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TITLE:
Effectiveness of a technology-based supportive educational parenting program on parental outcomes in Singapore: A randomized controlled trial

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ABSTRACT:

Background: Transition to parenthood can be stressful to new parents in Singapore, especially with the lack of continuity of care from healthcare professionals during the postpartum period. Short hospital stays limit the availability of support and time parents need to be well-equipped with parenting and infant care skills. Poor parental adjustment may in turn lead to negative parental outcomes and adversely affect the child’s development. Therefore, for the family’s future wellbeing and in order to facilitate smoother transition to parenthood, there is a need for easily accessible technology-based educational programs that can support parents during this crucial perinatal period.

Objective: To examine the effectiveness of a technology-based supportive educational parenting program (SEPP) on parenting outcomes during the perinatal period.

Methods: A randomized controlled pretest-posttest experimental study design was used. The study recruited 236 patients (118 couples) from an antenatal ward of a tertiary hospital. Eligible parents were randomly assigned to the intervention group (n = 118) or the control group (n = 118). The SEPP is based on Bandura’s self-efficacy theory and Bowlby’s theory of attachment. Components of the intervention include two telephone-based education sessions and a mobile-health application follow-up for one month. Outcome measures including parental bonding, parental self-efficacy, perceived social support, parenting satisfaction, postnatal depression, and anxiety were measured using reliable and valid instruments. Data were collected over 12 months (December 2016 to December 2017) at four timepoints: during pregnancy (third trimester), immediately postpartum, one month postpartum, and three months postpartum. A linear mixed methods analysis was used to compare the percentage change of all outcome variables.

Results: The intervention group had statistically significant improvements for parental bonding \( P < 0.001, 95\% CI: -4.78 \text{ to } -3.90 \), parental self-efficacy \( P < 0.001, 95\% CI: 1.94 \text{ to } 3.90 \),
2.79], social support \([P < 0.001, 95\% \text{ CI}: 2.78 – 3.47]\), parenting satisfaction \([P < 0.001, 95\% \text{ CI}: 3.14 – 3.83]\), postnatal depression \([P < 0.001, 95\% \text{ CI}: -3.93 – -3.15]\), and postnatal anxiety \([P < 0.001, 95\% \text{ CI}: -3.65 – -2.85]\) at one month and three months postpartum compared to the control group. A cessation of the intervention at one month postpartum showed a decline in all parental outcomes.

**Conclusions:** The technology-based SEPP is effective in improving parental bonding, parental self-efficacy, perceived social support, parental satisfaction, and parental bonding. Hence, nurses and midwives should incorporate it with existing hands-on parent-craft classes and routine care. Further studies should investigate the long-term effectiveness (beyond three months) of this program on parental outcomes.

**Registration:** ISRCTN48536064

**Keywords:** Educational program, parents, parental bonding, parenting satisfaction, perinatal period, self-efficacy, social support.
INTRODUCTION

The arrival of a newborn is often highly associated with positive emotions for parents. Nonetheless, the transition to parenthood can be overwhelming and disruptive to their individual lives as they balance their work lives and new parental roles [1]. During this stressful adaptation period, additional infant care responsibilities, lack of social support from one’s partner, and conflict on the division of childcare labor often place a strain on social relationships and marriages [2-4]. This in turn affects individual parental bonding with the infant, which may give rise to child developmental and attachment issues [5]. Additionally, poor adjustment to parenthood often arises due to vast differences between prenatal expectations and postnatal experiences [6, 7]. Unmet expectations and poor adjustment increase the risks of postnatal depression (PND) in both mothers and fathers [8,9]. However, high levels of perceived parental self-efficacy (PSE) [10] and social support help to facilitate smoother transition to parenthood [11], leading to increased parenting satisfaction and parenting competence [12] and lowered risks of postnatal depression [10] and postnatal anxiety (PNA) [13].

According to Bandura, self-efficacy refers to one’s feeling of effectiveness in accomplishing required tasks and activities [14]. For better PSE, Bandura emphasized that parents must have confidence in their ability to perform specific skills and believe that their actions will have the desired outcomes to ensure successful parenting [15]. Self-efficacy can be developed through mastery of experiences, vicarious experiences, social persuasion, and affective and physiological factors [14]. Especially for first-time parents, PSE is highly associated with better coping responses and parenthood adjustment and positive psychological and developmental outcomes for parents and children [16,17]. In addition, Bowlby’s attachment theory [18] also theorizes that PSE, social support, and parental emotional wellbeing are essential to establishing early parent-infant bonding, which is the
foundation of the positive development of social relationships in infants. Therefore, it is important to investigate the relationships between PSE, social support, parent-infant bonding, parents’ psychological wellbeing (i.e. postnatal depression and anxiety), and parenting satisfaction.

Singapore’s fertility rate has been dipping over the years despite the government’s desperate attempts to incentivize Singaporeans to get married and have more children. Career prioritization [19], previous negative childbirth experiences, and unmet parental expectations were the main reasons for this declining trend [20, 21]. Negative childbirth experiences are often due to obstetric complications, delivery mode, poor infant health, postnatal affective disorders, and a lack of professional support [22]. In order to mitigate negative childbirth experiences and prepare parents for parenthood, perinatal educational classes are available in Singapore hospitals. However, due to unawareness, time, and financial constraints, few parents attend these classes [23]. Even those who attended the classes found the information provided to be unsatisfactory [23]. Additionally, fathers reported feeling left out and lacking social support from healthcare professionals as mothers were given more attention [24]. Perinatal care by the hospital also mainly focused on breastfeeding and the physical wellbeing of mothers, often neglecting the psychological wellbeing of the mother and child [25]. Furthermore, during short hospital stays, infant care information was usually disseminated through pamphlets or in a didactic style, causing information overload for parents [23, 24]. Singaporean fathers have also indicated their preferences and shared that they learn better when baby care information was conveyed through videos [24]. Therefore, there is a need for an improved theory-based perinatal educational program incorporating multimedia elements to facilitate effective learning among parents.

