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The Efficacy of Text-Based Mentoring for Postpartum Mothers: A Pilot Study

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Abstract

Objectives Technology-based outreach offers promise for providing support to a broad population of postpartum mothers while keeping costs low. However, research on the efficacy of this approach is scarce. We conducted a pre-registered randomized pilot trial of the effects of a novel technology-based approach for supporting postpartum mothers – via text-based mentoring – from infant's birth through 18 months.

Methods Mothers (n = 201) were recruited at West Penn Hospital in Pittsburgh, PA in the days immediately following delivery. Treatment mothers were matched with volunteer mentors who communicated with them entirely via text messages. Control mothers received monthly one-way texts on basic safety topics. Measures were collected via hospital records and mother surveys. We estimated treatment effects on mothers' parenting stress, mental health, knowledge of child development, engagement in language and literacy activities, and child milestones at 4- and 18-months postpartum. We used a systematic coding approach and simple descriptive statistics to analyze the treatment mother-mentor texting transcripts.

Results We found no statistically significant impacts on targeted outcomes. However, impacts for some outcomes were meaningfully large (> 0.2 SDs). Analyses of texting transcripts showed that most mothers stayed engaged for the full 18-month study period and that mother-mentor pairs primarily discussed maternal wellbeing and child-focused topics.

Conclusions for Practice Postpartum mothers will engage with mentors in a text-based mentoring program around important maternal and child health topics. More research and development on technology-based supports for parents in the early childhood years is needed.

Significance

What is already known on this subject? Technology-based approaches to supporting parents of young children are proliferating, with some showing promise in rigorous trials.

What this study adds? Postpartum mothers will engage with mentors in text-based format and discuss maternal and child health topics. The efficacy of this approach should be tested further in larger trials.

Keywords Postpartum mothers · Maternal stress · Maternal depression · Technology-based supports

Introduction

An infant's arrival brings many changes, both situational and physiological, that can leave postpartum mothers feeling stressed, anxious, and/or depressed (Howard et al., 2014). Technology-based supports have potential as a low-cost, scalable strategy to reach postpartum mothers. Virtually all U.S. adults, including those in households with low incomes, own a cell phone (Pew Research Center, 2019), and today's millennial parents grew up with high levels of technology use. Furthermore, other approaches to supporting parents of young children often struggle with low

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take-up and high attrition, likely due to their intensity and/or intrusiveness (e.g., home visiting; Leyva et al., 2021). Parents report frequently turning to technology with parenting questions, but they also report concerns about the volume and reliability of information (Arnold, 2018).

Technology-based supports for parents of young children are proliferating, with some showing promise in rigorous trials (for systematic reviews, see Hall & Bierman 2015, Garcia et al., 2022). For example, the text4baby program, which provides parents with regular health- and safety-focused texts, has been shown to increase mothers' self-efficacy, though there were no impacts on 21 other maternal health and behavior outcomes in randomized controlled trials (RCTs) (Evans et al., 2012, 2015). More research is needed to understand the potential for technology-based approaches to engage postpartum mothers and improve maternal and child outcomes in the early years.

The Nurture® Program

This study is, to our knowledge, the first RCT of a text-based mentoring intervention for postpartum mothers. The Nurture® Program was created by NurturePA, a Pittsburgh-based nonprofit, and was motivated by the general lack of supports for postpartum mothers in the U.S. Participating mothers were recruited in the hospital during the immediate postpartum period and assigned a program-trained volunteer mentor.[1] Mother/mentor dyads then communicated entirely via text. Mentors, who were mothers themselves, provided emotional support, answered questions, encouraged activities promoting maternal wellbeing and healthy infant development, and directed mothers to relevant local resources. Mentors were expected to text mothers once a week at minimum. Mothers were encouraged to text mentors with questions as they arose, with mentors responding within 24 h. Mentors used a program-created, web-based platform for texting. The platform included a library of expert recommendations and resources on child development and maternal postpartum mental and physical health, with material drawn from reputable sources including the American Academy of Pediatrics, the Centers for Disease Control and Prevention, and Zero to Three. The platform allowed mentors to share accurate, evidence-based information and provided mentors with pre-loaded conversation prompts tailored by child age as an additional option for communication. Each mentor worked with up to 13 mothers and was expected to commit 2–3 h weekly to mentoring. In this study, the primary, proximal targeted aim was reducing maternal stress in a broad-based, non-targeted population of postpartum mothers, with the more distal aim of improving child development.

