PERINATAL MENTAL HEALTH AND WELL-BEING IN FATHERS

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PUBLISHED IN: Frontiers in Psychology

frontiers Research Topics

frontiers

ISSN 1664-8714
ISBN 978-2-88974-896-9
DOI 10.3389/978-2-88974-896-9

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PERINATAL MENTAL HEALTH AND WELL-BEING IN FATHERS

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Citation: Conde, A., Figueiredo, B., Milgrom, J., eds. (2022). Perinatal Mental Health and Well-being in Fathers. Lausanne: Frontiers Media SA.
doi: 10.3389/978-2-88974-896-9

Table of Contents

frontiers in Psychology

EDITORIAL
published: 21 March 2022
doi: 10.3389/fpsyg.2022.875620

Editorial: Perinatal Mental Health and Well-Being in Fathers

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Keywords: fatherhood, anxiety, depression, perinatal period, clinical intervention

Editorial on the Research Topic

Perinatal Mental Health and Well-Being in Fathers

Research focusing on fathers' perinatal mental health is recent and less substantial than the research focusing on mothers. Nevertheless, mental health problems and disorders are common in fathers during the perinatal period and should be the focus of attention, namely in planning promotion, preventive, and remedial interventions, with expected benefits for all of the family over time.

The major purpose and potential contribution of this Research Topic is to share conceptual, scientific and practical essays that can inform health care systems and policies about the best practices in the field. The proposals included in this Research Topic reflect the diversity of research aims among studies of fathers' perinatal mental health, namely the development and validation of assessment measures for a range of issues including involvement with the infant (Webb et al.; Pinto et al.), the study of the impact of parental relationship satisfaction on infant development (Nicolaus et al.) and associated processes, such as paternal bonding (Bieleninik et al.; Schaber et al.) and paternal postpartum mental health (Macdonald et al.). The effectiveness and scope of interventions aiming to promote fathers' psychological adjustment and family functioning during parenthood (Rodrigues et al.; Tandon et al.; Battle et al.) and the analysis of the neurobiological correlates of fatherhood (Sobral et al.) are other relevant emerging areas of research.

Consistent evidence supports the impact of fathers' mental disorders on children's mental health and development, on mothers' mental health, and on the overall family functioning. The importance of considering fathers' mental health in perinatal health care and treatments is also consistently suggested. Nevertheless, further research is needed to provide better tools to screen and assess fathers, focusing their specific needs and psychological experience specificities across different cultures. Moreover, a better understanding of the mechanisms and processes involved in father' perinatal psychological (mal)adjustment and parenting should be obtained.

More than being seen exclusively as a source of maternal support, empirical evidence strongly indicates that fathers should be seen as a developing individual, with a particular experience of the phenomena that occur during pregnancy and after childbirth, as well as of the parental role. Using a developmental approach, both the research and clinical practice should promote early (prenatal) identification of fathers at psychosocial risk, exploring the risk and protective factors of their mental health and well-being. Processes associated to father's mental health, as well as processes explaining the impact of father's mental health on children's development and mental health are also essential. Evidence-based interventions addressing the mental health and specific needs of fathers, but also considering all members of the family system, promoting communication, cohesion and mutual support, are still needed. Such promotion, preventive, and remedial interventions are expected to benefit both father's and children's developmental trajectories over time, as well as interrupt the intergenerational transmission of psychosocial risk. At this level, exploring the neurobiological processes involved in parenting is essential and should be prioritized.

OPEN ACCESS

Edited and reviewed by:
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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *14 February 2022*
Accepted: *17 February 2022*
Published: *21 March 2022*

Citation:
Conde A, Figueiredo B and Milgrom J (2022) Editorial: Perinatal Mental Health and Well-Being in Fathers. Front. Psychol. 13:875620. doi: 10.3389/fpsyg.2022.875620

In sum, despite the important steps that have been taken in the last two decades in the study and intervention in the perinatal mental health of parents, there is still a long way to go. And at this level, fathers are undoubtedly one of the main actors to consider!

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

ACKNOWLEDGMENTS

The authors thank Ian Potter Foundation, Perpetual Impact Philanthropy and Men of Malvern, for funding research involving fathers.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 03 March 2021
doi: 10.3389/fpsyg.2021.596779

Development and Validation of a Measure of Birth-Related PTSD for Fathers and Birth Partners: The City Birth Trauma Scale (Partner Version)

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Research suggests that some fathers and birth partners can experience post-traumatic stress disorder (PTSD) after witnessing a traumatic birth. Birth-related PTSD may impact on many aspects of fathers' and birth partners' life, including relationship breakdown, self-blame and reducing plans for future children. Despite the potential impact on birth partners' lives there is currently no measure of birth-related PTSD validated for use with birth partners. The current study therefore adapted the City Birth Trauma Scale for use with birth partners. The City Birth Trauma Scale (Partner version) is a 29-item questionnaire developed to measure birth-related PTSD according to DSM-5 criteria: stressor criteria (A), symptoms of re-experiencing (B), avoidance (C), negative cognitions and mood (D), and hyperarousal (E), as well as duration of symptoms (F), significant distress or impairment (G), and exclusion criteria or other causes (H). A sample of 301 fathers/birth partners was recruited online and completed measures of birth-related PTSD, bonding, and demographic details. Results showed the City Birth Trauma Scale (Partner version) had good reliability ($\alpha = 0.94$) and psychometric and construct validity. The fathers/birth partners version has the same two-factor structure as the original scale: (1) general symptoms and (2) birth-related symptoms, which accounted for 51% of the variance. PTSD symptoms were associated with preterm birth and maternal and infant complications. Overall, the City Birth Trauma Scale (Partner version) provides a promising measure of PTSD following childbirth that can be used in research and clinical practice.

