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A Randomized Trial of Text Messaging for Smoking Cessation in Pregnant Women

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Abstract

Introduction—There is a need for innovation in both the enrollment of pregnant smokers in smoking cessation treatment programs and in the type of treatment programs offered. The study tests whether an interactive and intensive text messaging program, Quit4baby, can promote smoking cessation for pregnant women already enrolled in a health text messaging program, Text4baby.

Methods—Between July 2015 and February 2016, a total of 35,957 recruitment text messages were sent to Text4baby subscribers. Eligible pregnant smokers were enrolled and randomized to receive Text4baby (control) or Text4baby and Quit4baby (intervention; N=497). Participants were surveyed at 1 month, 3 months, and 6 months post-enrollment, and saliva samples were collected at 3 months for biochemical verification of smoking status. Data were collected from 2015 to 2016 and analyzed in 2016.

Results—Using an Intention-to-Treat analysis, 28.80% of the intervention group and 15.79% of control group reported not smoking in the past 7 days at 1 month ($p<0.01$), and 35.20% of the intervention group and 22.67% of the control group reported not smoking in the past 7 days at 3 months ($p<0.01$). Biochemical verification of smoking status at 3 months indicated no significant differences between groups (15.60% in the intervention group and 10.93% in the control group [$p=0.13$]), although significant differences favoring the intervention were found for older smokers ($p<0.05$) and for those who enrolled in their second or third trimester of pregnancy ($p<0.05$). Self-

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report of late pregnancy 7- and 30-day point prevalence abstinence favored the intervention group ($p<0.001$, $p<0.01$). No significant differences were observed at the 6-month follow-up or in the postpartum period.

Conclusions—Results provide limited support of the efficacy of the Quit4baby text messaging program in the short term and late in pregnancy, but not in the postpartum period.

INTRODUCTION

In addition to the risks generally associated with smoking,¹ smoking during pregnancy has been shown to cause pregnancy complications and adverse fetal outcomes.^{2,3} Despite health risks and the urgency of quitting, an estimated 8.4% to 10.2% of women smoke throughout their pregnancy in the U.S.^{4,5} Smoking rates during pregnancy are higher among women with less than a high school education, with Medicaid insurance, of white or Native American ancestry, who live in certain states (e.g., West Virginia, Arkansas), and between the ages of 20 and 24 years.^{3,4}

Few evidence-based smoking cessation services exist that are targeted to pregnant smokers. The U.S. Public Health Service Clinical Practice Guidelines recommend intensive in-person counseling for smoking cessation for this group.^{6–8} Unlike for other adult smokers, nicotine replacement therapy and phone counseling are not strongly recommended for pregnant smokers.^{6,9–11} Of existing services targeted to this group, uptake is generally low.^{12,13} Less than one third of pregnant smokers accept the offer of in-person counseling after being screened as smokers.¹³ In addition, although most state quitlines offer pregnancy specific protocols, only a fraction of calls (<1%) are from pregnant smokers, even in the context of targeted outreach.^{14,15}

Thus, there is a need for innovation in both the development of efficacious smoking cessation services for pregnant women and in efforts to promote the uptake of such services among pregnant women. One promising strategy involves technology-based approaches on mobile phones. Smoking cessation programs on mobile phones that use automated text messaging have been found to be efficacious in general adult populations of smokers.^{16–19} A recent meta-analysis of 12 such studies concluded that individuals randomized to the mobile intervention had almost a doubling of chances of long-term quitting compared with a control condition.¹⁶

Such programs are well suited for pregnant smokers. Mobile phones and text messaging have near universal penetration among women of childbearing age, including those with low incomes.^{20,21} Additionally, given the stigma associated with smoking during pregnancy, pregnant smokers may be more comfortable with self-help programs.²²

Only a handful of mobile phone-based programs exist for pregnant smokers,²³ and few evaluations have been conducted.^{23–28} Existing studies consist of pilot studies that are underpowered for efficacy, have short-term follow-up,^{24–27} lack a control group,²⁴ or lack biochemical verification of self-reported smoking status.²⁴ Studies indicate that text messaging programs are acceptable for smoking cessation in pregnant women,^{24,25,28} can

result in favorable outcomes across a number of psychosocial mechanisms,²⁵ but have mixed efficacy.^{26–28}