Program supervisors oversaw mentors, providing technical, programmatic, and emotional support. Supervisors also helped mentors find and recommend appropriate local resources. Finally, supervisors evaluated mentors' performance and provided regular feedback.

The Nurture® Program design aligns with adult development and behavioral science principles. Regarding adult development, the postpartum period is one of vulnerability: new parents' brains experience structural changes, creating a unique window for behavioral change in the adult developmental life course (Kim et al., 2010; Kim & Watamura, 2015). From adult learning principles, adults learn best from hands-on experiences and from opportunities to process challenges with a knowledgeable mentor or peer (Knowles et al., 2005). Some research finds that mothers regard peers, rather than professionals, as their preferred source of parenting support and advice (Edwards & Gillies, 2004).

From behavioral science, the program has the potential to reduce the task complexity that can hinder postpartum enactment of research-informed parenting choices (Mullainathan & Thaler, 2000). The program provides information in small chunks through tailored communication that addresses in-the-moment concerns. Similarly, mentors encourage parenting behaviors, such as reading to infants, that yield long-term benefits but which may show few immediate effects. Such delayed gratification is a common barrier to optimizing any behavior (DellaVigna, 2009; Thaler & Sunstein, 2008).

Additionally, different from much of the parenting intervention literature, the Nurture® Program is strengths-based. Mentors are trained to reinforce positive behaviors and praise mothers' parenting and self-care whenever possible. A strengths-based approach may help address attrition from parenting programs and increase program effectiveness (Leyva et al., 2021).

In sum, the Nurture® Program may effectively support mothers and encourage positive parenting practices by targeting a particularly malleable period of adult development using strengths-based communication informed by adult learning and behavioral science principles. In a

[1] As Martin et al. (2018) detail, mentors attend a three-hour, in-person training which introduces the program and trains mentors on building relationships with mothers. Mentors then work through seven online training videos (each ~ 15–20 min long) that provide an overview of program goals and design, an explanation of the software mentors use, information about recognizing and responding to perinatal mood and anxiety disorders, and information about supporting breastfeeding, safe sleep, and early language and literacy. Each video features a different individual including a lactation consultant, the director of a safe-sleep education nonprofit, a mental health-focused social worker, an Allegheny County Health Department project coordinator, and a Carnegie Library of Pittsburgh representative. Optional ongoing training is provided via regular round table discussions, community presentations, and a mentor-exclusive Facebook group.

prior feasibility study (Martin, Weiland, & Page, 2018), we investigated the frequency and content of text communication between 162 mother-mentor dyads (18,897 texts total) during the first year postpartum. We found that mothers engaged with mentors throughout most of the year and that child-focused and maternal-health-focused topics were common. Mentors also addressed concerns promptly and reached out proactively, offering accurate information, advice, and emotional support. Taken together, this feasibility study revealed the Nurture® Program as a promising strategy for supporting postpartum mothers.

Specific Aims

In this first pilot RCT of the Nurture® Program, we addressed three research questions:

1) How did mothers and mentors engage in the program?
2) Did the program reduce maternal parenting stress at 4 and 18 months postpartum?
3) Did the program improve mothers' knowledge of child development, increase their engagement in parent-child language and literacy activities, improve children's early development, and reduce mothers' postpartum depression?

Methods

Participant Selection and Randomization

We pre-registered the study in April 2018.[2] We recruited 201 study participantsfrom the West Penn Hospital maternity ward in Pittsburgh, PA on a rolling basis between May 2018 and September 2019 and followed them for 18 months.[3] Clinical coordinators assessed potential participants on several inclusion criteria requiring that they: (1) be first- or second-time mothers, (2) be residents of Allegheny County, (3) plan to live in Allegheny County over the next two years, (4) have no history of substance abuse, and (5) have no more than one other child living with them full time. We also required a mother's focal infant to have (6) a gestational age at or above 34 weeks, (7) a birth weight at or above four pounds, and (8) a hospital discharge without an extended NICU stay. These criteria sought to minimize study attrition and to recruit mothers whom the program was designed to support.

Clinical coordinators described the study to mothers who met all criteria during their postpartum hospital stay. After obtaining consent, coordinators randomly assigned mothers to either the treatment or control group and notified NurturePA of these assignments.[4] In all, 31 mentors supported an average of 3.7 treatment mothers (with caseloads of treatment mothers ranging from 1 to 8 per mentor, in addition to non-study mothers).[5] Mentors were on average 40-years-old; 91% were white and 9% were Asian. 96% held a bachelor's degree and 59% a graduate degree. 62% were employed at least part-time, primarily as teachers, nurses, or social workers.