Keywords: birth trauma, PTSD, fathers, partners, birth

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *20 August 2020*
Accepted: *08 February 2021*
Published: *03 March 2021*

Citation:
Webb R, Smith AM, Ayers S, Wright DB and Thornton A (2021) Development and Validation of a Measure of Birth-Related PTSD for Fathers and Birth Partners: The City Birth Trauma Scale (Partner Version). Front. Psychol. 12:596779. doi: 10.3389/fpsyg.2021.596779

INTRODUCTION

Post-traumatic stress disorder (PTSD) is a trauma and stressor-related disorder that may develop following direct or indirect exposure to, or witnessing of, actual or threatened death, serious injury or sexual violence (American Psychiatric Association, 2014). Childbirth can act as a traumatic stressor in the development of postnatal PTSD (McKenzie-McHarg et al., 2015), and it is estimated

that this affects approximately 4% of women. Prevalence increases to 18.5% in high risk samples, such as women who experienced emergency cesarean sections, severe fear of birth, a history of sexual/physical violence or childhood abuse, babies that were born preterm or very ill or women who had severe pregnancy complications (e.g., HELLP syndrome) (Dikmen Yildiz et al., 2017).

Approximately 97% of women will have their partner or another close friend or family member with them during birth (Care Quality Commission, 2020). Approximately 90% of fathers will attend the birth (Redshaw and Henderson, 2013), followed by a sister, mother, mother in law or female friend (Bohren et al., 2019). A meta-synthesis of the experience of birth partners found that some (both male and female) were deeply affected by witnessing a woman's pain during labor, such as through feelings of frustration, fear, and helplessness (Bohren et al., 2019). This suggests being a birth partner may increase the risk of developing PTSD. In the context of childbirth, a father/birth partner witnessing a complicated birth involving his/her partner and/or child that has resulted in actual or threatened injury or death could qualify as fulfilling the DSM-5 Stressor A1 Criterion for PTSD. Rates of post-traumatic stress symptoms in birth partners have been found to vary in questionnaire studies from 0% to 8% of men attending their child's birth, depending on the symptoms being measured (Ayers et al., 2007; Bradley et al., 2008). Further, research suggests that men do not always ask for support and there is a lack of recognition or comprehension regarding the issue by healthcare professionals (Hinton et al., 2014; Poh et al., 2014; White, 2014; Elmir and Schmied, 2016). These factors may lead to the psychological needs of fathers/birth partners not being recognized and subsequently fathers/birth partners not being provided with appropriate support or treatment. Case studies and qualitative research suggests some men may continue for years without seeking professional support for the effects of birth trauma (Beck et al., 2013; Hinton et al., 2014; White, 2014).

Research around risk factors for the development of PTSD after witnessing a traumatic birth has mainly focused on fathers, with the exception of Hinton et al. (2014) who interviewed one female partner. Risk factors include pregnancy and birth related factors such as witnessing near-miss obstetric emergencies or complicated births, e.g., emergency cesarean sections (Hinton et al., 2014; Elmir and Schmied, 2016); preterm birth (Stramrood et al., 2013) and complications during the birth (Ayers et al., 2007). Demographic risk factors include higher paternal age (Stramrood et al., 2013); fewer children, unplanned pregnancy (Bradley et al., 2008);and being a single father (Skari et al., 2002). Predisposing psychological factors include depression and trait anxiety (Iles et al., 2011; Zerach and Magal, 2016); and interpersonal risk factors include poor communication, support or treatment by healthcare professionals (Hinton et al., 2014; Poh et al., 2014; White, 2014; Elmir and Schmied, 2016).

The impact on the father/birth partner of birth-related PTSD has not been widely researched but qualitative and case studies suggest in fathers it is associated with social isolation, job loss, mental breakdown, vasectomy and sexual scarring (Hinton et al., 2014; White, 2014). For the family, PTSD may lead to relationship breakdown, financial insecurities and affect the parent–baby bond (Nicholls and Ayers, 2007; Hinton et al., 2014; White, 2014). Furthermore, a qualitative study of 10 men in the United Kingdom who had witnessed their partner's labor and childbirth and perceived a threat to their partner or infant's life or physical wellbeing found some men blamed themselves for the traumatic events during birth, and reported that the traumatic birth affected their parenting and plans for future children, as well as the couple's relationship (Bristow, 2016).

Despite the potential impact of PTSD on fathers and birth partners, it remains under-researched. Lack of research evidence and awareness means it is also not recognized in maternity services. Routine assessment of fathers and birth partners' mental health is neither conducted nor recommended in clinical guidelines (e.g., The National Institute for Health and Care Excellence, 2014). One of the barriers to routine assessment of fathers and birth partners is that there are no validated tools specifically for assessing birth-related PTSD with fathers and birth partners. To date, research has used four measures of PTSD symptoms after birth with fathers and birth partners: the Post-traumatic Stress Disorder Questionnaire (PTSD-Q); Perinatal PTSD Questionnaire (PPQ); Post-Traumatic Stress Disorder Diagnostic Scale (PDS); and the Impact of Events Scale (IES). The PTSD-Q (Czarnocka and Slade, 2000) is a self-report questionnaire adapted from a diagnostic interview and can be used to assess symptoms of posttraumatic stress (Watson et al., 1991). The PTSD-Q has been used in two studies of birth partners, however, it is not specifically designed to measure PTSD in response to childbirth (Bradley et al., 2008; Iles et al., 2011). The PPQ (Callahan and Borja, 2008) is a 14-item scale which measures perinatal PTSD and has been used in a few studies with fathers/birth partners (Pierrehumbert et al., 2003; Koliouli et al., 2016; Janis et al., 2017). However, this measure does not ask about traumatic stressor criteria or cover diagnostic criteria. The PDS (Foa et al., 1993) is a 49-item self-report measure that assesses all of the DSM-IV criteria for PTSD (American Psychiatric Association, 2000) and has been used in four studies with birth partners (Parfitt and Ayers, 2009; Stramrood et al., 2013; Horsch et al., 2017; Janis et al., 2017). However, again it is not specifically designed to measure postpartum PTSD. The IES (Horowitz et al., 1979) is a 15-item scale that measures symptoms of intrusions and avoidance. The IES is the most widely used measure with birth partners (Johnson, 2002; Skari et al., 2002; Ayers et al., 2007; Bradley et al., 2008; Gürber et al., 2017; Winter et al., 2018), however, it was not designed for use in the perinatal period. In addition, none of these scales measure the updated DSM-5 diagnostic criteria for PTSD. Thus, all four measures have limitations and none have been validated specifically for use with fathers and birth partners.