In 2016, Singapore had the highest smartphone penetration rate of approximately 98% [26]. Under the smart nation initiative, Singapore aims to deliver holistic healthcare through
technological innovations [27]. Additionally, an increasing number of parents are relying on internet information and online support communities [28, 29]. However, information online may not be reliable as they are not moderated by healthcare professionals and are often based on personal opinions or experiences [30]. Previous local and international studies have mentioned the effectiveness of psychosocial interventions on boosting parental self-efficacy [10, 31], parenting satisfaction [31], mother child bonding [32, 33], and perceived social support [10, 32]. It also reduces risks of PND and PNA [10, 32]. However, most of these interventions are done face-to-face or through telephone calls, which were not cost effective and feasible due to a shortage of midwives [10, 32, 33]. Hence, delivering couple-based parenting educational programs in the form of mobile-health applications (m-health apps) will be a sustainable, reliable, cost effective, and convenient alternative for both healthcare professionals and parents.

**Aim and Hypotheses**

This study aims to examine the effectiveness of a technology-based supportive education parenting program (SEPP) on parental outcomes such as PSE, parental bonding, perceived social support, parenting satisfaction, PND, and PNA during the perinatal period.

Compared to those in the control group receiving standard care, we hypothesized that those in the intervention group will have statistically significant improvements for parental self-efficacy, perceived social support, parental bonding, and parental satisfaction and lower scores for PND and PNA from the baseline to three months postpartum.

**METHODS**

**Study Design**

A single-blinded randomized controlled pretest-posttest experimental study design was used. Participants were randomized into two groups (59 couples in each group) using an opaque
envelope containing non-duplicated numbers (1 - 118). A random allocation sequence was generated by a research randomizer [34].

**Participants’ Criteria**

Eligible participants were mothers and fathers who were 21 years old and above, were proficient in spoken and written English, had a smartphone with internet access, and planned to stay in Singapore for the first three months post-delivery. Mothers must also have a low-risk singleton pregnancy with more than 28 weeks gestation. Fathers and mothers were excluded if they were a single parent and/or had self-reported physical or mental disorders that would interfere in their ability to participate in the study and/or if the mother had a high-risk pregnancy (i.e. placenta-previa major, pre-eclampsia, pregnancy induced hypertension), had assisted delivery such as vacuum or forceps with a 4th degree perineal tear, and/or had given birth to a stillborn or a newborn with congenital abnormalities and/or medical complications. Upon recruitment, couples were informed of possible exclusion from the study if the mothers were to experience complications during the pregnancy and/or the delivery.

**Sample Size**

Based on a repeated measure analysis of covariance (ANCOVA) to examine the differences between two groups (intervention and control) and within four separate time points and for interaction (group x time) effects, and assuming a medium effect size of 0.3 (analysis of variance F-value) at a power of 80% with a significance level of 5% (2-sided), approximately 90 subjects (45 couples) in each group were required. Factoring a 30% attrition rate, 236 subjects (118 couples), with 118 (59 couples) in each group, were required. Details on the sample size calculation are reported in the study protocol [35].

**Intervention**
Parents assigned to the control group received routine perinatal care provided by the hospital, which includes antenatal check-ups with an obstetrician, optional antenatal educational classes and postnatal parent-craft educational classes, and regular follow-ups with doctors between 10 days to six weeks postpartum.

Parents in the intervention group received the SEPP in addition to the standard routine perinatal hospital care. The SEPP adopted a three-step approach, including 1) a 30-minute telephone-based antenatal educational session, 2) a 60-minute immediate postnatal educational session, and 3) a m-health app-based follow-up educational session that was made available for four weeks postpartum. Individual usernames, masking the parents’ identities, and passwords were issued to the parents for access to the m-health app. Details of the SEPP are summarized in the protocol [35].

The m-health app contained knowledge-based content that addressed issues on breastfeeding, maternal self-care, newborn care tasks, dealing with emotional challenges, enhancing parental efficacy and bonding, and providing insights for new parents to facilitate their transition to parenthood. Additionally, parental queries could be posted in the app’s discussion forum, which were answered daily by a trained midwife for the first four weeks post-childbirth. Other parents were also highly encouraged to share their personal insights and experiences in response to such queries. The m-health app also issued daily push notifications regarding important milestones on parenting. Further specifications on the intervention can be found in the study protocol [35].

**Procedure**

The study took place in the antenatal clinic of a tertiary hospital in Singapore from December 2016 to December 2017. Participants were recruited as a couple (father and mother dyad) when they went for their routine antenatal check-up at the antenatal clinic. With the support of nurse managers and clinicians at the antenatal clinic, a research assistant approached
referred couples to explain the purpose and details of the study. After being screened for eligibility, informed consent was obtained from interested couples and they had to complete a demographics form and a baseline questionnaire. They were randomized into either the intervention or control group. The research assistant then proceeded to deliver the telephone-based antenatal education session to participants in the intervention group. After childbirth, couples were re-approached by the research assistant in the postnatal wards to complete another set of questionnaires. Couples in the intervention group further received a telephone-based postnatal educational session conducted by the research assistant. They were also required to download the supportive parenting educational m-health app before discharge from the hospital. The research assistant guided them through the app’s functions on the spot. Individual usernames and passwords were provided for access to the m-health app, which expired in four weeks. For couples in the control group, only routine perinatal care by the hospital was provided. Subsequent posttest data collection was done through telephone calls by another research assistant who was blinded to the group allocation. Data collection took place at the following timepoints for all parents: 1) during pregnancy (baseline), 2) two days postpartum (interim data), 3) four weeks postpartum (posttest1), and 4) three months postpartum (posttest 2).

