Supporting parents of premature infants transitioning from the NICU to home: A pilot randomized control trial of a smartphone application

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ABSTRACT

Objective: To determine whether parents of Very Low Birth Weight (VLBW) infants in the Neonatal Intensive Care Unit (NICU) transitioning home with the NICU-2-Home smartphone application have greater parenting self-efficacy, are better prepared for discharge and have shorter length of stay (LOS) than control parents.
Methods: A four-week pilot randomized controlled trial during the transition home with 90 VLBW parents randomized to usual care (n = 44) or usual care plus NICU-2-Home (n = 46), a smartphone application designed for VLBW parents. Parenting Sense of Competence Scale (PSOC) was assessed at baseline, day after discharge, and two weeks post-discharge. Preparedness for discharge and length of stay (LOS) were secondary outcomes. Analyses by usage were also included.
Results: While parents of VLBW infants in the intervention group did not show an improvement in PSOC during the transition when compared directly to controls, after accounting for actual mean app usage, PSOC improved 7% (2.71 points/time greater; 95% CI = 1.45, 6.27) for intervention versus controls. Compared to controls, above-average users increased their PSOC score by 14% (6.84 points/time; 95% CL = 5.02, 8.67), average users by 11% (4.58 points/time; 95% CL = 2.89, 6.27) and below-average users by 6% (2.41 points/time; 95% CL = 0.04, 4.79). Moderate evidence showed LOS was shorter for above-average users compared to the control group (β = 12.2. SE = 6.9, p = 0.085).
Conclusion: A smartphone application used by parents of VLBW infants during the transition home from the NICU can improve parenting self-efficacy, discharge preparedness, and LOS with improved benefits based on usage.

1. Introduction

Premature birth occurs in almost 12% of births (Hamilton et al., 2012) with Very Low Birth Weight infants (VLBW, birth weight < 1500 g) comprising 18% of the premature low births (Hamilton et al., 2014). VLBW infants' survival becomes directly proportional to gestational age and birth weight (Stephens et al., 2010), with parents providing all care after successful discharge. Among neonates, VLBW infants have the longest average length of hospital stay and the highest rates of morbidity and re-

hospitalization in the first year (Escobar et al., 1999; Underwood et al., 2007).

While the admission experiences of parents of VLBW infants have been studied (Singer and Ryff, 1999; Singer et al., 1999; Singer et al., 2003; Singer et al., 2010), the needs of parents transitioning home has received less attention (Bruder and Cole, 1991; Fowlie and McHaffie, 2004). "Pervasive uncertainty" is how one study described the parents' feelings around the care of these medically vulnerable infants during the transition (Garfield et al., 2014). Despite efforts by NICU staff and the American Academy of Pediatrics' (AAP) policy statement on the importance of involving parents from admission through discharge (Committee on Fetus and Newborn, 2008), parents desire more information and frequently report feeling unprepared for discharge (Sneath, 2009; De Rouck and Leys, 2009; Brazy et al., 2001; Smith et al., 2012).

Technology is one novel approach for supporting parents making the transition from the NICU to home. Smartphones may be particularly useful for NICU parents because they are easy to transport between

home and the NICU, small enough to carry when caring for the baby, and almost 80% of adults in childrearing ages of 18–49 have a smartphone. While many applications (apps) are available for general newborn care, few were created with the NICU infant in mind and none have been scientifically evaluated for their efficacy in providing support to parents. Recent calls for evaluations of the utility of the growing number of health apps have been made. This article describes a pilot randomized controlled trial of a parent-empowering smartphone application called NICU-2-Home wherein we hypothesized as a primary outcome that the NICU-2-Home app would lead to improved parenting self-efficacy during the transition home with their VLBW infants compared to controls. Two secondary outcomes, preparedness of the VLBW infant's parents for discharge from the NICU and length-of-stay (LOS), were also investigated.