The City Birth Trauma Scale (Ayers et al., 2018) is a 29-item questionnaire developed to measure birth-related PTSD according to DSM-5 criteria (see **Table 1**). The original questionnaire was developed for use with postpartum women and has good reliability (Cronbach's $\alpha = 0.92$), psychometric validity and is easy to understand (Flesch reading score 64.17) (Ayers et al., 2018). Validations of translated versions of the City BiTS also find similar factor structure, reliability and validity

TABLE 1 | DSM-V diagnostic criteria for PTSD.

Criterion	Description
A – Stressor criteria (one required)	A1: The person was exposed to: death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence, in the following way(s):
	Direct exposure
	Witnessing the trauma
	Learning that a relative or close friend was exposed to a trauma
	Indirect exposure to aversive details of the trauma, usually in the course of professional duties (e.g., first responders, medics)
	A2: The person's response involved intense fear, helplessness or horror
B – Symptoms of re-experience (one required)	The traumatic event is persistently re-experienced, in the following way(s):
	Intrusive thoughts
	Nightmares
	Flashbacks
	Emotional distress after exposure to traumatic reminders
	Physical reactivity after exposure to traumatic reminders
C – Avoidance (one required)	Avoidance of trauma-related stimuli after the trauma, in the following way(s):
	Trauma-related thoughts or feelings
	Trauma-related reminders
D –Negative cognitions and mood (two required)	Negative thoughts or feelings that began or worsened after the trauma, in the following way(s):
	Inability to recall key features of the trauma
	Overly negative thoughts and assumptions about oneself or the world
	Exaggerated blame of self or others for causing the trauma
	Negative affect
	Decreased interest in activities
	Feeling isolated
	Difficulty experiencing positive affect
E – Hyperarousal (two required)	Trauma-related arousal and reactivity that began or worsened after the trauma, in the following way(s):
	Irritability or aggression
	Risky or destructive behavior
	Hypervigilance
	Heightened startle reaction
	Difficulty concentrating
	Difficulty sleeping
F – Duration of symptoms (required)	Symptoms last for more than 1 month.
G – significant distress or impairment (required)	Symptoms create distress or functional impairment (e.g., social, occupational).
H - Exclusion criteria (required)	Symptoms are not due to medication, substance use, or other illness.

(Handelzalts et al., 2018; Nakić Radoš et al., 2020; Caparros-Gonzalez et al., 2021). This is therefore a promising measure to be validated for use with fathers/birth partners. Therefore, to overcome the lack of validated measured available for assessing PTSD after birth in fathers/birth partners, the aim of the study was to adapt the City BiTS to create a partner version and examine its validity and reliability.

MATERIALS AND METHODS

Design

A cross-sectional psychometric study to assess the reliability and validity of the City BiTS (Partner version) using responses to an online survey.

Participants

Individuals were eligible for the study if they were present at their partner's labor or birth within the past 5.5 years (a wide time frame was used to ensure we could recruit an adequate sample size); were 18 years and older; and had a good enough command of English to understand and respond to the questions.

A total of 383 eligible fathers/birth partners started the questionnaire, of these 301 (78.6%) fathers/birth partners were included in the final sample. Remaining participants (n = 82) were excluded because they dropped out before completing the questionnaire (n = 58, 15.4% of eligible participants), their child was over the age of 5.5 years (n = 14, 3.7% of eligible participants) or their infant's date of birth was unreadable or incorrect (n = 10, 2.6% of eligible participants).

Measure

The City BiTS was written to correspond directly with DSM-5 criteria but adapted to be specific to childbirth and contains 29 items. The City BiTS (Partner version) and scoring information is available online at https://blogs.city.ac.uk/citybirthtraumascale/. Criterion A (Q1–2) items are scored on a yes/no scale. DSM-5 symptoms Criteria B to E (Q3–22) are measured using 20 items that measure the frequency of symptoms for these items over the last week, rated on a four-point scale with scores from zero (not at all) to three (five or more times). The total symptom scores for Criteria B to E range from 0–60 and symptoms are considered present if an item is rated as one or more. Two questions (Q23–24), scored the same as Criterion B to E, identify a dissociative subtype so are not symptoms of PTSD. The scores for Criteria F (Q26) range from zero (symptoms $<$ 1 month/no symptoms) to two (symptoms lasting $>$ 3 months). Criterion G items (Q27–28) are rated as yes/sometimes/no and the exclusion criteria item (Q29) is rated as yes/maybe/no. The City BiTS can be scored to measure PTSD symptoms [including subscales, total PTSD symptoms, dissociative symptoms or symptom clusters as identified by previous research (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020; Caparros-Gonzalez et al., 2021)] or PTSD diagnoses.

The City BiTS was adapted for use with fathers and birth partners by altering the instructions slightly and ensuring questions for stressor criteria A were phrased to ask whether they thought their partner or baby might be seriously injured or die. Fathers/birth partners were classed as fulfilling Criteria F and G if they scored one or more on symptom duration and for distress or impairment, respectively. Fathers/birth partners

who responded to the exclusion criteria question (Q29) as "yes" or "maybe" were considered not to have PTSD and therefore removed from estimates of PTSD prevalence.

To evaluate construct validity additional questions were asked which measured: (1) perceived trauma ("On a scale of 1–5 please comment on how traumatic you found the birth" [1 = not at all – 5 = extremely traumatic]); (2) maternal complications ("Did your partner suffer from any complications during the birth? [yes/no]. "If yes, what happened?" [Optional free text]); (3) infant complications ("Did your baby suffer from any complications during the birth?" [yes/no]. "If yes, what happened?" [Optional free text]); and (4) Father/parent – infant bond ("Since the birth, how bonded do you feel to your baby?" [1 = Extremely bonded – 5 = not at all bonded]).