**Outcome Measures**

The primary outcome (PSE) and secondary outcomes (parental bonding, PND, PNA, perceived social support, and parenting satisfaction) were measured using validated and reliable self-report questionnaires. PSE was measured using the 10-item Parenting Efficacy Scale (PES) [36], with a score range of 10 to 40. A high PES score indicates a high level of perceived self-efficacy. The intraclass correlation coefficient (ICC) of the PES in the current study is 0.669. Parental bonding was measured using the Parent-to-Infant-Bonding Questionnaire (PIBQ) [37]. Total scores range from 0 to 24, with higher scores suggesting
ineffective bonding between mother and infant [38]. The PIBQ has an ICC of 0.849 in this study at a cut-off score of 2. The 10-item Edinburgh Postnatal Depression Survey (EPDS) was used to measure PND at the recommended cut-off score of 12 [10, 39, 40] and has a good ICC of 0.803. A high EPDS score indicates a higher risk of PND. The 40-item State Trait Anxiety Inventory (STAI) is widely used to measure postnatal anxiety [41, 42] and has a score range of 40 to 160, with higher scores indicating higher levels of parental anxiety. It has an ICC of 0.855 in this study. The 8-item Perceived Social Support for Parenting (PSSP) [43] scale constitutes two sub-parts (4-item each) that are used to measure parents’ perceived social support received from their partner and others. It has a total score range of 0 to 40 and an ICC of 0.702. Lastly, parenting satisfaction was measured with an evaluation subscale of the What Being a Parent of a Baby is Like (WPBL) scale [44]. It consists of 11 items, each with a 10-point semantic differential scale ranging from 0 to 9. The ICC for the WPBL in this study is 0.802. A detailed description of the instruments can be found in the study protocol [35].

Data Analysis

All quantitative data were analyzed using IBM SPSS at a significance level of $P < 0.05$. Missing data were replaced (assuming 10%) for intention-to-treat analysis. Both intention-to-treat and per-protocol analyses were conducted to compare any differences between groups. Descriptive statistics were presented as mean, standard deviation, and range for continuous data, while for frequencies, n (%) was used for nominal and ordinal data. Assuming heterogeneity and normality for all variables, an independent sample t-test was performed to compare outcome differences between the control and intervention groups. Chi-square or Fisher’s Exact test was used to compare categorical variables. Linear mixed-effect model analyses were used to compare the two groups on PSE, parental bonding, PND, PNA, parental satisfaction scores, and social support percentage changes across the four timepoints.
(baseline, interim, posttest 1, and posttest 2). Absolute change in PND scores by adjusting for the baseline scores was calculated. Demographic variables such as age, gender, ethnicity, education, employment status, household income, length of marriage, antenatal class attendance, confinement period, maternal/paternal leave, and mode of feeding were adjusted for using the linear mixed-effect model analyses.

**Ethical Considerations**

The current study received ethics approval from the National Health Group Domain Specific Review Board (Ref. No: NHG DSRB: 2016/00651) before data collection. All participants were given a participant information sheet and were briefed thoroughly on the study’s purpose and procedures before their consent was obtained. Participation was strictly voluntary, and anonymity was guaranteed. Participants were also informed of the right to withdraw at any point of the study without consequences.

**RESULTS**

Figure 1 shows the consort flowchart of the study. A total of 236 (118 couples) participants were recruited and randomized into the SEPP intervention group (n = 59) and control group (n = 59). The baseline demographic data for all participants in the study are presented in Table 1. Participants have a mean age of 32 years (SD 4.81, range 22 - 51). All participants were married with an average marriage length of 3.5 years (SD 2.67, range 1 - 10). The majority of the participants were Chinese (46.2%, 109/236), university graduates (73.3%, 173/236), and employed (91.1%, 215/236) with a household income of more than SGD$5,000 (58.5%, 138/236). The majority of the participants did not attend antenatal classes, had a normal vaginal delivery, and followed a confinement period. There were no statistically significant differences between the control and intervention groups on demographic characteristics except for age ($P = 0.026$) and length of marriage ($P = 0.008$). Follow-up assessments for one month postpartum were completed for 47 couples (79.6%) in
the intervention group and 50 couples (84.7%) in the control group. At three months postpartum, analyses and follow-up assessments were completed for 44 couples (74.6%) in
the intervention group and 49 couples (83.1%) in the control group. The overall attrition rate
was 17.8% and the retention rate from the baseline was 82.2%. Table 2 summarizes the
baseline parental outcomes of parental bonding, PSE, PND, PNA, perceived social support,
and parenting satisfaction of the intervention and control groups.

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**Assessed for eligibility (256 couples)**

- Excluded (138 couples): Did not meet the inclusion criteria (64 couples) - Refused to participate (74 couples)

**Baseline measurements and randomization (118 couples):**

- PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf, demographic data

**Intervention group (53 couples):**

- PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf, newborn data
- 6 couples did not receive intervention or were lost to follow-up

**Control group (52 couples):**

- PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf, newborn data
- 7 couples were lost to follow-up

**Interim**

**Posttest 1**

- Intervention group (47 couples):
  - PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf, process evaluation
  - 6 couples did not receive the intervention or were lost to follow-up

- Control group (50 couples):
  - PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf, process evaluation
  - 2 couples were lost to follow-up

**Posttest 2**

- Intervention group (44 couples):
  - PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf
  - 3 couples were lost to follow-up

- Control group (49 couples):
  - PIBQa, PESb, EPDSc, STAId, PSSPe, WPBLf
  - 1 couple was lost to follow-up
Table 1. Summary of sociodemographic and pregnancy-related characteristics at the baseline