The current study builds upon an earlier pilot study in pregnant smokers²⁴ and investigates the supplemental effect of adding a smoking-cessation text messaging program, Quit4baby, to an established text messaging program, Text4baby. Text4baby is the largest health text messaging service for pregnant women and mothers in the U.S. By recruiting pregnant smokers from an existing mobile health (mHealth) program to a novel mHealth program, this study addresses the need for innovation in both outreach to pregnant smokers and the types of services offered to them. If found to be promising, Quit4baby has the potential to be scaled and disseminated both through Text4baby, as well as through other independent channels.

METHODS

Study Population

The study was approved by the George Washington University IRB in 2015. Recruitment occurred between July 22, 2015 and February 9, 2016 and consisted of sending a single recruitment text message to eligible Text4baby subscribers. Text4baby subscribers were eligible if they had a due date >8 weeks in the future at the time of sending. Text4baby subscribers from California, Oklahoma, Ohio, and Louisiana were excluded because Quit4baby was already available in those states. Recruitment messages were broadcast weekly on Tuesdays at 2:00PM Eastern Standard Time.²⁸

Text4baby subscribers who replied *yes* to the recruitment message indicating interest were followed up with a phone call by study staff. If interested and eligible, subscribers were consented, enrolled in the study, given a baseline survey, and then randomized using the REDCap application. Subscribers were eligible for the Quit4baby study if they had a cell phone for their personal use, were willing to receive text messages on their cell phone, were aged 14 years, were currently pregnant, and had smoked at least one puff of a cigarette in the past 2 weeks. Participants were followed up with a phone survey at 1, 3, and 6 months after enrollment with outcome measures repeated across surveys. A saliva sample was also collected from participants who reported not smoking in the past 7 days at the 3-month follow-up. They were mailed a kit with instructions, a salivette and a pre-paid postage envelope for sample return.^{18,29–31} Returned samples were mailed to J2 Labs for cotinine analysis. Participants received a \$15 gift card for completing the baseline, a \$20 gift card for the 1-month, and a \$25 gift card for the 3- and 6-month follow-ups and for providing a saliva sample.

Measures

The primary outcome was 7-day biochemically confirmed point prevalence abstinence (PPA) at the 3-month follow-up, defined as a self-report of no smoking in the past 7 days on the 3-month survey and a cotinine level <13 ng/mL from the saliva sample.³¹ Also of interest was 30-day biochemically confirmed PPA, defined as a self-report of no smoking in the past 30 days on the 3-month survey and a cotinine level <13 ng/mL.

Secondary outcomes consisted of self-report of abstinence (7- and 30-day) at the 1-, 3- and 6-month follow-up, late in pregnancy and in the postpartum period. Measures of late pregnancy and postpartum PPA were constructed from self-reported PPA and pregnancy status. Once a participant was coded as no longer pregnant on a given survey, her late pregnancy and postpartum smoking status were recorded in relation to that survey. Late pregnancy PPA was recorded as self-reported smoking status (7- and 30-day abstinence) on the prior survey (e.g., if no longer pregnant was first recorded on the 3-month follow-up, then late pregnancy smoking status was recorded as smoking status from the 1-month). Postpartum smoking status was recorded as their 7- and 30-day abstinence on the same survey where no longer pregnant was recorded. For participants who were no longer pregnant by the 1-month follow-up ($n=16$, 3.21% of the sample), their late pregnancy smoking status was recorded as missing and their postpartum smoking status was recorded from the 1-month survey. For participants who were still pregnant at the 6-month follow-up ($n=190$, 38.22% of the sample), their late pregnancy smoking status was recorded from the 6-month follow-up, and their postpartum smoking status was coded as missing.

The baseline survey included items assessing demographic (e.g., age, gender, race/ethnicity, and education), pregnancy related (e.g., gestational age), and smoking characteristics of participants (e.g., lives with one or more smokers in the household, cigarettes smoked/day, and past quit attempts). Nicotine dependence was measured with the Fagerström Test for Cigarette Dependence (FTCD).^{32,33}

Participants randomized to the intervention group received Text4baby and Quit4baby, whereas the control group received only Text4baby. The two programs were sent to the user on the same mobile short code (i.e., 511411). Each text message started with an identifier, “Quit4baby” or “Text4baby,” in order to identify the program.