Experimental Conditions

Treatment mothers were paired with a mentor and had the opportunity to participate in the Nurture® Program, as described above. Control mothers received monthly texts containing information about basic child safety and health.[6] NurturePA staff oversaw control message administration. Control communication was one-way; mothers could not text with a NuturePA mentor or other staff.

Participants

The sample includes 100 mothers randomized to treatment and 101 to control (total n = 201; Fig. 1). On average, sample mothers were about 29 years old; were mostly white (71% treatment and 67% control); and were diverse in terms of household income and education (Table 1). Approximately 85% of treatment mothers and 78% of control mothers were married or in a domestic partnership. Nearly one third had a history of anxiety at baseline, and fewer had a history of depression (12% treatment and 19% control). Our study was powered to detect an effect size of 0.34 SD on primary outcomes (alpha = 0.05; power = 0.8, $R^2 = 0.25$).

[2] See ClinicalTrials.gov Identifier: NCT03497286 for our pre-registration plan.

[3] This research was conducted in accord with prevailing ethical principles and was reviewed and approved by the Institutional Review Board of the Allegheny-Singer Research Institute which oversees research conducted at our recruitment hospital. The University of Pittsburgh Institutional Review Board reviewed and approved all procedures related to transfer, storage and analysis of deidentified data.

[4] Prior to the start of recruitment, the coordinator developed a list of study IDs that were randomly assigned to treatment and control conditions in equal shares. The IDs were then sorted in numeric order. After recruitment of a participant, the coordinator would assign the participant a study ID and link the participant to the treatment condition assigned to that ID.

[5] Approximately 18% of mothers experienced mentor attrition during the study period and were matched with a different mentor.

[6] For example, at eight months post-enrollment, control mothers received the message: "Greetings from NurturePA! At eight months old, your baby may be showing signs of crawling or may even be fully on the move. Be sure to secure cabinets and use safety gates where needed." Other messages addressed the importance of well-child visits, constant bath-time supervision, and guidelines for rear-facing car seats.