2. Material and methods

2.1. Study design, participants, and intervention

The NICU-2-Home study was a randomized controlled trial piloted with all parents of VLBW infants eligible who were ≥18 years old, English speaking, caring for a living infant together and willing to be randomized. The study period included the final two NICU weeks (beginning when the infant moved from an isolette to an open crib or 34 weeks, whichever came first), discharge, and two weeks at home; four-weeks in total. Once eligible parents were consented and baseline entry questionnaires were completed, parents were randomized to NICU-2-Home or control using a 1:1 blocked randomization using sealed and numbered envelopes. Couples were assigned to the same arm. The care team was not told (a) parents' decision to participate or (b) their assigned group. The study was registered at clinicaltrials.gov (NCT01987180) with the primary aim of examining parenting self-efficacy and secondary aims of analyzing collected salivary biomarkers currently under review. Our Institutional Review Board approved the study.

Control group parents received usual care including NICU care handouts and nurse education; those in the NICU-2-Home group received the same plus an Android smartphone with the NICU-2-Home application installed for the study period. All participants independently completed measurement tools and data collection via self-report surveys at three time points: baseline entry into study (T − 14), one day prior to discharge (T − 1), and 14 days after discharge (T + 14). Recruitment took place January 2013 through February 2014.

Each mother and father intervention parent was given a smartphone with the NICU-2-Home application, mobile phone service, a data plan and orientation to the app. NICU-2-Home was designed with a theoretical underpinning using Bandura's Self-Efficacy Theory (Bandura, 1995) and was developed with Motorola Mobility specifically for this project based on findings of the needs of VLBW parents who had transitioned home (Garfield et al., 2014). NICU-2-Home had four main features including: 1) Passport-2-Home—a selfguiding discharge checklist; 2) Education Center – curated, multimedia educational information on NICU infant care; 3) Baby Connect© – a commercially available app for tracking activities of daily living; and 4) Mood Tracker—synchronized updates of parents current mood (Supplemental Table S1: Components and Features; Supplemental Fig. S1: Thumbnail image of NICU-2-Home home page in Supplemental Information). Content was written and designed to be at a 7th grade reading level. Parents' phones were linked to share updates and only NICU-2-Home use was monitored and reported in time-stamped server logs.

2.2. Outcomes and measures

Our primary dependent variable of interest is parenting self-efficacy. Therefore, the *Parenting Sense of Competence Scale* (PSOC; $\alpha = 0.807$), a well-validated 17-item scale created to assess satisfaction of parenting

and parental self-efficacy in a variety of populations (Johnston and Mash, 1989; Gilmore and Cuskelly, 2009). All items were summed with ranges from 17 to 102 (no norm exists); higher scores indicate a greater sense of parental self-efficacy. The PSOC was measured over three occasions: entry into study (T − 14), the day before discharge (T − 1), and the final day of the study (T + 14).

As a pilot study, exploratory secondary outcomes were examined including preparedness for discharge and length of stay (LOS). The *Press-Ganey discharge questionnaire* was administered to assess preparedness for discharge. This single question asks "How prepared do you feel about your baby's discharge?" (range: "not at all" to "very well"). LOS was measured as the number of NICU days from study enrollment through discharge (i.e. intervention period) in order to make LOS clinically meaningful as all babies would in theory be likely to be discharged within similar timeframes.

In addition to study arm and time point, independent variables were examined including: average use of the NICU-2-Home app (coined *mean app usage*), calculated as the average number of uses of the app per day from baseline to the end of the study and considered as measure of exposure; gender, age, race, marital status, education, employment status, income, insurance status, gestational age and weight were also examined. Our study was powered to find statistically significant results with 40 participants in the two groups assuring 80% power at 0.05 to detect an effect size of 0.63 standard deviations of change in PSOC, for a longitudinal analysis assuming a 0.5 within-subject correlation (ICC) (Horrigan, 2007).

2.3. Analyses

2.3.1. Primary analysis

Our primary analysis was based on the intent-to-treat (ITT) principle where all randomized participants were included individually in the analyses. Since the data were longitudinal (and thus correlated) in nature, a repeated measures linear mixed-effects model assuming a compound symmetric covariance pattern was used to examine the change in mean PSOC scores over the three measurement occasions (i.e. the time points T − 14, T − 1, and T + 14) while controlling for possible confounding covariates of self-efficacy and the mismatched randomization of parental race and age.

2.3.2. Supplementary analyses

A mean app usage variable and a mean app usage and time point interaction variable were added in supplementary analyses to evaluate how app usage may have affected mean PSOC scores and other outcomes. A *user level* variable was created categorizing three groups based on average app usage from baseline until discharge (T − 1): below average (<25th percentile), average (25th–75th percentile), and above average (>75th percentile). Control participants were categorized as nonusers. The user level variable was included in the model for a third analysis.