Quit4baby was developed in 2012 for a pilot test²⁴ and adapted from a program for adult smokers called Text2Quit.^{18,34} Based on results of the pilot test,²⁴ Quit4baby was revised for this trial. Quit4baby content was based on the Social Cognitive Theory³⁵ and developed to be consistent with the Clinical Practice Guidelines around pregnancy smoking cessation.⁶ Messages were aimed at improving self-efficacy for quitting, describing the outcome expectations from quitting both to the mother and baby, increasing social support for quitting via an ex-smoker quitpal, and increasing behavioral capability for quitting.

The Quit4baby texts are timed around the Quit4baby enrollment date, the quit date, and the baby’s due date. Quit4baby sends between one and eight messages per day, with the highest number of messages sent on the quit date and on the days immediately following that date. After the quit date, outgoing messages taper over time and stop after 3 months, except for monthly smoking-status program surveys that continue for 6 months. Additionally, 24 messages related to postpartum relapse prevention are delivered between 1 month prior to the baby’s due date and 6 months after the baby’s arrival. If a participant indicates to the program that they have not quit, they are routed into a new protocol of messages aimed at motivation for setting a new quit date. Once a quit date is set, they are routed back into the messages timed around a quit date. Participants have the opportunity to text keywords to the program to receive additional support, such as “FACT” for messages on the harms of

smoking; “CRAVE” for a distraction tip or baby trivia game; “SMOKED” to get back on track after smoking; and “STOP” to unsubscribe from Quit4baby messages. Quit4baby was developed by George Washington University and Voxiva with input from a consultant, ZERO TO THREE and the Text4baby Content Council.²⁴

Text4baby sends three weekly health texts that are timed to a women’s due date, as well as modules of messages on ad hoc health issues, such as influenza vaccination.^{36–41} Messages cover pregnancy through the baby’s first year. Six of Text4baby’s 150 standard messages are aimed specifically at smoking cessation, with three timed to arrive prior to the baby’s due date and three following the due date (e.g., “text4baby: Quitting smoking early in pregnancy is best. But quitting any time during pregnancy will make you and your baby healthier. Get help at 800-874-8669.”). Subscribers can text STOP to unsubscribe from Text4baby.

Enrollment in Text4baby is promoted by a large network of partners including governmental agencies (e.g., Centers for Disease Control and Prevention, Centers for Medicare and Medicaid Services, and Health Resources and Services Administration) and health plans. Text4baby has had over one million enrollees since its launch in 2010.³⁷ Text4baby is aimed at low-income women, and 40% of participants live in medically underserved areas.⁴⁰ Text4baby has been found to have positive health effects on maternal influenza vaccination and alcohol consumption, but not on smoking.^{38,39,41}

Statistical Analysis

For sample size, the study was powered on biochemically verified 7-day abstinence at the 3-month follow-up. A sample size of 250 per group would give 80% power to detect an increase in abstinence from 10% to 19% ($\alpha=0.05$, two-sided test). Analyses were conducted utilizing an intent-to-treat approach. Outcomes were examined after imputation of missing data, such that those with missing data were assumed to be smokers. Demographic differences between intervention and control groups were tested with *t*-tests or chi-square tests. For analysis of primary and secondary outcomes, quit rates between groups were compared with chi-square tests. Additionally, using logistic regression, the unadjusted and adjusted relative risk (RR) of quitting was calculated for the primary and secondary outcomes. Models were adjusted for variables found to be significantly different between groups.

Finally, to identify subgroups of participants who may have benefited more from the intervention than others, logistic regression was used to test for group assignment $\times$ subgroup interactions in predicting the primary outcome, 7-day biochemically confirmed quitting. For significant interactions, separate logistic models were constructed for each predetermined subgroup. Subgroups analyzed were age (<26 years, >26 years), race (white, non-white), education (GED or less, high school graduate), partner smoking status (smokes; does not smoke), cigarette dependence (FTCD 0–2, 3–4, 5)^{9,42} and gestational age (first trimester; other) at enrollment.⁴³ A sensitivity analysis was conducted to determine the effects of imputing missing data on 7-day biochemically confirmed quitting. Analyses were conducted in 2016 using SAS, version 9.3.