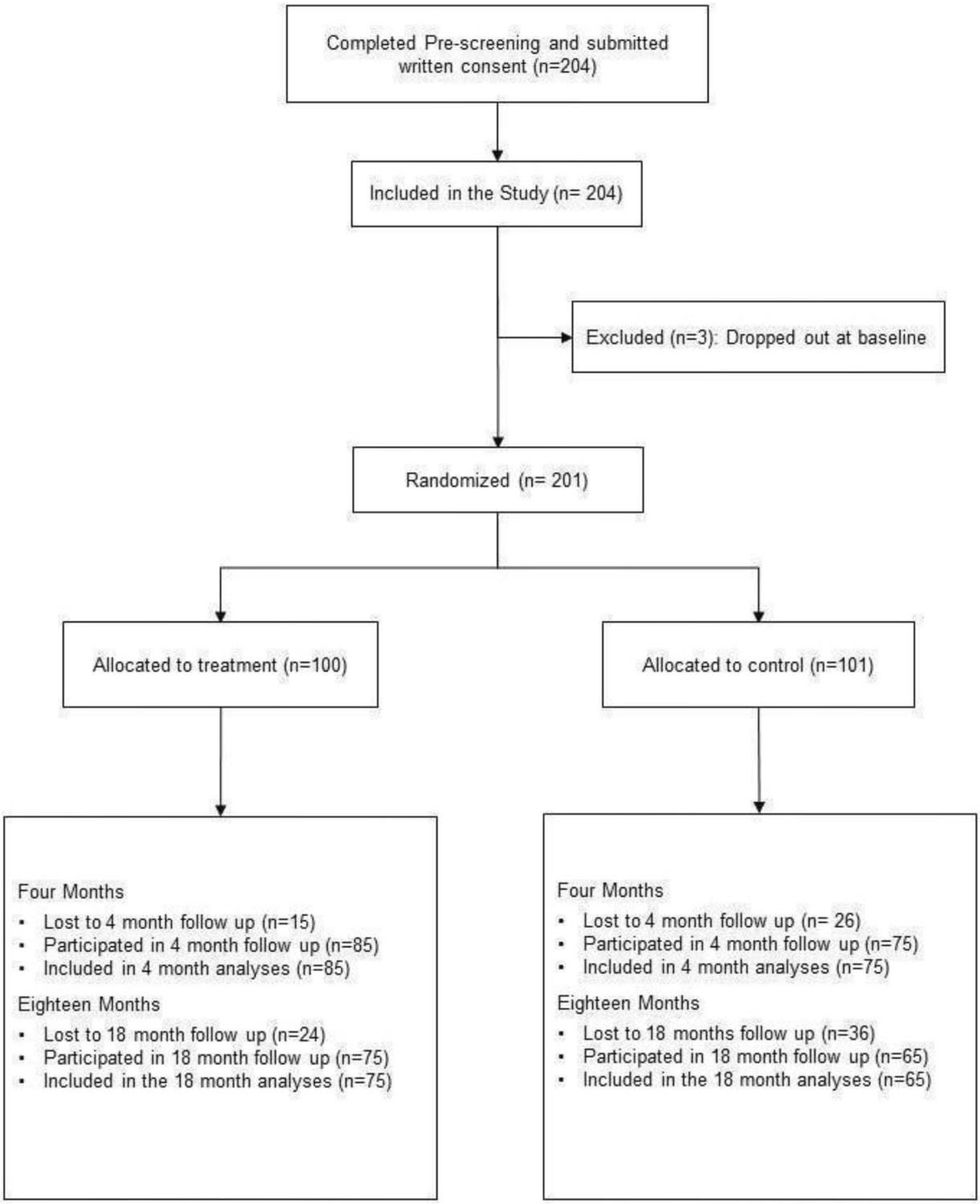

Fig. 1 CONSORT flow diagram

Balance on Observables

Randomization yielded equivalent groups at baseline. Despite imbalance on 4 of 23 individual covariates (Table 1), a joint *F*-test of differences in these 23 characteristics was not statistically significant.

Table 1 Baseline characteristics and assessment of balance

	Treatment group	Control group	Difference	Standardized Difference
Race/ethnicity				
White	0.710	0.673	0.037	0.08
Black	0.170	0.248	-0.078	-0.18
Other race	0.110	0.079	0.031	0.11
Income				
At or below 100% of national median income	0.306	0.417	-0.111	-0.22
100–200% of national median income	0.429	0.333	0.095	0.20
At or above 200% of national median income	0.265	0.250	0.015	0.03
	(0.444)	(0.435)	(0.809)	
Maternal Education				
High School or less, or other	0.210	0.238	-0.028	-0.07
Associate's degree / some college	0.160	0.267	-0.107*	-0.24
Bachelor's degree	0.320	0.208	0.112*	0.30
Any grad school	0.31	0.287	-0.02287	-0.05
Marital Status				
Married/Domestic partnership	0.859	0.790	0.069	0.167
History of				
Depression	0.120	0.188	-0.068	-0.17
Anxiety	0.320	0.297	0.023	0.05
Pregnancy & Delivery				
Had difficult pregnancy	0.140	0.178	-0.038	-0.10
Had difficult delivery	0.360	0.317	0.043	0.09
Resources used during pregnancy	4.820	4.386	0.434**	0.30
	(1.336)	(1.442)	(0.028)	
Other				
Age	29.289	29.502	-0.213	-0.04
	(5.342)	(5.472)	(0.782)	
English only at home	0.920	0.941	-0.021	-0.09
	(0.273)	(0.238)	(0.569)	
First time mother	0.720	0.584	0.136**	0.27
Enrollment month	6.020	5.970	0.050	0.02
Network size	6.200	6.119	0.081	0.03
	(3.207)	(3.157)	(0.857)	
Employed	0.810	0.792	0.018	0.04
N	100	101	201	
F statistic (*p*-value)	0.86 (0.33)			

Note: Race/ethnicity data is missing for one treatment group member. Income data is missing for two treatment and two control group members. Difficulty of delivery data is also missing for one control group member. Network data is missing for three mothers in each assignment group. *F*-statistic shown is for the baseline variables jointly predicting treatment status. Standard deviation for continuous variables in parentheses. ~$p<0.1$ * $p<0.05$ ** $p<0.01$

Procedures

Following consent, participating mothers completed an intake survey capturing demographic characteristics, mental health history, and pregnancy and delivery experiences. Participants received a $50 gift card as compensation. Coordinators also recorded selected information from participants' medical records (e.g., maternal age, infant's birth weight).

Four and 18 months after study enrollment, we collected data on pre-registered outcomes via Qualtrics surveys that coordinators distributed via text. Participants received up to three text-message reminders followed by up to three phone call reminders about the survey. We compensated participants with a $75 gift card for each survey. All participants had passed their 4-month mark by the COVID-19 pandemic onset, but few had done so by the time of the 18-month survey (Appendix Figures A.1 and A.2).