2.3.3. Statistical methods

The models included a random intercept and fixed effects for time (i.e., time point), study arm, parent gender, and demographic covariates. Since missing data can result in observations being excluded in the model, multiple imputations (N = 20) were used to account for missing data. The imputations were conditioned on all of the independent variables listed as well as two auxiliary variables: a *technology attitudes* summed score and a *technology for parenting attitudes* summed score (Horrigan, 2007). The technology for parenting attitudes questions were modified by adding "for parenting" to the various questions. All imputations were done in SAS 9.4 using **proc mi**. Estimates and 95% confidence limits were calculated using **proc mianalyze**. Chi-squared tests were conducted for the Press-Ganey questionnaire item comparing the percentage of each category's endorsement by study arm and user level. LOS was examined by study arm and by user level through

ANOVAs controlling for gestational age and birth weight. ANOVAs were conducted using **proc glm**.

3. Results

3.1. Baseline characteristics and NICU-2-Home use

Participant flow and response rates from initial screening through analysis are shown in Fig. 1.

Randomization created two similar groups, but was uneven in age (p = 0.019) and race (p = 0.015; Table 1). Most parents were married, educated through college, and had private insurance. Infants' overall were mostly singletons with 29.7 weeks average gestational age and 1224 g average birth weight; there was no statistically significant differences between the control and intervention groups. The average LOS from study admission to discharge was 17.0 days for the entire sample. NICU-2-Home app use fell into three categories: above average users (mean usage = 9.7 times/day, n = 10), average users (mean usage = 3.8 time/day, n = 18), and below average users (mean usage = 1.3 times/day, n = 10). The sample PSOC score had a baseline mean of 70.8 (SD = 10.2) for the whole sample with no significant difference between the two study arm groups (Table 1). LOS was also not statistically significantly different between the two study arm groups not accounting for gestational age and birth weight.

3.2. Parenting sense of competence

3.2.1. Study arm models

Statistically significant variables predicting mean PSOC score change included time (β = 1.06, 95% CI = 0.40, 1.72) and college education (β = 8.45, 95% CI = 1.06, 15.85); study arm was not statistically significantly related to mean PSOC score change in the primary analysis (Table 2).

3.2.2. Mean app usage & user level models

When mean app usage was added in supplementary analyses of the primary model, the variable for time (β = 1.06, 95% CI = 0.41, 1.72), time by study arm interaction (β = 2.71, 95% CI = 1.45, 3.96), mean app usage (β = 1.51, 95% CI = 0.47, 2.56), and time by mean app usage interaction (β = −1.02, 95% CI = −1.44, −0.60) were all statistically significant (Table 2). In other words, there is an overall positive time effect wherein the PSOC score increased over time for all parents, but increased at a higher overall rate over time for the intervention group (7% increase) compared to the control group (<1% increase). Other significant effects include marital status (β = −8.78, 95% CI = −17.38, −0.18) and college education (β = 8.72, 95% CI = 1.42, 16.02).