Procedure

This study was approved by City, University of London Research Governance Ethics Committee. The City BiTS (Partner version) and questions about participants demographic details were hosted on an online survey platform Qualtrics. The survey was available online for 9 months from June 2016 to March 2017. Participants were recruited though adverts placed on social media websites of United Kingdom perinatal charities (i.e., BLISS, PANDAS, DADS Matter UK, and the Birth Trauma Association), Twitter, and a study website created on Facebook. Consent to advertise the survey on charity websites was sought from moderators and research officers of relevant organizations and websites. Social media adverts contained hyperlinks to frequently asked questions and a link to the survey. Recruitment adverts were specifically targeted to fathers; however, the study did not ask participants for their sex or what their relationship was to the baby/child. It is therefore probable the sample was of fathers but possible that other types of birth partners were included. We therefore refer to fathers/birth partners throughout.

Participants were given information about the study and had to tick a box to confirm they were 18 years or older and consented to take part in the study. If participants did not tick this box they were unable to progress to the survey. Participation was voluntary and anonymous unless participants chose to give their email address to receive their assessment scores and/or a summary of the study results.

Statistical Analysis

Analyses were conducted using the statistics environment R (R Core Team, 2019) and SPSS (IBM Corp, 2017). Descriptive statistics were calculated for all 22 items in the scale (see **Supplementary Material**). To assess symptom severity according to the DSM-5 criteria, the sums of subscales B–E were calculated to give scores for re-experiencing, avoidance, negative cognitions and mood, and hyperarousal. These were also totaled to provide a total PTSD symptoms score. Responses to stressor criteria were calculated, as were responses to questions about the onset of symptoms, duration, distress and impairment. The association between PTSD symptoms and time since birth was calculated using a one-way ANOVA. To test reliability, Cronbach's alpha was calculated which estimates how well the set of questions measures a single overall construct. To test factorial validity an exploratory factor analysis was carried out as in Ayers et al. (2018). A two-factor solution with varimax rotation was sought. Additionally, a confirmatory factor analysis was carried out using two models. Two confirmatory models were examined. The first model is where each set of items B, C, D, and E, are influenced by separate factors, and these factors are correlated. The second is the two-factor solution as identified in Ayers et al. (2018). As an exploratory factor analysis was carried out it was not possible to do hypothesis tests for the confirmatory factor analysis. Therefore, BIC values were used to determine the fit of the models.

Further, the readability of the scale was determined using the Flesch readability scale and years of formal education required using the Gunning Fog index. As the data were not normally distributed, to test known-group validity, non-parametric Mann–Whitney *U*, and Kruskal–Wallis tests were carried out using birth-related symptoms, general symptoms and total symptoms as the dependent variables, and whether or not the mother or baby had any complications during the labor and birth (yes vs. no), what type of birth the mother had (unassisted vaginal vs. assisted vaginal or emergency CS), the partners bond with the baby, and the partners subjective rating of the birth as traumatic (1 = not traumatic – 5 = extremely traumatic) as the independent variables.

Screening of Items

Initial data screening was conducted to examine whether any questions were not performing well. First, the range of each question was examined to ensure there were no restricted items where participants did not use the full range of the scale. This confirmed all questions used the full range. Secondly, the distributions of the questions were examined through inspection of skewness values and histograms. As with the original City BiTS scale, the majority of the symptom subscale items (B–E) were positively skewed (17 out of 20). PTSD scales are frequently skewed when used in normal populations (Ayers et al., 2018) and this was expected. Therefore, it was not appropriate to remove questions on this basis. Finally, questions were screened and noted if they were too highly correlated with other questions $r > 0.90$ (0 questions) or did not significantly correlate with other questions (0 questions). Eighty four percent of the correlations were between $r = 0.20$ and $r = 0.60$ (IQR: 0.31, 0.49). The highest correlation was $r = 0.76$ between Q6B (getting upset when reminded of the birth) and Q7B (feeling tense or anxious when reminded of the birth).

RESULTS

Sample Characteristics

Fathers/birth partners included in the final sample ($n = 301$) ranged in age from 21 to 60 years ($M = 34.59$; $SD = 6.08$). From those that responded to the demographic questions, the majority of fathers/birth partners were first-time parents ($n = 143$; 54.20%) and most were White ($n = 183$; 92.00%). The children were aged from 0 to 64 months ($M = 13.20$; $SD = 13.08$) and most were born by unassisted vaginal birth ($n = 85$; 40.70%) or

emergency cesarean birth ($n = 83$; 39.70%). See **Table 2** for sample characteristics.

There was a high proportion of preterm birth, maternal and infant complications. The majority of fathers/birth partners had a preterm infant (59.6%, $n = 161$) with the mean gestational age of 33.67 weeks (SD = 5.61; range = 21–43 weeks). Similarly, over half the sample reported maternal complications during birth (52%; $n = 156$) and/or infant complications during birth 56.3% ($n = 169$). Optional open text responses describing the complications experienced ($n = 149$) suggested the most common maternal complications were issues with cord/placenta [e.g., retained placenta, placental abruption, cord prolapse ($n = 23$); post-partum hemorrhage ($n = 37$); pre-eclampsia or issues with blood pressure ($n = 24$); and tears/episiotomies ($n = 14$)]. With regards to infants, the most commonly reported complications were the infant being born unable to breathe and needing resuscitation ($n = 55$); and pre-term birth ($n = 49$). Four fathers/birth partners reported that their infant died.

TABLE 2 | Sample characteristics.