Finally, the Nurture® Program texting platform captured mother-mentor text message transcripts that were coded by a team trained to reliability. The team used a scheme previously developed to investigate program feasibility (Martin et al., 2018).

Measures

Our study includes pre-registered outcomes, baseline covariate measures, and systematic coding of texting transcripts.

Primary Outcomes

Maternal Parenting Stress

At four months, we assessed maternal parenting stress using five subscales from the nationally normed Parenting Stress Index (PSI; Fourth Edition): attachment, child reinforces parent, isolation, depression, and parent competence (40 items; Abidin 2012). At 18 months, we used two subscales from the PSI Short Form – parent-child dysfunctional interaction and parent distress (24 items; Abidin 2012). We selected these subscales given their alignment with the Nurture® Program's theory of change (Martin et al., 2018). We used different subscales at each time point to avoid potential retesting effects. The PSI is widely used, is sensitive to intervention effects, and has excellent psychometric properties (Abidin, 2012; Burke, 1978; Hamilton, 1982). Items are Likert-scaled (1–5) with higher scores indicating higher stress levels. For interpretability, we converted raw subscale scores to percentiles.

Secondary Outcomes

Maternal Mental Health

We obtained mothers' mental health information from outpatient records at 38 days postpartum, on average. Mothers completed the Edinburgh Postnatal Depression Scale (EPDS) consisting of 10 Likert-scaled (1–4) questions (Cox et al., 1987). We summed across items to create a total; higher total scores indicate worse mental health. We created indicators for a total EPDS score exceeding 10 (recommended by the American Academy of Pediatrics as a threshold for mental health-support referral) and exceeding 13 (indicating risk for a depression diagnosis).

Maternal Knowledge

We used eight items drawn from the Opinions about Babies questionnaire (OAB), a criterion-referenced measure of child-development knowledge pediatric professionals generally think parents should have (Reich, 2005).[7] Previous research found OAB to be sensitive to detecting intervention effects on maternal knowledge (Reich et al., 2010). Together with NurturePA staff, we wrote three additional maternal-knowledge items on topics the program targets. Response options to each item are agree, disagree, or no opinion. Correct responses received one point; incorrect and no-opinion responses received zero points. For analysis, we calculated percent of responses that were correct.

Language and Early Literacy Practices

Mothers completed items at 4 and 18 months capturing the frequency of language and early literacy practices with the focal child (e.g., singing songs, playing games without toys, reading books), on a 4-point Likert scale (rarely/not at all, a few times per month, a few times per week, or every day). Mothers completed the same 8 items at both time points, plus 3 additional items at 18 months on toddler-appropriate practices. Items were drawn from the MetroBaby Study (Tamis-LeMonda, 2013) and the Early Head Start Evaluation (Mathematica Policy Research, 1998). We also wrote one item based on the American Academy of Pediatrics (2006) best practices for supporting early language development. Together, these items measured parent behaviors sensitive to intervention and important for promoting child development (Brown et al., 2018; Heymann et al., 2020). For analysis, we computed an average across items, with higher scores indicating more frequent language and early literacy practices.

Child Development

Mothers reported on the basic language and fine and gross motor milestones their infants had reached with 5 questions at the 4 months and 10 questions at 18 months. Questions were drawn from the Metrobaby Study, the Ages and Stages Questionnaire, and Bright Beginnings. Items were scored 1 (not yet), 2 (rarely), or 3 (yes) and summed, for a total score range of 5–15 at 4 months and 10–30 at 18 months.

Covariates

We use baseline variables reported in Table 1 as covariates. Using hospital records, we calculated mothers' age as of their delivery date. From the baseline survey, we captured mother'srace/ethnicity using a set of dichotomous variables (white, Black, or Other) and level of education using a set of four dichotomous variables: high school or less, some college, bachelor's degree, and any graduate school. Additional baseline variables included first-time mother status; history of anxiety/depression; difficult pregnancy/delivery; marital status; employment status at time of delivery; and English home language. We described income as a function of 2018 National Median Income (NMI; $60,293), with indicators for at or below 100% NMI, 100 to 200% NMI, and at or above 200% NMI (U.S. Census Bureau, 2019). We

[7] OAB items were created based on Bright Futures Guidelines for Health Supervision and the American Academy of Pediatrics Guidelines for Health Supervision III (Reich, 2005). Sample items we included: "Babies put things in their mouths to learn about them," and "Having a blanket in the crib, in case the baby gets cold, is a good idea."

used a count of the number of resources mothers reported using during pregnancy (0–8) and the number of individuals mothers felt they could count on to help with the infant, capped at 10 (e.g., their network). Finally, we controlled for month of enrollment.