When including user level to the model, mean app usage over time is still significant (β = −1.47, 95% CI = −1.84, −1.10). User levels over
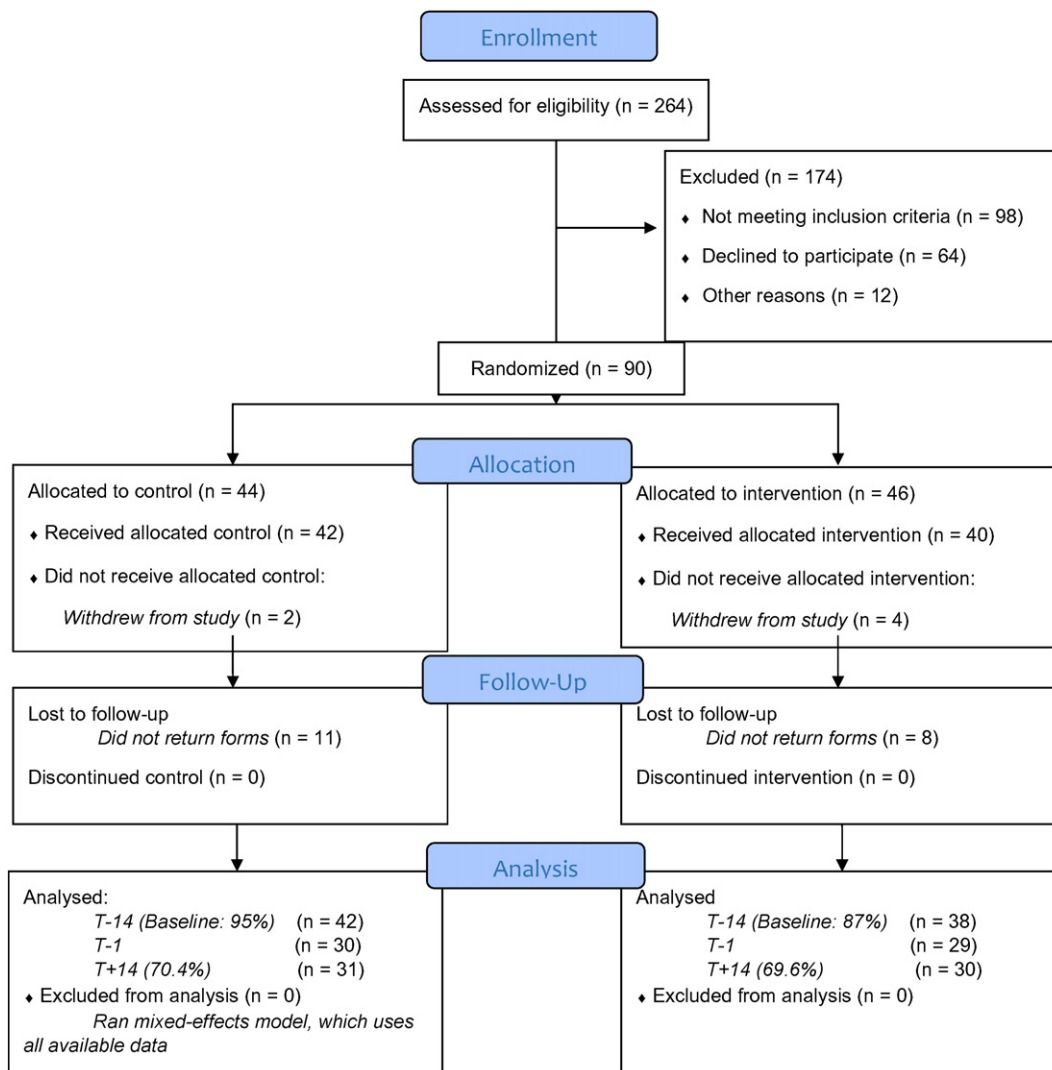

Fig. 1. CONSORT participant flow diagram with response rates.

Table 1
Sociodemographic characteristics of participants by study arm & user level.