Characteristic	M (SD)
Fathers/Birth partners' age (years; responses $n = 249$)	34.59 (6.08)
Children's age (months; responses $n = 301$)	13.20 (13.08)
Characteristic	***N* (%)**
Time since birth (responses $n = 301$)	
Less than 6 months	97 (32.2)
6–12 months	110 (36.5)
13–24 months	43 (14.3)
More than 24 months	51 (16.9)
Ethnicity (responses $n = 199$)	
White	183 (92.0)
Asian	7 (3.5)
Mixed	5 (2.5)
Black	2 (1.0)
Other	2 (1.0)
Job role (responses $n = 264$)	
Professional	122 (46.2)
Managerial or technical	67 (25.4)
Skilled (non-manual)	16 (6.1)
Skilled (manual)	38 (14.4)
Partially skilled	5 (1.9)
Unemployed	2 (0.8)
Other	14 (5.3)
Relationship status (responses $n = 266$)	
Married	192 (72.2)
Cohabiting	62 (23.3)
In a relationship, but not cohabiting	4 (1.5)
Single Separated	3 (1.1) 4 (1.5)
Divorced	1 (0.4)
Type of birth (responses $n = 209$)	
Unassisted vaginal birth	85 (40.7)
Assisted vaginal birth	35 (11.6)
Emergency cesarean	83 (39.7)
Elective cesarean	6 (2.9)
Maternal complications during labor and birth (responses $n = 300$)	
Yes	156 (52.0)
Infant complications during labor and birth (responses $n = 300$)	
Yes	169 (56.3)
Father/Birth partner's perception of bond with infant (responses $n = 266$)	
Extremely bonded	143 (53.8)
Very bonded	61 (22.9)
Moderately bonded	45 (16.9)
Slightly bonded	13 (4.9)
Not at all bonded	4 (1.5)

PTSD Symptoms

The sum of the 20 PTSD symptom subscale items (scales B–E) has a possible range from 0 to 60 and the observed range was 0 to 54 ($M = 17.38$; $SD = 13.89$; IQR: 5.00–26.00). The majority of fathers/birth partners reported at least one symptom ($n = 249$, 82.7%). The distribution was positively skewed (skew = 0.75).

Responses to the stressor criteria A can be found in **Table 3**. It can be seen that 58% of fathers/birth partners thought their partner or baby would be seriously injured, and 52% thought their partner or baby would die during the birth. Stressor criteria A for a traumatic birth were fulfilled by 64% of the sample. Seventy-seven fathers/birth partners (26%, 95% CI: 21, 31) fulfilled all DSM-5 diagnostic criteria for PTSD. Twenty-one fathers/birth partners (7%) indicated their symptoms might be due to medication, alcohol, drugs or physical illness so excluding these fathers/birth partners meant 22% of the sample met diagnostic criteria for PTSD (95% CI: 18, 27). Time since birth was not associated with PTSD symptom severity [$F(49,229) = 1.284$, $p = 0.115$].

Responses to questions about the onset of symptoms, duration, distress, and impairment are shown in **Table 4**. Not applicable responses are shown for the first two items, and then the percentages without these. This shows the majority of fathers/birth partners with symptoms reported onset within the first 6 months after birth (59%); and that their symptoms

TABLE 3 | PTSD and stressor criteria ($n = 301$).

Criteria	Yes Freq (%)	No Freq (%)
During the birth did you believe your partner or your baby would be seriously injured?	174 (58)	124 (42)
Did you believe your partner or your baby would die?	157 (52)	144 (48)
Criterion A (stressors)	193 (64)	108 (36)
Criterion B (re-experiencing)	212 (70)	89 (30)
Criterion C (avoidance)	147 (49)	154 (51)
Criterion D (negative cognitions and mood)	187 (62)	114 (38)
Criterion E (hyperarousal)	214 (71)	87 (29)
Criterion F (duration)	247 (82)	54 (18)
Criterion G (distress or impairment)	158 (52)	143 (48)
DSM-5 PTSD	77 (26)	224 (74)
Could these symptoms be due to medication, alcohol, drugs or physical illness?	21 (7)	280 (93)
DSM-5 PTSD after removing partners who meet potential exclusion criteria	66 (22)	235 (78)

had lasted 3 months or more (45%). However, a proportion of fathers/birth partners reported their symptoms started before the birth (11%), suggesting they had pre-existing PTSD or related symptoms. There was an association between the onset of symptoms before vs. after birth and severity of symptoms, in that more fathers/birth partners reported feeling distressed if their symptoms started more than 6 months after birth (n = 9, 40.9%), rather than before birth (n = 9, 30%) or within the first 6 months after birth (n = 47; 28.3%), [$\chi^2(2) = 6.50$; $p = 0.039$; $V = 0.186$].

Factorial Validity

Statistical checks confirmed the sample was adequate for factor analysis (Kaiser-Rice MSA measure = 0.926) and correlations between questions were suitably large [Bartlett's test of sphericity, $\chi^2(190) = 3745.14$, $p < 0.001$]. The exploratory factor analysis which sought two-factor solution with varimax rotation (Ayers et al., 2018) was found, and accounted for 50.81% of the variance. After rotation the first factor, which reflected general symptoms, accounted for 25.45% of the variance and the second factor, which reflected birth-related symptoms, accounted for 25.36% of the variance. **Table 5** shows the item loadings and it can be seen that items loaded onto the same factors found in the women's version (Ayers et al., 2018).

Confirmatory factor analysis showed that both the four-factor (model 1, AIC = 13484; BIC = 13647) and two-factor (model 2, AIC = 13505; BIC = 13649) fit similarly (see **Supplementary Material** for more details).

Reliability

The symptom subscales and total symptoms had good internal consistency with Cronbach's alphas above the acceptable level of 0.7 ($\alpha = 0.94$ for the total scale; range for subscales = 0.78–0.87; see **Table 6**). Removing items from the total scale, re-experiencing, avoidance, or hyperarousal subscales did not improve the Cronbach's alpha. Cronbach's alpha was high for the birth-related symptoms factor of the scale ($\alpha = 0.92$) and for the general symptoms factor ($\alpha = 0.91$).

TABLE 4 | Onset and impact of PTSD in Fathers/Birth partners.