Nurture® Program Engagement

Following our previous feasibility study (Martin et al.,2018), we created several quantitative measures of mother-mentor interactions from texting transcripts: total length of engagement (in months), number of conversations, mean length of conversations (i.e., number of texts per conversation), mean time between conversations (in days), percent of mother-initiated conversations, and percent of conversations addressing a problem. We coded conversation topics as child-focused, mother-focused, joint mother-child focused; relationship building; COVID-19-focused; or program operations (i.e., technology-related issues). The first three categories had sub-codes that provided more detail (see Table 3). We based topic codes on the Nurture® Program's theory of change and developmental checklists published by the CDC and Bright Beginnings.

Data Analytic Plan

To address RQ1 – how mothers and mentors engaged in the Nurture® Program – we calculated descriptive statistics on the features of treatment mothers' texting transcripts. To estimate the program's impact (RQ2 and RQ3), we conducted intent-to-treat (ITT) analyses using Stata with models of the following form:

$$Y_i = \beta_0 + \beta_1 TREAT_i + X\theta + \epsilon_i \quad (1)$$

where Y_i is the outcome of interest, $TREAT_i$ indicates assignment to treatment or control, **X** represents the vector of baseline covariates, and ε_i is random error clustered by mentor assignment.[8] We focus on ITT effects, as mothers could have benefited from mentor outreach even if they never responded via text. We report results from models both with and without covariates.

Table 2 Duration and frequency of mother-mentor communication in the treatment group

	Mean	SD	Min	Max	ICC
Total length of engagement (in months)	16.38	3.00	5.03	18.07	0.00
Number of conversations	41.02	20.15	16.00	118.00	0.62
Mean length of conversations	4.83	3.60	1.00	22.55	0.25
Mean time between conversations (in days)	15.13	7.12	4.67	33.89	0.60
Percent mother-initiated conversations	6.20	8.00	0.00	38.60	0.40

Note: *N* coded transcripts = 100. ICC = Intra-cluster correlation (i.e., the amount of variance in the outcome at the mentor level)

Attrition

Figure 1 presents follow-up rates at 4 and 18 months. At 4 months, 15% of treatment mothers and 26% of control mothers were lost to follow-up (24% and 36% respectively at 18 months). At both timepoints, attrition rate differences were statistically significant (Appendix Table A.1), although among participants who completed the follow-up surveys, balance on background characteristics was maintained (Appendix Tables A.2 and A.3). Further, within both treatment and control groups, attritor and non-attritor baseline characteristics were similar (Appendix Tables A.4 and A.5).

Missing Data

To address low rates of covariate missingness (0-3.1%), we replaced missing values with 0 and added an indicator equal to 1 (0 otherwise) if data were missing on a given variable (Puma et al., 2010). Among survey respondents, there were low rates of missingness for outcomes (0–5%). We did not adjust for missing outcomes (i.e., complete case analysis).

Results

RQ1: Program Engagement

Table 2 presents the duration and frequency of text communication between treatment mothers and their mentors. On average, treatment mothers engaged with their mentor for 16.4 months, with 76% of mothers participating through the full 18-month study period (Appendix Figure A.3). The average mother-mentor pair had 41 unique conversations (range 16–118), with typical conversations consisting of five messages between mentor and mother. The average time between conversations was just over two weeks. Nearly 94% of conversations were initiated by mentors, indicating the importance of proactive mentor outreach to encourage engagement.

Overall, 75% of the 4,102 conversations in our study were focused on the child, 39% on the mother, 8% joint mother-child, 20% on relationship building, 7% on COVID-19, and

[8] All treatment mothers served by the same mentor are a cluster. We assigned each control mother to a unique mentor id for the purpose of clustering. We calculate cluster-robust standard errors to account for clustering of participants by mentor.

6% on program functioning (Table 3).[9] This engagement was consistent, although somewhat less intensive, than that observed in our earlier feasibility study (Martin et al., 2018). All mothers experienced conversations focused on child, mother, and relationship-building topics.

RQ2 and RQ3: Program Impacts

In Table 4, for each outcome we report the control group mean and the treatment group mean difference (e.g., ITT effect), estimated with and without covariates. Overall, there were no consistent, statistically significant effects of the Nurture® Program opportunity on our primary or secondary outcomes. Mothers assigned to control scored in the 36th to 53rd percentile on the PSI subscales. Translating treatment effects on the PSI into effect sizes, impacts ranged from $d = 0.07$–0.24 SDs for four of six PSI outcomes and were closer to zero for the remaining two ($p > 0.05$). Estimates were imprecise, due to small pilot sample and subsequent attrition (i.e., confidence intervals of 11 to 18% points).