Characteristic	Total (N = 82)	Control (N = 42)	NICU-2-Home (N = 40)	p-Value	Below average user (N = 10)[a]	Average user (N = 18)[a]	Above average user (N = 10)[a]
Parents							
PSOC score (T − 14)	70.8 (10.2)	69.8 (10.0)	71.8 (10.5)	0.369	72.3 (11.1)	68.5 (9.9)	74.2 (7.9)
Length of stay	17.0 (9.8)	17.5 (7.2)	16.5 (12.6)	0.658	22.0 (13.8)	18.4 (12.9)	7.4 (4.5)
Age	33.7 (5.80)	35.2 (5.12)	32.2 (6.54)	0.019	28.5 (4.33)	33.4 (5.74)	32.6 (8.64)
Female	41 (50.0%)	21 (50.0%)	20 (50.0%)	0.912	0 (0.0%)	10 (55.6%)	8 (80.0%)
Race				0.015			
White	54 (65.9%)	35 (79.6%)	19 (47.5%)		2 (20.0%)	10 (55.6%)	5 (50.0%)
Black	13 (15.6%)	5 (11.9%)	8 (20.0%)		4 (40.0%)	2 (11.1%)	2 (20.0%)
Asian	6 (7.3%)	0 (0.0%)	6 (15.0%)		1 (10.0%)	3 (16.7%)	2 (20.0%)
Hispanic, Latino	9 (10.9%)	2 (4.8%)	7 (17.5%)		2 (20.0%)	3 (16.7%)	1 (10.0%)
Gestation number[c]				0.508			
Singleton	29 (70.7%)	15 (71.4%)	14 (70.0%)		9 (90.0%)	12 (66.7%)	7 (70.0%)
Twins	11 (26.8%)	6 (28.6%)	5 (25.0%)		0 (0.0%)	5 (27.8%)	3 (30.0%)
Triplets	1 (2.5%)	0 (0.0%)	1 (5.0%)		1 (10.0%)	1 (5.6%)	0 (0.0%)
Marital status[b,c]				0.923			
Married	38 (92.7%)	20 (95.2%)	18 (90.0%)		8 (80.0%)	17 (94.4%)	9 (90.0%)
Cohabiting	2 (4.8%)	1 (4.8%)	1 (5.0%)		1 (10.0%)	1 (5.6%)	1 (10.0%)
Other	1 (2.4%)	0 (0.0%)	1 (5.0%)		1 (10.0%)	0 (0.0%)	0 (0.0%)
Education				0.183			
Through HS	4 (4.9%)	1 (2.4%)	3 (7.5%)		2 (20.0%)	0 (0.0%)	1 (10.0%)
Through college	47 (57.3%)	22 (52.4%)	25 (62.5%)		4 (40.0%)	14 (77.8%)	7 (70.0%)
Advanced degree	31 (37.8%)	19 (45.2%)	12 (30.0%)		4 (40.0%)	4 (22.2%)	2 (20.0%)
Employed	67 (81.7%)	35 (83.3%)	32 (80.0%)	0.696	9 (90.0%)	14 (77.8%)	7 (70.0%)
Household income[b,c]				0.916			
<$60 k	7 (17.1%)	3 (14.3%)	4 (20.0%)		4 (40.0%)	2 (11.1%)	2 (20.0%)
≥$60 k	34 (82.9%)	18 (85.7%)	16 (80.0%)		6 (60.0%)	16 (88.9%)	8 (80.0%)
Insurance type[b]				0.522			
Private	68 (82.9%)	36 (85.7%)	32 (80.0%)		8 (80.0%)	15 (83.3%)	7 (70.0%)
None	1 (1.2%)	0 (0.0%)	1 (2.5%)		1 (10.0%)	0 (0.0%)	0 (0.0%)
Other	13 (15.8%)	6 (14.3%)	7 (17.5%)		1 (10.0%)	3 (16.7%)	3 (30.0%)
Gestational age, weeks[d]	29.7 (2.6)	30.0 (2.7)	29.4 (2.4)	0.276	N/A	N/A	N/A
Birth weight, grams[d]	1224.2 (308.2)	1170.2 (315.4)	1283.2 (302.9)	0.094	N/A	N/A	N/A

[a] Two participants randomized to NICU-2-Home app did not use it and are missing from secondary analyses.
[b] Categories were collapsed.
[c] Frequencies given at household level.
[d] Gestational age and birth weight were calculated at family level, so user level statistics were not calculated for these variables.

Table 2
Combined results of effects of study arm and usage level on parental sense of competence scores.