RESULTS

As shown in Figure 1, a total of 35,957 recruitment messages were texted to selected Text4baby subscribers, and 5.8% (2,096) of these texted back with interest. Of those who expressed interest, 50.10% (1,050) were reached on the phone by study staff and screened for eligibility. Of those found not to be eligible ($n=410$), the vast majority had not smoked in the past 2 weeks (92.20%). Among those found to be eligible ($n=595$), 85.2% ($n=508$) were consented and enrolled in the trial. It was later determined that in 1 week (October 13, 2015), subscribers from ineligible states were erroneously sent a recruitment message. Participants from these states who enrolled ($n=10$) were later removed from the study sample. One additional participant was later found not to smoke cigarettes at baseline and was also removed. The final sample for the remaining analyses was 497 participants.

Follow-up rates for the 1-, 3-, and 6-month surveys were 86.92%, 81.09%, and 71.83%, respectively. Follow-up rates were similar between groups except for the 1-month survey, where the response rate was slightly lower for the intervention group ($p<0.05$). Of those eligible to provide a saliva sample ($n=144$), 102 (70.83%) provided a saliva sample, with no significant difference between groups. Of these, 36 samples (35.29%) were found to have high levels of cotinine in their saliva ($>13\text{ng/mL}$) with no significant difference between groups.

Participants were on average aged 26.31 years ($SD=5.85$) and 17.80 weeks pregnant ($SD=7.92$). They were predominantly white (63.18%), with Medicaid or Medicare insurance (80.08%), with a high school degree or less as their highest level of education (59.96%), and unemployed (66.60%). At the time of enrollment, participants smoked an average of 7.36 ($SD=6.09$) cigarettes per day and had a FTCD score of 2.48 ($SD=1.85$). Intervention and control group participants were similar across all variables except for education, where more participants in the intervention group had an Associate's degree or higher ($p<0.01$; Table 1).

Unadjusted and adjusted logistic regression models were conducted. Adjusted models were adjusted for education because of significant differences between groups at baseline. Because the results were similar for the unadjusted and adjusted, unadjusted models are presented in Table 2.

An examination of the primary smoking cessation outcome—biochemically confirmed 7-day PPA at 3 months with missing data imputed as smoking—showed that 15.60% of participants in the intervention group were biochemically confirmed point prevalence abstainers compared with 10.93% of the control group. This difference did not reach statistical significance ($p=0.13$). Similarly, for biochemically confirmed 30-day PPA at 3 months, no significant differences were observed.

Analyses were conducted to examine effects for particular subgroups of interest on biochemically confirmed 7-day PPA at 3 months, the primary outcome. Those aged ≥ 26 years were found to be more likely to benefit from the intervention compared with those aged <26 years ($p<0.05$). Among those aged ≥ 26 years, 18.97% in the intervention group had biochemically confirmed abstinence compared with 6.86% in the control group ($RR=2.76$, 95% $CI=1.23$, 6.20, $p<0.01$). Among those aged <26 years old, there was no

difference in quit rates (12.69% in the intervention group compared with 13.97% in the control group). Another significant interaction effect was found for gestational age at time of study enrollment ($p<0.05$). Among those who enrolled in their second or third trimester, 15.43% in the intervention group had biochemically confirmed abstinence compared with 7.22% in the control group ($RR=2.14$, 95% $CI=1.14, 4.00$, $p<0.05$). There was no difference in the effect of the intervention on biochemically confirmed abstinence for those enrolled within their first trimester.