Item	Response scale	*N* (%)	95% CI
Onset of symptoms	Before the birth	30 (11)	8–15
	First 6 months after birth	166 (59)	54–65
	More than 6 months after birth	22 (8)	5–12
	Not applicable	61 (22)	17–27
Duration of symptoms	Less than 1 month	54 (18)	14–23
	1–3 months	53 (18)	14–22
	More than 3 months	136 (45)	40–51
	Not applicable	58 (19)	15–24
Do these symptoms cause you a lot of distress?	Yes	66 (22)	18–27
	Maybe	78 (26)	21–31
	No	157 (52)	47–58
Do they prevent you from doing things you usually do?	Yes	42 (14)	10–18
	Maybe	60 (20)	16–25
	No	199 (66)	61–71
Could these symptoms be due to medication, alcohol, drugs or physical illness?	Yes	5 (2)	1–4
	Maybe	16 (5)	3–8
	No	280 (93)	90–95

Readability

The Flesch readability scale indicated that the City BiTS (Partner version) has a reading ease score of 57.8 meaning it should be easily understood by age 16–17 years. The number of years of formal education required to easily read the scale (Gunning Fog index) was 12.9.

Known-Group Validity

Results of known groups analyses are shown in **Table 7**. This shows that fathers/birth partners who met criteria for a traumatic birth reported significantly more general symptoms (Mean rank = 81.34, Mann–Whitney U 7238, $p < 0.001$) and birth-related symptoms (Mean rank = 70.77, Mann–Whitney U 8060.5, $p < 0.001$). Fathers/birth partners who reported maternal complications during birth reported significantly more birth-related symptoms (Mean rank = 159.11; Mann–Whitney U 8178, $p = 0.002$) but not general symptoms (Mean rank = 143.54; Mann–Whitney U 9034, $p = 0.373$). Fathers/birth partners who reported infant complications reported significantly more birth-related symptoms (Mean rank = 162.91; Mann–Whitney U 7186, $p < 0.001$) and general symptoms (Mean rank = 156.70; Mann–Whitney U 6688, $p < 0.001$). Subjective rating as the birth as traumatic was associated with general symptoms (*rho* 0.45, $p \leq 0.001$) and birth-related symptoms (*rho* 0.59, $p < 0.001$). General symptoms were also associated with poorer bonding with the baby (*rho* 0.21, $p < 0.001$).

DISCUSSION

The aim of this paper was to adapt the City BiTS to create a version for fathers and birth partners and test the reliability and psychometric validity in a sample of fathers/birth partners. The results suggest the City BiTS (Partner version) has good reliability, is relatively easy to use, and has the same two-factor structure as the original City BiTS. Results showed 26% of fathers/birth partners in this sample met criteria for PTSD after birth on this scale, which reduced to 22% after excluding those whose symptoms could have been due to medication, alcohol, drugs or physical illness. Twenty-two percent of fathers/birth partners reported that their symptoms caused them a lot of distress.

Psychometric Properties of the City BiTS

This study adds to the evidence that the City BiTS has good internal consistency. Internal consistency in this study ($\alpha = 0.94$) is similar to that found in the original City BiTS scale and translated into Croatian ($\alpha = 0.90$–0.92) (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020). This suggests the City BiTS (original)

TABLE 5 | Factor structure of the City BiTS (Partner version).

			Factor analysis of all symptoms (varimax rotation)	
		Uniqueness	General symptoms	Birth-related symptoms
B	**Intrusions**			
3	Recurrent or unwanted memories of the birth that you can't control	0.36	0.26	0.75
4	Bad dreams or nightmares about the birth	0.69	0.25	0.49
5	Flashbacks to the birth and/or reliving the experience	0.50	0.20	0.68
6	Getting upset when reminded of the birth	0.30	0.23	0.80
7	Feeling tense or anxious when reminded of the birth	0.32	0.28	0.77
C	**Avoidance**			
8	Trying to avoid thinking about the birth	0.34	0.24	0.77
9	Trying to avoid things that remind me of the birth	0.45	0.22	0.71
D	**Negative mood and cognitions**			
10	Not being able to remember details of the birth	0.93	0.24	0.11
11	Blaming myself or others for what happened during the birth	0.67	0.34	0.46
12	Feeling strong negative emotions about the birth	0.36	0.42	0.68
13	Feeling negative about myself or thinking something awful will happen	0.50	0.62	0.34
14	Lost interest in activities that were important to me	0.39	0.72	0.30
15	Feeling detached from other people	0.30	0.77	0.32
16	Not being able to feel positive emotions	0.40	0.71	0.24
E	**Hyperarousal**			
17	Feeling irritable or aggressive	0.47	0.69	0.24
18	Feeling self-destructive or acting recklessly	0.61	0.57	0.25
19	Feeling tense and on edge	0.36	0.77	0.22
20	Feeling jumpy or easily startled	0.61	0.56	0.28
21	Problems concentrating	0.41	0.75	0.16
22	Not sleeping well because of things that aren't due to the baby's sleep pattern	0.58	0.61	0.21
	Total variance explained		25.45%	25.36%

Items 23 and 24 do not measure symptoms of PTSD but identify a dissociative PTSD subtype so were therefore excluded from this analysis.

and City BiTS (Partner version) are reliable measures for assessing postpartum PTSD. However, further research is needed looking at other measures of reliability, such as test–retest.

The City BiTS (Partner version) also appears to have good validity. Known-group validity showed scores on the City BiTS were associated with partners subjective ratings of birth as traumatic and reporting complications with their partner or baby during the birth. Total and general symptoms were also associated with poorer parent-child bond.