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention (n = 118)</th>
<th>Control (n = 118)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, Mean (SD) [Min, Max]</td>
<td>31.3 (4.6) [24, 51]</td>
<td>32.6 (5.0) [22, 51]</td>
</tr>
<tr>
<td>Females, % (n)</td>
<td>50 (59)</td>
<td>50 (59)</td>
</tr>
<tr>
<td>Ethnicity, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>46.6 (55)</td>
<td>45.8 (54)</td>
</tr>
<tr>
<td>Malay</td>
<td>27.1 (32)</td>
<td>23.7 (28)</td>
</tr>
<tr>
<td>Indian</td>
<td>14.4 (17)</td>
<td>18.6 (22)</td>
</tr>
<tr>
<td>Others</td>
<td>11.9 (14)</td>
<td>11.9 (14)</td>
</tr>
<tr>
<td>Marriage length in years, Mean (SD) [Min, Max]</td>
<td>3.1 (2.5) [1, 10]</td>
<td>4.0 (2.8) [1, 10]</td>
</tr>
<tr>
<td>University graduates, % (n)</td>
<td>76.3 (90)</td>
<td>70.3 (83)</td>
</tr>
<tr>
<td>Employed participants, % (n)</td>
<td>93.2 (110)</td>
<td>89.0 (105)</td>
</tr>
<tr>
<td>Monthly household income, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; S$3,000</td>
<td>10.2 (12)</td>
<td>15.3 (18)</td>
</tr>
<tr>
<td>S$3,000 - S$5,000</td>
<td>25.4 (30)</td>
<td>30.5 (36)</td>
</tr>
<tr>
<td>&gt; S$5,000</td>
<td>64.4 (76)</td>
<td>52.5 (62)</td>
</tr>
<tr>
<td>Planned pregnancy, % (n)</td>
<td>67.8 (80)</td>
<td>67.8 (80)</td>
</tr>
<tr>
<td>Attended antenatal class, % (n)</td>
<td>33.1 (39)</td>
<td>26.3 (31)</td>
</tr>
<tr>
<td>Mode of delivery, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal vaginal delivery/water birth</td>
<td>62.7 (74)</td>
<td>59.3 (70)</td>
</tr>
<tr>
<td>Instrumental delivery</td>
<td>3.4 (4)</td>
<td>6.8 (8)</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>27.1 (32)</td>
<td>27.1 (32)</td>
</tr>
<tr>
<td>Male babies, % (n)</td>
<td>54.2 (64)</td>
<td>54.2 (64)</td>
</tr>
<tr>
<td>Birth order, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>61.0 (72)</td>
<td>69.5 (82)</td>
</tr>
<tr>
<td>Second</td>
<td>30.5 (36)</td>
<td>18.6 (22)</td>
</tr>
<tr>
<td>Third and above</td>
<td>3.4 (4)</td>
<td>8.5 (10)</td>
</tr>
<tr>
<td>Paternal/maternal leave, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No leave</td>
<td>3.4 (4)</td>
<td>1.7 (2)</td>
</tr>
<tr>
<td>≤ 12 weeks</td>
<td>55.1 (65)</td>
<td>49.2 (58)</td>
</tr>
<tr>
<td>&gt; 12 weeks</td>
<td>25.4 (30)</td>
<td>34.7 (41)</td>
</tr>
<tr>
<td>Confinement period, % (n)</td>
<td>71.2 (84)</td>
<td>78.0 (92)</td>
</tr>
<tr>
<td>Mode of feeding, % (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breastfeeding</td>
<td>56.0 (66)</td>
<td>61.0 (72)</td>
</tr>
<tr>
<td>Formula feeding</td>
<td>1.7 (2)</td>
<td>1.7 (2)</td>
</tr>
<tr>
<td>Breastfeeding and formula</td>
<td>30.5 (36)</td>
<td>27.2 (32)</td>
</tr>
</tbody>
</table>

SD = Standard deviation; Min = Minimum; Max = Maximum.
### Table 2. Summary of parental outcomes at the baseline

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Father</td>
<td>Mother</td>
</tr>
<tr>
<td></td>
<td>(n = 59)</td>
<td>(n = 59)</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Parental bonding (0 – 24)</td>
<td>2.7 (3.3)</td>
<td>3.0 (3.5)</td>
</tr>
<tr>
<td>Parental self-efficacy (10 – 24)</td>
<td>30.8 (5.7)</td>
<td>30.5 (6.1)</td>
</tr>
<tr>
<td>Postnatal depression (0 – 30)</td>
<td>5.6 (4.2)</td>
<td>7.2 (4.0)</td>
</tr>
<tr>
<td>Postnatal anxiety (40 – 160)</td>
<td>65.9 (17.4)</td>
<td>70.5 (17.8)</td>
</tr>
<tr>
<td>Perceived social support (0 – 40)</td>
<td>34.4 (5.3)</td>
<td>33.5 (5.8)</td>
</tr>
<tr>
<td>Parenting satisfaction (0 – 99)</td>
<td>77.9 (14.0)</td>
<td>78.4 (12.1)</td>
</tr>
</tbody>
</table>

SD = Standard deviation.
As shown on Table 3, the changes in the adjusted scores of all outcomes immediately postpartum from the baseline were not significantly different between the intervention group and the control group. At both one month postpartum and three months postpartum, the changes in the adjusted scores of all outcomes from the baseline were significantly different between the intervention group and the control group. The changes in mean outcome scores across all timepoints are shown in Figure 2.

For changes in adjusted parental bonding scores from the baseline at one month postpartum, there was a mean difference of -4.34 ($t = -19.55$, $P < 0.001$, 95% confidence interval (CI): -4.78 - -3.90) between the intervention and control groups. At three months postpartum, there was a mean difference of -1.60 ($t = -4.84$, $P < 0.001$, 95% CI: -2.26 - -0.94) between the intervention and control groups.

At one month postpartum, the change in the intervention group’s adjusted PSE scores from the baseline was significantly higher than the change of the control group’s (MD = 2.36, $t = 10.97$, $P < 0.001$, 95% CI: 1.94 – 2.79). Similarly, at three months postpartum, the change in the intervention group’s adjusted PSE scores from the baseline was significantly higher than the change of the control group’s (MD = 0.45, $t = 2.15$, $P = 0.034$, 95% CI: 0.035 – 0.86).

The change in the adjusted PND scores from the baseline between the intervention group and the control group at one month postpartum has a mean difference of -3.54 ($t = -17.83$, $P < 0.001$, 95% CI: -3.93 – -3.15). Likewise, at three months postpartum, there was a mean difference of -0.92 ($t = -4.07$, $P < 0.001$, 95% CI: -1.38 – -0.47) in the adjusted PND score change between the intervention and control groups.

At one month postpartum, the change in the intervention group’s adjusted PNA scores from the baseline was significantly lower than the change in the scores of the control group’s (MD = -3.25, $t = -15.65$, $P < 0.001$, 95% CI: -3.65 – -2.85). At three months postpartum, the
change in the intervention group’s adjusted PNA scores from the baseline was also significantly lower than the change in the scores of the control group’s (MD = -0.82, t = -4.91, \( P < 0.001 \), 95% CI: -1.15 – -0.49).