At the 1-month follow-up, significant differences were observed for self-report of PPA in the past 7 days ($p<0.05$), but not in the past 30 days. At 1 month, 28.80% of the intervention group reported PPA in the past 7 days compared with 15.79% of the control group ($RR=2.16$, 95% $CI=1.39, 3.34$, $p<0.01$). For self-reported results at 3 months, the outcomes favored the intervention group: 35.20% of the intervention group reported PPA in the past 7 days compared with 22.67% of the control group ($RR=1.85$, 95% $CI=1.25, 2.75$, $p<0.01$), and 29.20% of the intervention group reported PPA in the past 30 days compared with 19.03% of the control group ($RR=1.76$, 95% $CI=1.15, 2.67$, $p<0.01$). At the 6-month follow-up, there were no significant differences between the intervention and control groups for past 7- or 30-days smoking. Among those who were still pregnant at the 6-month survey ($n=190$), past 7-day PPA at 6 months favored the intervention group, but differences did not reach statistical significance ($p=0.08$).

During late pregnancy, the outcomes favored the intervention group for both 7- and 30-day PPA: 34.40% of the intervention group reported 7-day PPA compared with 21.46% of the control group ($RR=1.35$, 95% $CI=1.14, 1.61$, $p<0.001$), and 27.60% of the intervention group reported 30-day PPA compared with 18.62% of the control group ($RR=1.27$, 95% $CI=1.06, 1.52$, $p<0.01$). For the postpartum period, there were no significant differences between the groups for past 7- or 30-day PPA.

The analysis for the primary and secondary outcomes was repeated without imputing missing data and limiting analysis to only complete cases (Table 2). The results overall were similar. For the primary outcome, results indicate that 19.90% of participants in the intervention group were biochemically confirmed 7-day point prevalence abstainers compared with 13.04% of the control group ($p=0.06$).

Participants in the intervention group were enrolled in Quit4baby for 129.08 days ($SD=72.26$) on average and enrolled in Quit4baby for 7.84 days ($SD=4.27$) before their quit date. Approximately 9% (8.80% [$n=22$]) of participants unsubscribed from Quit4baby within the first week of receiving the program, 23.60% of participants ($n=59$) within the first month, and 38.80% ($n=97$) before the end of the study period (180 days). For Text4baby, participants from both groups were enrolled on average for 158.22 days ($SD=51.05$) during the study, with intervention group participants enrolled for significantly fewer days (152.53 days [$SD=56.77$]) compared with control group (163.98 days [$SD=43.89$], $p<0.05$). For Text4baby, 2.41% ($n=12$) of all participants unsubscribed within the first week of the study, 7.44% ($n=37$) unsubscribed within the first month, and 19.92% ($n=99$) unsubscribed during the study period (180 days). There was no association observed between unsubscribing from

Quit4baby or Text4baby during the first month of the study and 7-day biochemically confirmed PPA at the 3-month follow-up ($p=0.37$ and $p=0.07$, respectively).

DISCUSSION

This study builds upon the previous findings from pilot studies of text messaging for smoking cessation in pregnant women^{24,25,27} and shows that text messaging is not only acceptable^{24,25} and results in changes in the putative mediators of smoking cessation,²⁵ but can be effective for smoking cessation on a number of outcomes. For the primary outcome, biochemically confirmed 7-day PPA at the 3-month follow-up, there was no overall effect of the intervention, although effects were found among two subgroups: those who enrolled in the study in their second or third trimester and those who were aged ≥ 26 years. Additionally, for secondary outcomes based on self-report, an effect of Quit4baby on 7-day PPA at 1 and 3 months and in late pregnancy was observed. However, no effects were observed on self-reported 7-day PPA at 6 months or in the postpartum period.

That effects were found with self-reported measures even in the short term and in late pregnancy is encouraging as studies have shown that infants born with less prenatal exposure experience better birth outcomes.² These effects may be because the automated text messaging program was able to replicate some of the elements of intensive in-person counseling previously found to be effective with pregnant smokers.⁶ Although modest, these findings could have clinical importance in large samples.

Additionally, that pregnant smokers in the intervention group aged ≥ 26 years and those enrolling in their second or third trimester of pregnancy were found to be more likely to have biochemically confirmed abstinence compared with the control group is noteworthy. These groups are typically found to be less likely to quit during their pregnancies in the absence of an intervention.^{43–45} One implication of this finding is that the timing of the invitation to quit smoking may be important for pregnant smokers. It may be that as pregnant women enter their second and third trimesters and become more noticeably pregnant, they feel more social pressure to quit and therefore become more open to quitting. Older pregnant smokers may be more likely to quit with the intervention because older smokers generally have more interest in quitting.⁴⁵ Future research should be directed at understanding the optimal timing of the smoking cessation offer, the value of repeated offers throughout pregnancy, and how to assist smokers of all ages.