The two-factor structure of the Partner version is the same as that found in psychometric studies of the original scale (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020). As with the original scale the item '*Not being able to remember details about the birth*' did not load strongly on either factor suggesting this item has consistently poor loadings in women and men after birth (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020; Caparros-Gonzalez et al., 2021). This may be because the birth of one's baby is a central life event which is likely to be remembered in detail. This study also adds to the evidence that postpartum PTSD symptoms measured by the City BiTS are consistently explained by two factors, one relating to general symptoms and the other relating to birth-related symptoms (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020; Caparros-Gonzalez et al., 2021). Research examining the factor structure of postpartum PTSD using other measures also finds two factors that are broadly consistent with the City BiTS. For example, Ayers et al. (2009), Stramrood et al. (2010), and Reichenheim et al. (2018) identified two clusters of re-experiencing and avoidance and numbing and (hyper)arousal. However, not all studies of postpartum PTSD find this two-factor structure, Olde et al. (2006) identified a three-factor structure of intrusion, avoidance and hyperarousal, and a systematic review of PTSD symptoms' latent structure in other populations even

TABLE 6 | Cronbach's alpha for total scale and subscales.

Scale	Number of items	α	95% CI
A: Stressor	2	0.78	0.74–0.81
B: Re-experiencing	5	0.87	0.85–0.89
C: Avoidance	2	0.82	0.79–0.85
D: Negative cognitions and mood	7	0.86	0.84–0.89
E: Hyperarousal	6	0.87	0.84–0.89
Total symptoms (without A)	20	0.94	0.93–0.95
Total scale	22	0.94	0.93–0.95

suggests six [e.g., Anhedonia model (Liu et al., 2014)[1] or seven-factor (Hybrid model, Armour et al., 2015)[2] models (Armour et al., 2016)].

The amount of postpartum PTSD variance explained by these two factors is over 50% in the Partner version and the original City BiTS (Ayers et al., 2018). However, a much lower proportion of the variance was explained by birth-related symptoms in the Partner version compared to the original scale for women [25% compared to 40–45%, respectively (Ayers et al., 2018; Handelzalts et al., 2018; Nakić Radoš et al., 2020)]. This suggests that birth-related symptoms and cognitions may be more influential in the development of PTSD in women than they are for fathers/birth partners.

It is interesting that the factor structure and item loadings for postpartum PTSD are the same in birth partners and women who went through labor and birth, despite potential differences in the way birth trauma may be experienced fathers/birth partners. For example, for women giving birth the threat is nearly always direct (i.e., to themselves or their baby *in utero*) and they will experience the physiological phenomena of labor and birth, which includes pain and invasive bodily procedures. In contrast, for fathers/birth partners the threat is indirect (i.e., to their partner and/or baby), they do not have the same physiological phenomena to cope with, but may feel ill-equipped and powerless to help. This is consistent with evidence that many fathers report feeling helpless during the birth of their child (Leonard, 1977; Nichols, 1993; Johansson et al., 2015; Elmir and Schmied, 2016) and often hide their emotions and feelings during labor to avoid upsetting their partners (Chandler and Field, 1997). A meta-ethnographic synthesis of qualitative studies of fathers' experiences of complicated births found themes of '*the unfolding crisis*' and '*stripped of my role: powerless and helpless.*' Remaining themes were '*craving information,*' and '*scarring the relationship*' (Elmir and Schmied, 2016). Further research examining both women giving birth and fathers/birth partners experiences of birth trauma is therefore needed to increase understanding of possible differences between experienced and witnessed trauma, as well as between genders, in how trauma is experienced and expressed.

[1]Intrusion, avoidance, negative affect, anhedonia, anxious hyperarousal, and dysphoric arousal.

[2]Re-experiencing, avoidance, negative affect, anhedonia, externalizing behaviors, anxious arousal, and dysphoric arousal.

Prevalence of PTSD

Although this study was not designed to establish prevalence, results suggested 26% of fathers/birth partners in our sample fulfilled diagnostic criteria for PTSD which is higher than the 7% of women with PTSD in the original City BiTS evaluation (Ayers et al., 2018) and the 3–4% prevalence of postpartum PTSD in women estimated by reviews and meta-analyses (Grekin and O'Hara, 2014; Dikmen Yildiz et al., 2017). Higher prevalence rates of 15–18% are observed in high risk samples, and as this sample was self-selected it is probable we recruited a high-risk sample of

TABLE 7 | Known group analyses.

		Total PTSD symptoms		General PTSD symptoms		Birth-related PTSD symptoms	
		***Mdn* (*IQR*)**	***Kruskal–Wallis*, *p***	***Mdn* (*IQR*)**	***Kruskal–Wallis*, *p***	***Mdn* (*IQR*)**	***Kruskal–Wallis, p***
Type of birth	Vaginal	13.5 (16.75)	3.84, 0.147	8 (11.00)	2.49, 0.288	4 (9.75)	5.36, 0.069
	Assisted vaginal	10 (20.00)		6 (11.00)		2 (9.00)	
	Emergency cesarean	15 (23.00)		9 (14.00)		5 (12.00)	
			U, p		***U, p***		***U, p***
Traumatic birth (criterion A)	Yes	20 (21.00)	7841.5, <0.001	11 (14.50)	7238, <0.001	8 (12.00)	8060.5, <0.001
	No	8 (12.25)		6 (8.50)		1 (4.00)	
Maternal complications	Yes	16 (24.25)	8222, 0.044	10 (17.00)	9034, 0.373	6 (11.00)	8178, 0.002
	No	13 (20.00)		9 (11.00)		3 (10.00)	
Infant complications	Yes	18 (23.00)	6322, <0.001	11 (13.00)	6688, <0.001	8 (12.00)	7186, <0.001
	No	10.5 (18.25)		6.5 (11.00)		3 (8.00)	
			Rho, p		***Rho, p***		***Rho, p***
Subjective rating of birth as traumatic	Not at all	1 (4.00)	0.559, <0.001	1 (4.00)	0.446, <0.001	0 (0.00)	
	Slightly traumatic	6.5 (11.75)		5.5 (9.00)		1 (2.75)	
	Moderately traumatic	10 (14.00)		6 (11.00)		3 (7.00)	0.587, <0.001
	Very traumatic	20 (17.00)		11 (9.50)		8 (10.00)	
	Extremely traumatic	30 (24.50)		17 (12.50)		12 (11.00)	
Bond with the baby	Extremely bonded	12 (25.00)	0.179, 0.003	7 (15.00)	0.211, 0.001	4 (12.00)	0.106, 0.086
	Very bonded	14 (20.50)		9 (13.50)		4 (10.00)	
	Moderately bonded	21 (15.00)		12 (9.50)		9 (9.50)	
	Slightly bonded	18 (26.00)		12 (15.40)		8 (13.00)	
	Not at all bonded	26[α]		15[α]		11[α]	