Variable	Study arm model (N = 86)			Study arm with usage (N = 86)			User level with usage (N = 84)		
	Estimate	95% Confidence limits	p-Value	Estimate	95% confidence limits	p-Value	Estimate	95% confidence limits	p-Value
Intercept	89.26	(62.61, 115.91)	<0.001	88.44	(62.14, 114.74)	<0.001	93.25	(67.16, 119.35)	<0.001
Time	1.06	(0.40, 1.72)	0.003	1.06	(0.41, 1.72)	0.003	0.85	(−0.31, 2.00)	0.150
Intervention vs. control	1.75	(−2.19, 5.68)	0.384	−2.42	(−7.02, 2.19)	0.310	–	–	–
Female vs. male	2.17	(−1.54, 5.87)	0.252	2.58	(−1.12, 6.27)	0.170	1.65	(−2.19, 5.50)	0.400
Time × intervention	−0.11	(−0.97, 0.75)	0.800	2.71	(1.45, 3.96)	<0.001	–	–	–
Mean app usage (uses per day)	–	–	–	1.51	(0.47, 2.56)	0.005	0.86	(−1.05, 2.77)	0.380
Time × mean app usage	–	–	–	−1.02	(−1.44, −0.60)	<0.001	−1.47	(−1.84, −1.10)	<0.001
Below average user vs. control	–	–	–	–	–	–	−1.85	(−9.39, 5.68)	0.630
Average user vs. control	–	–	–	–	–	–	−4.96	(−11.96, 2.03)	0.170
Above average user vs. control	–	–	–	–	–	–	−2.67	(−12.97, 7.64)	0.620
Time × below average user	–	–	–	–	–	–	2.41	(0.04, 4.79)	0.050
Time × average user	–	–	–	–	–	–	4.58	(2.89, 6.27)	<0.001
Time × above average user	–	–	–	–	–	–	6.84	(5.02, 8.67)	<0.001
Age (years)	−0.27	(−0.59, 0.05)	0.102	−0.26	(−0.58, 0.05)	0.110	−0.26	(−0.60, 0.07)	0.120
Gestational age (weeks)	−0.34	(−1.03, 0.34)	0.329	−0.31	(−0.99, 0.36)	0.370	−0.46	(−1.14, 0.23)	0.190
Black vs. White	4.64	(−2.57, 11.84)	0.208	4.29	(−2.84, 11.41)	0.240	5.15	(−1.89, 12.20)	0.150
Hispanic, Latino vs. White	−0.21	(−8.25, 7.83)	0.959	−0.15	(−8.09, 7.78)	0.970	3.87	(−3.94, 11.67)	0.330
Asian vs. White	1.95	(−6.00, 9.90)	0.631	2.54	(−5.35, 10.42)	0.530	3.63	(−4.07, 11.33)	0.360
Other race vs. White	8.37	(−4.19, 20.93)	0.192	7.93	(−4.47, 20.33)	0.210	5.88	(−7.94, 19.69)	0.400
Singleton vs. multiple	−2.46	(−6.60, 1.68)	0.245	−2.57	(−6.66, 1.51)	0.220	−2.21	(−6.31, 1.89)	0.290
Married vs. unmarried	−8.51	(−17.22, 0.21)	0.056	−8.78	(−17.38, −0.18)	0.050	−6.01	(−14.76, 2.74)	0.180
College graduate vs. less	8.45	(1.06, 15.85)	0.025	8.72	(1.42, 16.02)	0.020	8.37	(1.04, 15.70)	0.030
Employed vs. not	−2.43	(−7.47, 2.60)	0.344	−2.23	(−7.21, 2.74)	0.380	−3.44	(−8.28, 1.39)	0.160
Less than $60 k vs. $60 k+	1.44	(−7.95, 10.83)	0.764	1.59	(−7.67, 10.85)	0.740	−0.07	(−9.17, 9.02)	0.990
Private insurance vs. public	1.22	(−5.67, 8.10)	0.729	0.69	(−6.13, 7.51)	0.840	−0.51	(−7.40, 6.37)	0.880
No insurance vs. public	−3.77	(−22.03, 14.50)	0.686	−4.9	(−22.92, 13.11)	0.590	−2.04	(−20.25, 16.18)	0.830
Other insurance vs. public	−8.03	(−26.52, 10.45)	0.395	−9.07	(−27.35, 9.22)	0.330	−6.67	(−24.59, 11.25)	0.470

time are associated with a greater mean PSOC scores than those in the non-user group. Specifically, above average users had a 14% increase (6.84 units higher over each time point) compared to controls (95% CI = 5.02, 8.67), average users had an 11% increase (4.57 units higher over each time point) compared to controls (95% CI = 2.89, 6.27), and below average users had a 6% increase in PSOC (2.41 units higher over each time point) compared to controls (95% CI = 0.04, 4.79) over the study (Table 2).

Fig. 2 plots the model-estimated mean series for the intervention versus control and each of the four user levels at each time point. The figure illustrates that the rate of increase in mean PSOC scores over time for the intervention group was larger than for the control group and that the rate of increase over time for the above average users, average users, and below average users were all higher than for non-users.