That Quit4baby was not effective at sustaining abstinence in the postpartum period is not surprising. Indeed, few pregnancy cessation interventions have been found to be effective into the postpartum period when relapse rates are high.^{46,47} Although Quit4baby had a postpartum relapse protocol, it was brief consisting of only a handful of text messages. Future studies should investigate whether a more intensive postpartum relapse prevention text messaging protocol, perhaps coupled with self-help booklets that have been previously found to be effective,⁴⁸ may be effective in this context.

The lack of a significant finding at the 6-month follow-up may indicate that Quit4baby has an effect in the short term on cessation, but by 6 months into pregnancy, the messages lose

their effectiveness. Because approximately two thirds of the sample had their baby by the 6-month follow-up, the statistical power to demonstrate a long-term effect of the intervention on those who were still pregnant was limited.

One aspect of the innovation of this study is that by making use of the subscriber base of an established mHealth program, it not only evaluates a novel intervention, but demonstrates the feasibility of a new model for recruiting and reaching pregnant smokers. Given the low uptake of treatment by pregnant smokers,^{13–15} mHealth programs such as Quit4baby may be able to expand the reach of treatment by providing an intervention in the context of existing mHealth programs. It remains an open question as to whether this type of offering reaches pregnant smokers who would not have been reached otherwise by more traditional services.

This study has several strengths. This study represents the largest randomized trial to date that evaluates the efficacy of text messaging for smoking cessation in pregnant women. Another strength is that the study has good generalizability to the target population. Participants were recruited from a national program and under real world conditions in which they might receive the program in future. Compared with other studies,¹¹ there were very few exclusion criteria. Additionally, participants' demographic characteristics—based on their being predominantly of white ethnicity, on public insurance, and having a household income of \$30,000 per year⁴—were found to be similar to those of previous national samples of pregnant smokers. Their frequency of sending or receiving close to 100 texts per day also mirrors national levels for young adults.⁴⁹ Nonetheless, future studies may wish to investigate this type of intervention with non-Text4baby subscribers and other high-prevalence populations, such as Native-American pregnant smokers.⁵⁰

Additional strengths of this study include the inclusion of biochemical confirmation of smoking status. The decision to confirm smoking status biochemically was made because of the high deception rate documented in previous studies of pregnant smokers.^{11,13,51} Indeed in this study, of those who returned the saliva samples, 35.29% were found to have discrepancies between their self-report on the 3-month survey and cotinine levels, though discrepancies resulted in similar reductions in quit rates in both groups.

Limitations

Limitations for this study include that this study may have been insufficiently powered to adequately detect significant effects in the primary outcome. Although there was approximately a 50% increase in quitting in the intervention group (15.60%) over the control group (10.93%), results on this outcome were not significantly different. Future studies may consider evaluating such a program with a larger sample size. Also, because of the design of the study where participants were enrolled in all trimesters of pregnancy, not all participants were followed up for 6 months of pregnancy and conversely, those who were followed up for 6 months of pregnancy were not surveyed during the postpartum period. Thus, analyses of pregnancy cessation at 6 months are based on a much-reduced sample size. Another limitation of the study was that the intervention group was less responsive to the 1-month follow-up compared with the control group ($p < 0.05$), though equally responsive to other surveys. This means that the intervention group at this time point had more missing data and imputations relative to the control group. Also, there appears to be a low level of

contamination of the control group, as six participants from the control group (2.42%) indicated on their 3-month survey that they had used a texting program for smoking cessation other than Text4baby. It is possible that these participants independently enrolled in a different program. Finally, although recruitment through an existing mHealth program represents a solid innovation, this might also somewhat reduce generalizability as only mHealth subscribers are included in the sample.