Sample mothers generally exhibited low EPDS scores, on average, with 8% of control mothers showing any sign and 4% showing a high probability of postpartum depression. These values were higher in the treatment group ($d = 0.11$–0.18 SDs), though only the ITT model without covariates for the raw score was statistically significant ($p < 0.05$).

Control mothers answered 75% of maternal knowledge questions correctly at 4 months. Treatment mothers scored 0.15 SDs higher but this difference was not statistically significant ($p > 0.05$). Control mothers scored near the ceiling on the language/literacy practices outcome (3.7/4 points), and treatment mothers scored similarly ($p > 0.05$). Finally, treatment mothers reported their infants exhibited marginally more progress on developmental milestones at 4 months ($d = 0.29$, $p < 0.10$), but this difference was smaller at 18 months ($d = 0.10$).

Table 3 Topics of mother-mentor conversations

Topic	Mean % of conversations	% experiencing at least once
Child focused	**75.2**	**100**
Basic care	7.9	71
Feeding	7.8	70
Sleep	9.6	72
Cognitive Development	3.5	49
Language Development	10.3	77
Motor Development	9.8	79
Social Emotional Development	16.0	97
Physical Development	2.9	60
Child wellbeing	7.4	80
Maternal and Family Focused	**39.1**	**100**
Maternal wellbeing	28.6	100
Family support	3.6	55
Family conflict	0.2	7
Partner relationship	0.8	26
Siblings	1.9	20
Work	4.0	54
Maternal and Child Focused	**7.8**	**68**
Child care	2.4	38
Breastfeeding	4.2	51
Resources	1.2	23
Relationship building	**19.7**	**97**
COVID-19	**6.8**	**61**
Program Operations	**5.9**	**81**

Note: Mean number of conversation topics is larger than number of conversations shown in Table 2 because conversations could have > 1 topic

[9] Percentages sum to over 100 as conversations could address multiple topics.

Discussion

We investigated new mothers' engagement in the Nurture® Program and its impact on maternal parenting stress, postpartum depression, knowledge of child development, and child milestones. Mothers stayed engaged in the program and discussed maternal- and child-focused topics. On average, mothers remained enrolled in the program for the majority of the 18-month study and engaged in conversations with their mentors every 16 days, with conversations that included 4 to 5 messages back and forth. About 75% of conversations featured child-focused topics, and 39% were mother-focused. Given the substantial attrition in many parenting interventions (Leyva et al., 2021), this engagement is promising.

Despite this promise, we found no impacts on primary maternal stress outcomes in this pilot RCT. However, some were practically sizable (d range = 0.16–0.24), with treatment mothers reporting higher levels compared to control mothers. Also notable, effects on achievement of child developmental milestones and maternal knowledge of child development at 4 months – two outcomes key in the theory change – were sizable in magnitude (d range = 0.10–0.29), even if not statistically significant. It is unclear if our findings are due to statistical power issues or if the engagement was not intense enough or was too variable. Future, better-powered studies should investigate the effects of text-based mentoring on these important early outcomes.

Our study points to several potentially important directions for the Nurture® Program as well as other text-based parenting support programs (Garcia, 2022; Hall & Bierman 2015). First, our sample was not representative of mothers

Table 4 4- and 18-month impacts of NurturePA

	4 months					18 months				
	Control Mean	ITT	ITT (covariates)	N	Scale range	Control Mean	ITT	ITT (covariates)	N	Scale range
Parenting Stress Index Subscales (Percentiles)										
Attachment	45.72	-0.80 (2.61)	-0.65 (2.79)	159	0–100	--	--	--	--	--
Reinforces	37.04	0.72 (2.82)	0.19 (3.24)	159	0–100	--	--	--	--	--
Isolation	43.55	4.55 (3.96)	5.64 (3.64)	159	0–100	--	--	--	--	--
Depression	44.03	5.93 (3.77)	6.52 (3.96)	159	0–100	--	--	--	--	--
Competence	36.41	0.58 (3.07)	1.58 (3.22)	159	0–100	--	--	--	--	--
Parent-child dys. interaction	--	--	--	--	--	52.98	0.24 (2.52)	1.26 (2.86)	140	0–100
Parental distress						48.85	5.07 (4.08)	4.15 (4.59)	140	0–100
Edinburgh Postnatal Depression Scale										
EPDS raw score	4.05	1.45* (0.73)	0.87 (0.77)	148	0–30					
Sign of postpartum depression (cutoff 10)	0.08	0.05 (0.05)	0.03 (0.05)	145	0–1					
High probability of postpartum depression (cutoff 13)	0.04	0.04 (0.04)	0.03 (0.03)	145	0–1					
Maternal Knowledge										
Opinions about Babies (number correct)	8.38	0.44 (0.27)	0.40 (0.26)	158	0–11					
Opinions about Babies (% correct)	0.76	0.04 (0.03)	0.04 (0.02)	158	0–1					
Language/Literacy and Child Milestones										
Language & literacy practices	3.67	-0.09	-0.09	158	1–4	3.70	0.06 (0.05)	0.00 (0.05)	138	1–4
Child development milestones	13.71	0.34~ (0.20)	0.35~ (0.21)	160	5–15	26.78	0.37 (0.48)	0.29 (0.55)	138	10–30

