional and regulatory standards (Torous et al. 2016). Privacy policies, including third-party data storage and handling, should be disclosed by developers (Hsin et al. 2016). To address these issues, the American Psychological Association is developing ethical guidelines for mobile app development for mental health (Jones and Moffitt 2016). Another concern is the lack of a solid evidence base for many mobile apps (Zhao et al. 2016). The growth of mobile apps is outstripping the effort required for evaluation of safety and quality (Luxton et al. 2011a, b). Thus, describing these limitations and setting clear expectations with patients are essential.

In summary, smartphones may bypass some barriers to screening, particularly since smartphone use is on the rise. Screening via smartphone frees up valuable office time and gives physicians immediate results. Smartphone response rates may be lower than paper screening, although electronic screening offers functionality to automatically rescreen non-compliant patients and schedule automatic screening during and after pregnancy. Because there was no verification that supportive texts were actually read, we are unable to state whether supportive texts may be effective as adjunctive treatment. Our findings suggest that by addressing technological barriers, smartphone screening and texting may result in improved mental health care for perinatal women.

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Compliance with ethical standards

Conflict of interest Dr. Robert Gibbons is a founder of Adaptive Testing Technologies, which distributes the CAT-MH™ battery of adaptive tests.

Benjamin Zagorsky is an employee of Zagaran Inc., the company that owns the text messaging software used in the study. The rest of the authors declare that they have no conflict of interest.

Research involving human participants and/or animals As noted in the manuscript text, all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent As noted in the manuscript text, informed consent was obtained from all individual participants included in the study.

Disclaimer The study sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

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