For the change in adjusted perceived social support scores from the baseline to one month postpartum, the intervention group had a significantly higher change than the control group (MD = 3.13, t = 17.89, \( P < 0.001 \), 95% CI: 2.78 – 3.47). Similarly, at three months postpartum, the intervention group had a significantly higher change in adjusted perceived social support scores from the baseline than the control group (MD = 0.76, t = 3.71, \( P < 0.001 \), 95% CI: 0.36 – 1.16).

Lastly, at one month postpartum, there was a mean difference of 3.48 (t = 19.89, \( P < 0.001 \), 95% CI: 3.14 – 3.83) between the changes in the adjusted parenting satisfaction scores of the intervention and control groups. At three months postpartum, there was a mean difference of 1.44 (t = 7.42, \( P < 0.001 \), 95% CI: 1.05 – 1.82), between the changes in the adjusted parenting satisfaction scores of the intervention and control groups.

Scores were also analyzed between mothers and fathers. The results were similar, expect for PSE. At three months postpartum, only the change in the adjusted PSE scores of fathers showed a significant difference (MD = 0.51, t = 2.12, \( P = 0.036 \), 95% CI: 0.03 – 0.99). Mothers did not show any significant difference in their change in adjusted PSE scores (MD = 0.33, t = 1.22, \( P = 0.223 \), 95% CI: -0.20 – 0.85). The results are summarized in Table 4 for mothers and Table 5 for fathers.
<table>
<thead>
<tr>
<th>Standardized outcomes</th>
<th>Immediately postpartum</th>
<th>1 month postpartum</th>
<th>3 months postpartum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusted</td>
<td>Unadjusted</td>
</tr>
<tr>
<td></td>
<td>Difference (95% CI)</td>
<td>Difference (95% CI)</td>
<td>Difference (95% CI)</td>
</tr>
<tr>
<td></td>
<td>[P]</td>
<td>[P]</td>
<td>[P]</td>
</tr>
<tr>
<td>Parental bonding</td>
<td>-0.04 (-0.33, 0.25)</td>
<td>-0.19 (-0.57, 0.20)</td>
<td>-4.16 (-4.48, -3.85)</td>
</tr>
<tr>
<td></td>
<td>[0.788]</td>
<td>[0.334]</td>
<td>[&lt;0.001]</td>
</tr>
<tr>
<td>Perceived self-efficacy</td>
<td>-0.20 (-0.53, 0.12)</td>
<td>-0.29 (-0.75, 0.17)</td>
<td>2.23 (1.92, 2.54)</td>
</tr>
<tr>
<td></td>
<td>[0.212]</td>
<td>[0.212]</td>
<td>[&lt;0.001]</td>
</tr>
<tr>
<td>Postnatal depression</td>
<td>(-0.33, 0.22)</td>
<td>(-0.26, 0.35)</td>
<td>(3.97, -3.22)</td>
</tr>
<tr>
<td></td>
<td>[0.694]</td>
<td>[0.766]</td>
<td>[&lt;0.001]</td>
</tr>
<tr>
<td>Postnatal anxiety</td>
<td>0.11 0.15</td>
<td>-3.30 -3.25</td>
<td>-3.65 -2.85</td>
</tr>
<tr>
<td></td>
<td>[0.367]</td>
<td>[0.264]</td>
<td>[0.068]</td>
</tr>
<tr>
<td>Perceived social support</td>
<td>-0.13 (-0.42, 0.16)</td>
<td>-0.18 (-0.47, 0.10)</td>
<td>3.14 (2.75, 3.53)</td>
</tr>
<tr>
<td></td>
<td>[0.365]</td>
<td>[0.199]</td>
<td>[&lt;0.001]</td>
</tr>
<tr>
<td>Parenting satisfaction</td>
<td>(-0.21, 0.49)</td>
<td>(-0.37, 0.34)</td>
<td>(2.92, 3.69)</td>
</tr>
<tr>
<td></td>
<td>[0.439]</td>
<td>[0.831]</td>
<td>[&lt;0.001]</td>
</tr>
</tbody>
</table>

Unadjusted differences were estimated by subtracting control group estimates from intervention group estimates using a linear mixed model adjusted for baseline values. Adjusted differences were estimated using the same model with additions of covariates ethnicity, maternal/paternal leave, confinement period, infant feeding mode, age, length of marriage, household income, employment status, and education. See the Methods section for outcome and covariate definitions. CI = Confidence interval.
Figure 2. Changes in the estimated means of parental outcomes in the control and intervention groups across all timepoints
| Standardized outcomes | Immediately postpartum | | | 1 month postpartum | | | 3 months postpartum | | |
|-----------------------|------------------------|---|---|-------------------|---|---|-------------------|---|
|                      | Unadjusted | Adjusted | Unadjusted | Adjusted | Unadjusted | Adjusted | Unadjusted | Adjusted |
| Parental bonding     | -0.07 (-0.43, 0.28)  | -0.19 (-0.62, 0.25) | -4.07 (-4.49, -3.65) | -4.28 [-0.001] | -1.26 (-1.77, -0.75) | -1.53 [-0.001] | -0.07 (-0.43, 0.28) | -0.19 (-0.62, 0.25) | -4.07 (-4.49, -3.65) | -4.28 [-0.001] | -1.26 (-1.77, -0.75) | -1.53 [-0.001] |
| Perceived self-efficacy | -0.12 (-0.49, 0.26)  | -0.22 (-0.76, 0.31) | 2.29 [0.539] | 2.38 [0.411] | 0.29 0.33 | -0.09 0.68 | 0.133 0.223 | 2.29 [0.539] | 2.38 [0.411] | 0.29 0.33 | -0.09 0.68 | 0.133 0.223 |
| Postnatal depression | -0.33 (-0.68, 0.03)  | -0.15 (-0.54, 0.25) | -3.69 [-0.070] | -3.57 [-0.461] | -0.84 0.81 | -1.24 -0.44 | -1.25 -0.37 | -0.33 (-0.68, 0.03) | -0.15 (-0.54, 0.25) | -3.69 [-0.070] | -3.57 [-0.461] | -0.84 0.81 | -1.24 -0.44 | -1.25 -0.37 |
| Postnatal anxiety    | -0.02 (-0.39, 0.35)  | 0.17 (-0.22, 0.57) | -3.26 [-0.914] | -3.32 [-0.392] | -0.55 -0.55 | -0.93 -0.17 | -0.94 -0.15 | -0.02 (-0.39, 0.35) | 0.17 (-0.22, 0.57) | -3.26 [-0.914] | -3.32 [-0.392] | -0.55 -0.55 | -0.93 -0.17 | -0.94 -0.15 |
| Perceived social support | -0.03 (-0.40, 0.33)  | -0.10 (-0.52, 0.33) | 3.36 [-0.856] | 3.40 [-0.650] | 0.57 0.69 | -0.06 1.20 | 0.06 1.33 | -0.03 (-0.40, 0.33) | -0.10 (-0.52, 0.33) | 3.36 [-0.856] | 3.40 [-0.650] | 0.57 0.69 | -0.06 1.20 | 0.06 1.33 |
| Parenting satisfaction | 0.02 (-0.42, 0.46)   | -0.15 (-0.61, 0.32) | 3.64 [-0.922] | 3.77 [-0.533] | 1.31 1.31 | 0.72 1.90 | 0.61 2.02 | 0.02 (-0.42, 0.46) | -0.15 (-0.61, 0.32) | 3.64 [-0.922] | 3.77 [-0.533] | 1.31 1.31 | 0.72 1.90 | 0.61 2.02 |