Note: "ITT" and "ITT covariates" are OLS estimates from estimation of Eq. 1, with and without controlling for covariates respectively. Standard errors are clustered by mentors and are shown parentheses. We used two-tailed tests. ~$p < 0.10$ *$p < 0.05$ **$p < 0.01$.

nationally regarding maternal stress and depression, and control mothers scored highly on child-development knowledge. Sample mothers were more educated, on average, than adult women in Allegheny County. Following the program's theory of change, this trial also excluded mothers with more intensive needs, such as mothers of premature infants and those with substance abuse histories. Given that marginalized mothers may be more vulnerable to stress and depression and may have limited access to educational and parenting resources, targeting text-based supports to these populations may increase efficacy.

Second, engagement varied substantially; the most intensive engagement included 118 conversations, conversations of 23 messages, and more than half of conversations addressing problems the mother was experiencing. It is possible that programs like Nurture® can have a positive impact even among those who do not engage robustly. In companion work, we are examining the relationship between frequency of program engagement and impact. If a positive relationship is found in this and other, related work, future program implementation – particularly for programs requiring human resources such as mentors – should explore predictors of engagement for more efficient and effective scaling.

Finally, text-based communication may be a helpful component of a multipronged support system. For example, text communication can reinforce topics covered in a facilitated, in-person mothers' group and encourage attendance at upcoming meetings. At least one established home

visiting program is piloting including texting in its approach (Taboada et al., 2021).

Our work has several limitations. This pilot study was under-powered. Attrition was higher than optimal, with statistically significant differences by treatment assignment. Also, our sample size limited exploration of heterogeneity. Supplemental analyses revealed little evidence of differential impacts by race, household income, and first-time mother status. However, due to being under-powered, this analysis was difficult to interpret. Future research should prioritize larger samples that permit precise estimation of differences by maternal characteristics. Despite earlier feasibility research that informed outcome selection (Martin et al., 2018), our outcomes simply may not have captured the ways that the Nurture® Program affected mothers' experiences. Another possibility is that our data collection did not allow sufficient time for longer-run impacts to develop. Critically, very little research addresses *how* parents engage with technology-based supports (Hall & Bierman, 2015). Accordingly, in companion work, we interviewed mothers and mentors to understand the program from their perspectives. In interviews, mothers overall rated the program opportunity very positively and appreciated having a non-judgmental, interactive source of support. These interviews may raise more appropriate outcomes and mechanisms for future studies of text-based mentor programs for postpartum mothers. Finally, most of the study participants completed the 18-month survey after the onset of COVID-19. Accordingly, the generalizability of our 18-month impacts is unclear (Weiland & Morris, 2022).

In conclusion, technology-based programs may be a low-cost, scalable support for new parents. Further research should identify the key design elements and targeting approaches for refining such supports for parents of young children.

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Author Contributions Weiland and Page designed the study, obtained funding, and led writing and analysis. Musaddiq led coding and contributed to the writing. Martin helped design the transcript coding procedures and contributed to the literature review. Homitsky provided expert consultation that shaped the study's design and contributed to the writing.

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Data Availability We do not have consent to provide data in this trial. We can provide copies of measures.

Code Availability Available upon request from the authors.

Declarations

Conflicts of interest None.

Ethics approval This research was conducted in accord with prevailing ethical principles and was reviewed and approved by the Institutional Review Board of the Allegheny-Singer Research Institute which oversees research conducted at West Penn Hospital. The University of Pittsburgh Institutional Review Board reviewed and approved all procedures related to transfer, storage, and analysis of deidentified data.

Consent to participate Mothers provided active consent.

Consent for publication N/A.

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