3.2.3. Discharge preparedness and length of stay

Discharge preparedness, an outcome important for parents, was affected by intervention group and by user level. The intervention group reported higher endorsements of feeling prepared about their infant's discharge than did the control group (Table 3). Further, the above average group had higher endorsements of feeling prepared for their infant's

discharge compared to all other groups. The LOS was 1 day shorter for NICU-2-Home users compared to controls but did not reach significance. When accounting for gestational age and birth weight, the LOS was also not statistically significantly different between the intervention and control groups ($\beta = 4.8$. SE = 4.7, p = 0.316). When comparing above average users to controls, LOS was moderately significant ($\beta = 12.2$. SE = 6.9, p = 0.085) suggesting a potential dose response; however, no statistically significant evidence was found for LOS between average users and control or between below average users and control.

4. Discussion

In this randomized clinical trial of a novel smartphone app intervention for VLBW NICU parents, parents' had improved parenting self-efficacy and discharge preparedness that were also both influenced by app usage. While parents in the NICU-2-Home smartphone intervention did not show an improvement in parenting self-efficacy for the intention to treat analysis during the transition home compared to controls, when accounting for mean app usage, overall parenting self-efficacy did increase by 7% for the intervention group compared to <1% for the
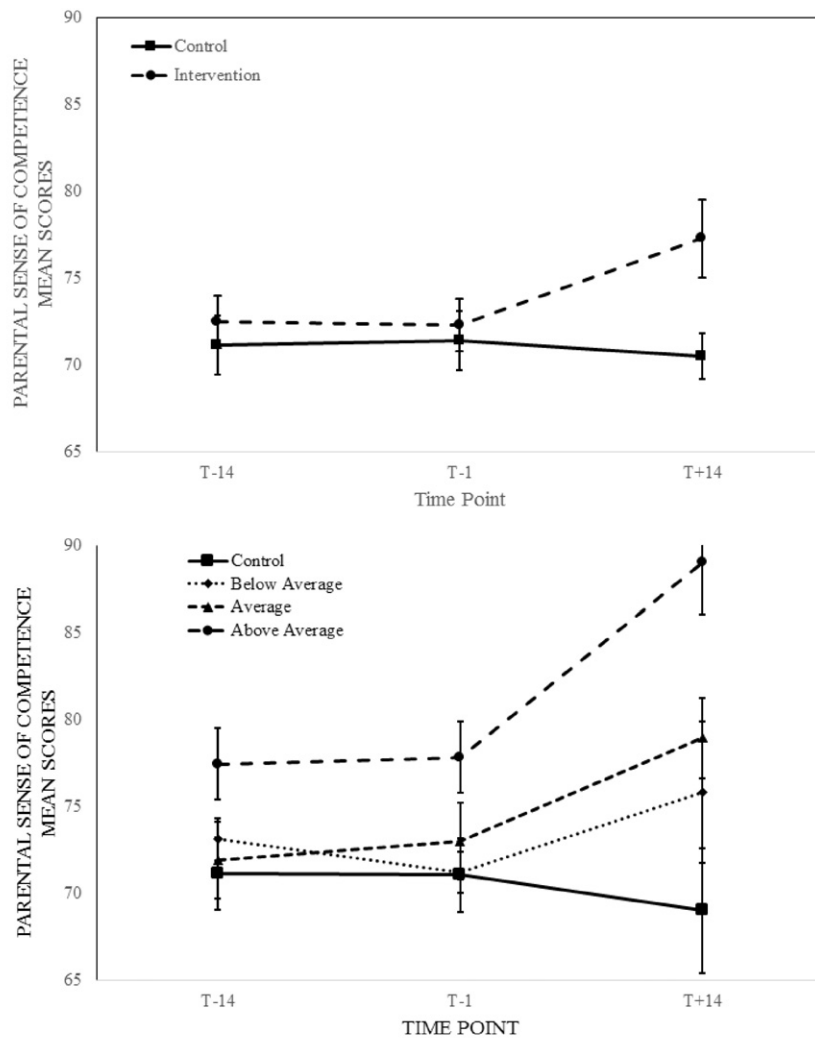
[1] = Time point refers to measurement occasion of PSOC score
[2] = Below average, average, and above average refer to user levels calculated by mean app usage over the course of the study

Fig. 2. NICU-2-Home usage rate predicting parental sense of competence scores by study arm and user level controlling for covariates.[1,2]

Table 3
Evaluation of discharge preparedness by study arm and user level.