Unadjusted differences were estimated by subtracting control group estimates from intervention group estimates using a linear mixed model adjusted for baseline values. Adjusted differences were estimated using the same model with additions of covariates ethnicity, maternal/paternal leave, confinement period, infant feeding mode, age, length of marriage, household income, employment status, and education. See the Methods section for outcome and covariate definitions. CI = Confidence interval.
Table 5. Estimated differences between the intervention and control groups for changes in standardized parental outcomes at postpartum visits from the baseline between fathers

<table>
<thead>
<tr>
<th>Standardized outcomes</th>
<th>Immediately postpartum</th>
<th>1 month postpartum</th>
<th>3 months postpartum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Difference (95% CI) [P]</td>
<td>Adjusted</td>
</tr>
<tr>
<td>Parental bonding</td>
<td>-0.01</td>
<td>(-0.44, 0.41) [0.953]</td>
<td>-0.05</td>
</tr>
<tr>
<td>Perceived self-efficacy</td>
<td>-0.28</td>
<td>(-0.77, 0.21) [0.263]</td>
<td>-0.40</td>
</tr>
<tr>
<td>Postnatal depression</td>
<td>0.11</td>
<td>(-0.24, 0.45) [0.537]</td>
<td>0.13</td>
</tr>
<tr>
<td>Postnatal anxiety</td>
<td>-0.17</td>
<td>(-0.14, 0.48) [0.264]</td>
<td>-0.13</td>
</tr>
<tr>
<td>Perceived social support</td>
<td>-0.22</td>
<td>(-0.57, 0.13) [0.224]</td>
<td>-0.22</td>
</tr>
<tr>
<td>Parenting satisfaction</td>
<td>-0.09</td>
<td>(-0.09, 0.61) [0.149]</td>
<td>-0.23</td>
</tr>
</tbody>
</table>

Unadjusted differences were estimated by subtracting control group estimates from intervention group estimates using a linear mixed model adjusted for baseline values. Adjusted differences were estimated using the same model with additions of covariates ethnicity, maternal/paternal leave, confinement period, infant feeding mode, age, length of marriage, household income, employment status, and education. See the Methods section for outcome and covariate definitions. CI = Confidence interval.
DISCUSSION

Overview

The present study examined the effectiveness of a technology-based SEPP among new parents in Singapore. From our results at one month postpartum, parents who received the SEPP showed significant improvements in PSE, parental bonding, psychological wellbeing (i.e. low levels of depression and anxiety), parenting satisfaction, and perceived social support, which suggests the effectiveness of the intervention. At third months postpartum, there are noticeable increases in the outcome scores for PSE, social support, and parenting satisfaction and decreases in the outcome scores for PND, parental bonding, and PNA for the control group. For the intervention group, scores for PSE, social support, and parenting satisfaction decreased, while scores for PND, PNA, and parental bonding increased. However, the intervention group still scored significantly better than the control group in terms of parent-infant bonding, parenting satisfaction, and personal psychological wellbeing. Levels of self-efficacy and perceived social support were not significantly different between the groups at the third month. This implies that the cessation of the m-health app usage at one month caused a decrease in parental outcomes. Therefore, parents should be granted prolonged access to the m-health app in order to retain their positive wellbeing and high levels of self-efficacy beyond one month.

Parental Self-efficacy

The improvement of the total scores for PSE in the intervention group proposes that the SEPP is effective in enhancing parents’ confidence in their infant care skills and capability as a parent. The components of this technology-based SEPP allow parents to obtain self-efficacy through mastery experiences, vicarious experiences, and verbal persuasion, as mentioned in Bandura’s self-efficacy theory [14]. In order to feel efficacious, Bandura [14] also mentioned the need for knowledge retrieval from an appropriate knowledge base. In the present study, parenting information addressing the emotional needs and expectations of parents was
disseminated in the late trimester of their pregnancy. Unlike the usual hospital antenatal classes, which focus on practical infant-care skills, this short telephone-based antenatal education session was more family-oriented and focused on the importance of bonding, PSE, and parental expectations during the immediate postpartum. These topics were further reinforced immediately post-childbirth with additional information on parent-craft topics. The last component of the SEPP involves a m-health app, which served as a readily accessible platform for the retrieval of information on parenting and infant care through knowledge-based content and audio and video recordings. The vast amount of information provided during the entire course of the program was able to better equip parents with the necessary parenting knowledge and skills. Parents were more confident in handling challenging parenting tasks themselves, hence boosting their PSE through mastery experiences. Likewise, in a Finnish study [45], PSE scores increased for both mothers and fathers after an online intervention; maternal parenting satisfaction also improved.