CONCLUSIONS

The use of mobile phones is widespread, with 98% of young adults between the ages of 18 and 29 years owning a mobile phone.²⁰ The results from this trial of pregnant smokers provide some indication that an intensive smoking cessation text messaging program may help pregnant smokers quit smoking during pregnancy and in the short term, particularly for those aged 26 years and those in the second and third trimesters of pregnancy. Future studies are needed that explore how to improve such programs to maintain effects throughout pregnancy and into the postpartum period.

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Dr. Abroms has stock in Wellpass Inc. (formerly Voxiva, Inc.) and has licensed Text2Quit and Quit4Baby to Wellpass Inc. Dr. Johnson is employed by Wellpass Inc., the company that operates Text4baby and Quit4baby. Ms. Bushar is employed by ZERO TO THREE, a partner operating the Text4baby service. Dr. Brandon has served as a paid consultant to Voxiva, Inc. (now Wellpass Inc.), and has received research support from Pfizer, Inc. No other financial disclosures were reported by the authors of this paper.

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Figure 1.
Study enrollment and analysis flow chart.

Table 1**Demographic Characteristics of Participants (%)**

Characteristic	Intervention <i>n</i> =250	Control <i>n</i> =247	All <i>N</i> =497
Age, M (SD)	26.68 (5.94)	25.95 (5.74)	26.31 (5.85)
Race/Ethnicity			
White, Non-Hispanic, Latino or Spanish	164 (65.60)	150 (60.73)	314 (63.18)
Black/African American- Non-Hispanic, Latino or Spanish	55 (22.00)	62 (25.10)	117 (23.54)
Other- Non-Hispanic, Latino or Spanish	11 (4.40)	14 (5.67)	25 (5.03)
Hispanic, Latina or Spanish	20 (8.00)	20 (8.1)	40 (8.05)
Insurance			
Medicaid/Medicare	199 (79.60)	199 (80.57)	398 (80.08)
Private, Veterans, or other	40 (16.00)	38 (15.38)	78 (15.69)
None	11 (4.40)	8 (3.24)	19 (3.82)
Education ^a			
12th grade or less with no high school diploma	55 (22.00)	81 (32.79)	136 (27.36)
High school graduate, GED, or equivalent	80 (32.00)	82 (33.20)	162 (32.60)
Some college	83 (33.20)	69 (27.94)	152 (30.58)
College degree	32 (12.80)	15 (6.07)	47 (9.46)
Employment status			
Part time	48 (19.20)	36 (14.57)	84 (16.90)
Full time	42 (16.80)	37 (14.98)	79 (15.90)
Not at all	158 (63.20)	173 (70.04)	331 (66.60)
Household income			
<\$15,000	130 (52.00)	143 (57.89)	273 (54.92)
\$15,001–\$30,000	82 (32.80)	67 (27.13)	149 (29.98)
\$30,001–\$47,099	21 (8.40)	25 (10.12)	46 (9.26)
>\$47,100	12 (4.80)	7 (2.83)	19 (3.82)
Marital status			
Single, never married	92 (36.80)	102 (41.30)	194 (39.03)
Living with significant other	85 (34.00)	78 (31.58)	163 (32.80)
Married	47 (18.80)	48 (19.43)	95 (19.11)
Divorced/Separated/ Widowed	25 (10.00)	19 (7.69)	44 (8.85)
Gestational age, in weeks, M (SD)	17.67 (7.86)	17.93 (8.00)	17.80 (7.92)
First trimester (<13 weeks)	90 (36.00)	83 (33.60)	173 (34.81)
Second trimester (14–26 weeks)	124 (49.60)	115 (46.56)	239 (48.09)
Third trimester (>27 weeks)	36 (14.40)	49 (19.84)	85 (17.10)
Health history			
Physical health (hypertension, preeclampsia, diabetes, gestational diabetes, asthma, or anemia)	90 (36.00)	86 (34.82)	176 (35.41)
Mental health (anxiety disorder, depression or bipolar disorder)	98 (39.20)	96 (38.87)	194 (39.03)
Regions			
West	20 (8.00)	13 (5.26)	33 (6.64)