"How prepared do you feel about your baby's discharge?"					
	Not at all	Not too well	Somewhat well	Very well	X^2	p-Value
Control	6%	19%	45%	30%	272.5	<0.001
Intervention	5%	22%	31%	42%		
Control	6%	19%	45%	30%	1208.7	<0.001
Below average	0%	16%	42%	42%		
Average	11%	25%	36%	28%		
Above average	1%	22%	9%	68%		

control group. Examined further, user-level improvements over time are evident with a 14% increase in PSOC score for parents who were above average users compared to the 11% for average and 6% for below-average users. Discharge preparedness was higher in the intervention group compared to controls. This study expands the scientific basis for evidence-based smartphone apps designed for parents and the potential of these interventions to differentially support primary caregivers of VLBW infants.

Parenting self-efficacy, discharge preparedness, and LOS are interrelated constructs for VLBW infants.

and their parents. Low parenting efficacy has also been associated with parental depression (Gauthier et al., 2010; Demontigny et al., 2013) and children with overly concerned parents due to a real or perceived vulnerability may have restricted social development and behavioral problems (Pearson and Boyce, 2004). As more infants survive the initial NICU course, finding ways to train, support, and empower parents that are efficient, timely, and draw minimally on healthcare resources is essential. The role of technology is still being explored in this clinical population. Parents who are appropriately supported may end up feeling more competent, confident, ready for discharge, and have a shorter LOS.

Supporting parents is one of the six critical components of a successful transition from the NICU (Committee on Fetus and Newborn, 2008). To date, several reports of specific NICU discharge programs exist in the literature (Smith et al., 2013; Forsythe and Willis, 2008), but to our knowledge no studies have tested an intervention using technology and employing a randomized trial approach with specific outcomes focusing on primary caregivers. In this study, above average app users benefited most from the intervention, resulting in the highest PSOC and shortest overall NICU stay. At the same time, users with the lowest app usage had the longest LOS, nearly double that of the above average and control groups, suggesting that there is something different about this group not only in their uptake of the intervention but in their clinical course. Other variables from our analysis, such as marriage and education, may be considered by NICU staff when seeking to identify parents needing tailored help around discharge. Ultimately, initiatives supporting parents and building their self-efficacy may decrease morbidities, unnecessary healthcare utilization, and re-hospitalizations in this population.

Using a smartphone app specifically designed around the needs of parents of VLBW infants embodies the promising potential of mobile health technologies (mhealth). Debate surrounds mhealth initiatives in part due to regulatory concerns (Cortez et al., 2014) and a lack of scientific evidence for improved care, outcomes, or cost savings, especially around newborn health (Agarwal and Labrique, 2014). NICU parents are already using the internet as a resource (De Rouck and Leys, 2011), however, with most agreeing there is useful information available on premature infants (Gabbert et al., 2013). Providing a scientific foundation and evidence of the usefulness of these technologies is therefore incumbent on researchers and health professionals.

The current study is an example of a patient-level, parent-empowering, consumer-focused strategy to address the concerns of this population and their caregivers. Though other technological approaches such as a website may also be useful, the smartphone app is especially practical for NICU parents shuttling for months between home, work, and the hospital with a desire for personalized and synchronized information. As mHealth interventions increase, examining the results closely for scientific significance is essential; for example, though the primary intention-to-treat analysis study in this study was negative, analyses including user levels provide important insight into which users receive the most benefit and which may require a different approach. Future work can also explore the mechanisms through which self-efficacy is affected, teasing out the specific features to replicate. With the growing number of mHealth offerings finding their way into parents' hands and everyday healthcare encounters, critical evaluations of their utility are essential.

The study has limitations. First, the randomization was not wholly effective with differences in race and age by study arm. Second, comorbidities were not measured. Third, this study focused on the transition home for parents of VLBW infants at one institution and only toward the end of the stay. The usefulness, feasibility, or efficaciousness over a different time period, in a different population or institution is unknown. Finally, this population was well educated and presumably comfortable with technology.

5. Conclusion

As VLBW infants survive to discharge, bolstering parents' self-efficacy is one method to support primary caregivers of these infants and possibly reduce NICU stays. Technology, and in particular apps designed to reach key sub-populations, hold promise as a delivery vehicle for interventions aimed at improving care and outcomes for these vulnerable populations.

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