Another component of the m-health app includes an online discussion forum where parents shared and exchanged information with other parents. This provided an alternate source of informal social support and enhanced PSE through vicarious learning. The forum was moderated by a professional midwife to ensure information accuracy. In addition, constructive feedback by the midwife and encouragement from other parents in similar situations acted as forms of verbal persuasion, which helped parents to overcome self-doubt and enhance their PSE. Similar results were found in Linberg and colleagues’ [46] study, where parents felt more confident and affirmed in their parenting roles after receiving positive feedback from healthcare professionals. An additional source of verbal persuasion was the timely push notifications, which tailored messages to inform parents of their baby’s milestones. These helped parents to track their progress and were a source of encouragement and reassurance that they were doing well as parents. Push notifications also included
medical appointment reminders to remind parents of important infant care responsibilities and help maintain PSE.

After the cessation of the m-health app usage, the PSE of parents in the intervention group decreased slightly while PSE in the control group increased, resulting in similar scores. This suggests that parents in the control group needed three months of mastery experience to reach the same level of PSE as parents in the intervention group, who were able to achieve high levels of PSE within one month. These results correspond with Porter and Hsu’s [47] study on first-time mothers, which reported a significant increase in maternal self-efficacy at three months postpartum even without an educational intervention. A pilot study in Iran discovered an improvement in maternal self-efficacy after six weeks of an intervention and no change in PSE even one month after the withdrawal of the intervention [48]. Along with our results, this supports Bandura’s theory [14] that childcare experience increases maternal parenting self-efficacy regardless of the intervention received, and that the SEPP is only effective in helping parents gain PSE in a shorter time.

**Parental Bonding**

There were significant differences in parental bonding scores between the control and intervention groups at one month and three months postpartum. For parents in the intervention group, parental bonding scores were at constantly low since childbirth to three months postpartum, which signify high levels of parent-infant bonding. According to Bowlby’s attachment theory [18], good parental bonding is dependent on high PSE, good psychological wellbeing, and social support. This corresponds with a recent review by Edward and colleagues [49] that reported PND and poor maternal social networks as predictors of impaired maternal bonding. Since the SEPP was effective in increasing PSE, parents were more confident in infant care skills such as breastfeeding, bathing, and swaddling the baby. These interactions and increased skin-to-skin contact [50] help to release the oxytocin hormone, which is essential for parent-infant bonding [51]. In a local study on fathers [24], despite feeling detached and unable to relate to the baby during the antenatal
period, fathers felt a strong need to bond with their baby in the postpartum period; however, they were often unsure and not confident of how to do so. Consistent with our study results, this emphasizes the need for an educational intervention during the perinatal period to enhance PSE which in turn boost parental bonding.

Results from existing studies on the effectiveness of educational interventions on parental bonding are still inconclusive. Some studies have found increased parental bonding after receiving an intervention [32, 33, 52] while other studies reported no change in parental bonding [53-55]. Seeing that parental bonding plays an important role in promoting the healthy psychosocial wellbeing of parents, and the social development of the child [32, 52], more vigorous testing is required to determine the effectiveness of such educational interventions on parental bonding.

**Social Support**

At one month postpartum, the results showed significant differences in social support scores between the control and intervention groups with those in the intervention group scoring higher. This implies that the SEPP was able to provide the necessary social support need by parents. Local studies [23,24] reported that fathers often deem informational support and constructive feedback from healthcare professionals the most important in enhancing their parenting abilities whereas mothers required more informational and emotional support, especially from their partners and healthcare professionals. Fathers also preferred technology-based educational programs as they learned better through videos instead of plain text [24]. Therefore, the SEPP is a reliable source of informational support for parents with its rich knowledge-based content, video and audio recordings on infant care, and the involvement of a professional midwife in the execution of telephone-based sessions and moderation of forum information. In addition, the discussion forum in the m-health app fostered a sense of belonging and formed a social support system among parents. Parents were able to exchange information and share experiences regarding similar situations, forming friendships and being a source of emotional support for one another. Two reviews revealed that such online-based
forums are common sources of peer support, helping to reduce stigma and promote help-seeking behavior, which reduces PND and PNA [28,56]. An increasing number of young parents are also turning to the internet for social support rather than their family and friends [29]. A combination of professional and peer support was also found to increase the efficacy of educational programs [57].

At three months postpartum, PSSP scores for the intervention group dipped slightly while scores for the control group increase until there was no significant difference between the control and intervention groups. For the intervention group, the decreased scores were due to the cessation of the m-health app usage, which removed an essential source of social support that may have affected PSE and psychological wellbeing of parents. For the control group, the results could be attributed to the intrusiveness of family members or in-laws and the one-month confinement period. Singapore has a collectivist Asian culture, which emphasizes on filial piety [58], family bonding, and family support. In addition, confinement practices are commonly practiced in the Asian society. It involves social seclusion, mandated rest, special dietary preparations, and infant care tasks that are usually handled by the mother’s mother or mother-in-law [59, 60]. In local studies [23,24], young parents felt highly pressured to follow cultural confinement rules out of respect for their elders, but they expressed skepticism towards certain traditional beliefs as these conflicted with their online knowledge. Although confinement practices provide a form of instrumental support, the conflict of modern day versus traditional beliefs between new parents and their elders can cause new parents further distress and adversely affect their perceived social support [23,24]. In other Asian studies, the presence of female relatives during the confinement was enough to induce stress on new mothers [61,62]. Even Western studies [63, 64] revealed that receiving motherhood-related support can actually cause further distress to mothers by undermining their autonomy and self-efficacy. It is also possible that after one month of confinement, parents are able to make more autonomous decisions and mothers may actively seek out
friends as a source of emotional support; hence, increased PSSP scores are observed. However, further studies are required to validate these findings.