Characteristic	Intervention <i>n</i> =250	Control <i>n</i> =247	All <i>N</i> =497
Northeast	26 (10.40)	46 (18.62)	72 (14.49)
Midwest	66 (26.40)	58 (23.48)	124 (24.95)
South	138 (55.20)	130 (52.63)	268 (53.92)
Smartphone versus basic phone	215 (86.00)	211 (85.43)	426 (85.71)
Unlimited text messaging plan	248 (99.20)	245 (99.19)	493 (99.20)
# of texts per day	98.25 (361.10)	85.99 (193.70)	92.17 (290.20)
% Lives with a smoker	159 (63.60)	148 (59.90)	307 (61.80)
% Partner smokes	108 (43.20)	96 (38.90)	204 (41.00)
Cigarettes per day at baseline, M (SD)	7.48(6.38)	7.25 (5.79)	7.36 (6.09)
Fagerstrom Test for Cigarette Dependence (0–10), M (SD)	2.43 (1.87)	2.54 (1.82)	2.48 (1.85)
E-cigarette use in the past 30 days	52 (20.80)	36 (14.57)	88 (17.71)
Alcohol consumption in the past 30 days	21 (8.40)	23 (9.31)	44 (8.85)
Marijuana use in the past 30 days	28 (11.20)	26 (10.53)	54 (10.87)

^aSignificant difference ($p<0.01$) was observed between control and intervention group based on chi-square test.

GED, general educational development test

Table 2

Smoking Cessation Outcomes by Measure and Time Period

Follow-up survey/Measure	Smoking status imputed ^a			Complete cases ^b		
	Intervention (%)	Control (%)	RR (95% CI) (unadjusted)	Intervention (%)	Control (%)	RR (95% CI) (unadjusted)
Primary outcome						
3-month						
Biochemically confirmed 7-day point prevalence abstinence	39 (15.60)	27 (10.93)	1.51 (0.89–2.55)	39 (19.90)	27 (13.04)	1.53 (0.97–2.39)
Biochemically confirmed 30-day point prevalence abstinence	32 (12.80)	26 (10.53)	1.12 (0.83–1.52)	32 (16.33)	26 (12.56)	1.30 (0.81–2.10)
Secondary outcome						
1-month						
Not smoked in past 7 days	72 (28.80)	39 (15.79)	2.16 (1.39–3.34)**	72 (34.78)	39 (17.49)	1.64 (1.25–2.15)***
Not smoked in past 30 days	31 (12.40)	19 (7.69)	1.70 (0.93–3.10)	31 (14.90)	19 (8.56)	1.41 (0.97–2.03)
3-month						
Not smoked in past 7 days	88 (35.20)	56 (22.67)	1.85 (1.25–2.75)**	88 (44.90)	56 (27.05)	1.47 (1.21–1.78)***
Not smoked in past 30 days	73 (29.20)	47 (19.03)	1.76 (1.15–2.67)**	73 (37.44)	47 (22.71)	1.41 (1.16–1.71)***
6-month						
Not smoked in past 7 days	73 (29.20)	63 (25.51)	1.21 (0.81–1.79)	73 (41.95)	63 (35.20)	1.15 (0.93–1.44)
Not smoked in past 30 days	60 (24.00)	57 (23.08)	1.05 (0.70–1.59)	60 (33.52)	57 (31.49)	1.05 (0.84–1.31)
Late pregnancy						
Not smoked in past 7 days	86 (34.40)	53 (21.46)	1.35 (1.14–1.61)***	86 (46.49)	53 (28.19)	1.46 (1.20–1.78)***
Not smoked in past 30 days	69 (27.60)	46 (18.62)	1.27 (1.06–1.52)**	69 (37.10)	46 (24.21)	1.34 (1.09–1.64)**
Postpartum						
Not smoked in past 7 days	41 (16.40)	42 (17.00)	0.98 (0.77–1.24)	41 (35.96)	42 (33.33)	1.12 (0.66–1.91)
Not smoked in past 30 days	35 (14.00)	38 (15.38)	0.95 (0.73–1.22)	35 (29.66)	38 (30.16)	0.98 (0.56–1.69)

Note: Boldface indicates statistical significance (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

^aMissing data were imputed to indicate smoking; The full sample was used in the analysis.

^bNo imputation of missing data; Only complete cases were used in this analysis.

RR, relative risk

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