PND and Anxiety
For PND, there were significant differences between the control and intervention groups at one month and three months postpartum, but the intervention group’s PND scores increased after the termination of the SEPP, indicating more depressive symptoms. This is evident that the SEPP is effective in mitigating PND and the lack of it increases the risk of PND. Discontinuation of the SEPP could be equivalent to removing a pillar of support for parents. Without their ‘friends’ in the forum and the lack of a community support, PND scores of parents could have most likely increased. This corresponds with Leahy-Warren and colleagues’ [65] study findings whereby a positive correlation between social support (i.e. functional and informal social support) and PND was found. A Singapore-based study [10] on a postnatal psychoeducation program also reported that higher scores of PSE and social support resulted in lower PND scores at 6 and 12 weeks postpartum. However, in another local study [66], an educational m-health app administered for one month postpartum did not show significant effectiveness in mitigating PND, but there were significant increases in PSE, social support, and parenting satisfaction scores. The contradictory results of both studies were probably due to the different intervention lengths of one month [66] and three months [10], which highly corresponds with our results. Therefore, further studies should investigate the effectiveness of such psychoeducation interventions beyond three months.

As for PNA, there were also significant differences between the intervention and control groups at one and three months postpartum. A study by Seymour and colleagues [13] reported that postpartum maternal anxiety was associated with poor partner relationship quality, need for social support, low involvement, low efficacy, and low parenting satisfaction. However, comorbid depression and anxiety were more strongly correlated to these negative experiences than anxiety alone [13]. Studies often investigate PNA and depression together due to their high comorbidity rates [67]. According to a study in the
Netherlands, in 57% of the comorbid cases, anxiety preceded depression, and in 18%, depression preceded anxiety [68]. Therefore, in the current study, PND and PNA had similar trends in both groups, with PNA scores being slightly lower than PND at all timepoints. A study by Falah-Hassani and colleagues [67] reported that maternal self-efficacy, self-esteem, and partner support were associated with lower risks of developing comorbidity. Although few studies focus on the comorbidity of depression and anxiety in fathers [69], previous studies had mentioned the spillover effects of maternal psychological wellbeing on paternal psychological wellbeing [70], which could adversely affect the development of the child [69]. Therefore, couple-based educational programs will be more effective in ensuring each parent’s wellbeing and increasing their parenting dynamics [71]. A couple-based antenatal program was found to improve marital adjustment and reduce anxiety in both parents [72]. Another couple-based education program focusing on co-parenting, equal division of labor, and joint conflict resolution was effective in decreasing maternal PND and PNA at six months postpartum, but significant decreases in paternal PND and PNA were not reported [73]. Nevertheless, co-parenting alliance and paternal self-efficacy were found to reduce the paternal stress and overall psychological wellbeing of fathers [74,75]. Therefore, having a couple-based educational parenting program is important for facilitating partner support and improving marital adjustment, which can boost overall parental psychosocial wellbeing and promote healthy parent-infant bonding.

**Parenting Satisfaction**

There was an increase in parenting satisfaction scores in the intervention group while there was a huge decrease in parenting satisfaction scores in the control group. Scores for the control group increased after the third month to match up with the scores in the intervention group, but there were still significant differences in scores at six months postpartum. These results are congruent with Salonen and colleagues’ [45] study in which mothers who received
an online educational intervention reported higher parenting satisfaction, but not fathers. However, Hudson and colleagues [31] reported an increase in paternal parenting satisfaction after an online fathers’ network intervention. In both studies [31, 45], PSE was found to be positively correlated to parenting satisfaction as parents gained more confidence in caring for their baby. This suggests that higher PSE scores predict higher levels of parenting satisfaction, which corresponds to our current findings.

**Strengths and Limitations**

While most studies focused on technology-based interventions in the postpartum period [31, 32, 45, 66], the current study administered its intervention during the perinatal period, which can increase the effectiveness in improving parental outcomes. This study does not only add on to existing literature on maternal wellbeing, but also fill in knowledge gaps on paternal wellbeing during the perinatal period. Given that most parents today are turning to the internet for information and social support, this technology-based SEPP is also an ideal time-cost efficient method to meet parental needs and reduce the dependency on the availability of midwives.

However, a major limitation was that since the SEPP was a technology-based intervention, there was no hands-on application skills incorporated in the program, which reduces the effectiveness of skill-based learning, especially for experiential/hands-on learners. However, the short telephone-based educational classes (30 minutes to 1 hour) in this program might be more suitable for working parents who lack the time to attend antenatal classes, which may last up to 16 hours. Therefore, future studies should investigate the difference in effectiveness between technology-based classes and traditional face-to-face didactic perinatal classes. Due to a lack of available data, we were also unable to analyze the cost-effectiveness of this program; hence, future research can consider evaluating cost-effectiveness as an outcome. Also, this is a single-site study, which only included married
English-speaking couples. We believe the SEPP will be equally beneficial to parents of the minority group (i.e. single parents, other races, etc.); hence, future research should be more inclusive and consider conducting a multisite study with the minority population.

CONCLUSION

The study demonstrated the effectiveness of the technology-based SEPP in improving parental self-efficacy, parental bonding, perceived social support, and parenting satisfaction and reducing PND and PNA. Such educational programs are vital to equipping parents with necessary parenting skills to facilitate smoother transition to parenthood by increasing their self-efficacy and enhancing parental bonding. It also serves as a reliable source of social support that promotes healthy psychological wellbeing in both fathers and mothers. We hope that the clinical implementation of the SEPP will be able to meet parents’ needs and create positive childbirth experiences, which may in turn encourage parents to have more children and alleviate Singapore’s declining birth rate.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

None.
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### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ANCOVA</td>
<td>Analysis of Covariance</td>
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<tr>
<td>CONSORT</td>
<td>Consolidated Standards Of Reporting Trial</td>
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<tr>
<td>EPDS</td>
<td>Edinburg Postnatal Depression Scale</td>
</tr>
<tr>
<td>ICC</td>
<td>Intraclass Correlation Coefficient</td>
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<tr>
<td>m-health app</td>
<td>Mobile-health application</td>
</tr>
<tr>
<td>NHG DSRB</td>
<td>National Health Group Domain Specific Review Board</td>
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<tr>
<td>PES</td>
<td>Parenting Efficacy Scale</td>
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<td>Parent-to-infant Bonding Scale</td>
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<td>Postnatal Anxiety</td>
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<td>Supportive Educational Parenting Program</td>
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<td>State Trait Anxiety Inventory</td>
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<td>WPBL</td>
<td>What Being the Parent of a Baby is Like</td>
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