[α]*Not enough data to calculate interquartile range (n = 3).*

NB. Due to missing data n varies: traumatic birth (Criterion A) n = 207; type of birth n = 203; maternal and infant complications n = 277, subjective rating of birth and bond with baby n = 266.

fathers/birth partners. Online sampling and recruitment through organizations such as the Birth Trauma Association and BLISS, a preterm birth charity, probably meant fathers/birth partners with PTSD were over-represented and we inadvertently recruited a high-risk sample. The high proportion of fathers/birth partners who believed that their partner or baby was going to be seriously injured (54%) or die (48%) is consistent with this, as is the number of infants born prematurely (59%), and the number of fathers/birth partners reporting complications with their partner or baby (52 and 56%, respectively). In the original City BiTS study these rates were much lower (15% and 14%, respectively) (Ayers et al., 2018).

Limitations

A number of limitations should be considered before drawing conclusions. First, the sample in this study was recruited online so is self-selected and not representative. As discussed, prevalence rates are therefore unlikely to be representative and this study probably recruited high-risk fathers/birth partners who were more likely to have PTSD symptoms. This is reflected in the average preterm gestation of the infants when they were born and the number of fathers/birth partners who reported complications during birth for their partner and/or baby. Recruitment was targeted at fathers but sex of participants or their relationship to the baby/child was not recorded so it is possible our sample included birth partners who were not biological fathers or men. As research that looks at the experience of birth from the perspective of birth partners is usually carried out with fathers (Hinton et al., 2014; White, 2014; Bristow, 2016), it is not known whether birth partners or fathers would respond differently to the scale. This needs to be examined in future studies to ensure other types of birth partners are represented.

Demographic characteristics indicate the sample was predominantly white, which is similar to the United Kingdom population but results will not be representative of those from minority ethnic communities. Additionally, this study did not assess convergent or predictive validity. The original scale has high convergent validity with the Impact of Events Scale-Revised, Edinburgh Postnatal Depression Scale and Pittsburgh Sleep Quality Index (Handelzalts et al., 2018). More research is needed to establish convergent and predictive validity of the original scale and the Partner version; along with factor structure and reliability of the Partner version in more diverse samples of fathers/birth partners.

CONCLUSION

This study is the first to adapt a specific measure of postpartum PTSD according to DSM-5 criteria for use with fathers and birth partners and examine its reliability and psychometric validity. Results suggest the City BiTS (Partner version) has good reliability, reasonable face validity and the same two-factor structure as the original scale. However, more research is needed to replicate and extend this study. In particular to examine PTSD symptoms, prevalence, and factor structure in more representative samples, as well as the psychometric properties of the City BiTS (Partner version) in more diverse groups of fathers/birth partners. Potential differences in how birth trauma is experienced and expressed by fathers compared to other birth partners needs to be explored. Future research should also include additional measures of reliability (e.g., test–retest) and validity (e.g., convergent, predictive) to establish the utility of the scale for research and clinical practice.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by City, University of London Research Governance Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RW prepared the data for analysis, interpreted the data, and wrote the manuscript and manuscript revisions. AS carried out data collection and provided feedback on the manuscript. SA co-created the measure, overviewed the entire research process, provided feedback, and edited the manuscript. DW co-created the measure, carried out the analysis, and provided feedback on the manuscript. AT co-created the measure and provided feedback on the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This study was part-funded by City, University of London Higher Education Innovation Fund (HEIF). DW's research was supported by an endowment from the Dunn Family Foundation. The views expressed are those of the authors and not necessarily those of the HEIF, UK Research and Innovation, or Dunn Family Foundation.

ACKNOWLEDGMENTS

We are grateful to all the fathers and birth partners who took part in this study, as well as to Nazihah Uddin who helped with research administration.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.596779/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 09 April 2021
doi: 10.3389/fpsyg.2021.628650

Paternal Postpartum Bonding and Its Predictors in the Early Postpartum Period: Cross-Sectional Study in a Polish Cohort

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Introduction: Parental postpartum bonding has been studied by many researchers focusing on maternal bonding. The objective of this study was to examine the psychological and socio-demographic predictors of paternal postpartum bonding in the early postpartum period.

Methods: In this cross-sectional study, 131 couples (fathers median age of 32.37 years, *SD* = 4.59; mothers median age of 30.23 years, *SD* = 3.90) of newborns from full-term pregnancies were recruited from November 2019 until March 2020. The primary outcome was paternal postpartum bonding as measured by the Postpartum Bonding Questionnaire (PBQ). Secondary outcomes included: maternal and paternal anxiety [with the Generalized Anxiety Disorder (GAD) Assessment]; maternal and paternal stress [with the Parental Stress Scale (PSS)]; maternal depressive symptoms [with the Edinburgh Postpartum Depression Scale (EPDS)]; and maternal and paternal socio-demographic variables as fathers' presence at childbirth, education level, age, and parental experience.

Results: Paternal postpartum bonding was significantly correlated with paternal anxiety (moderate strength), maternal stress (strong correlation), and maternal postpartum bonding. No significant correlations between paternal postpartum bonding, maternal depression symptoms, and maternal anxiety were found. The mediating role of paternal stress in paternal postpartum bonding was proven. Paternal anxiety strengthens paternal stress (b = 0.98). Further, a high level of paternal stress disrupts paternal postpartum bonding (b = 0.41). Results of regression analyses have revelated that maternal infant bonding ($p < 0.01$) and paternal stress ($p < 0.01$) are the only predictors of parental postpartum bonding across all included variables. None of investigated socio-demographic variables were associated with paternal postpartum bonding.

Conclusion: Notwithstanding limitations, the current findings add to a growing body of literature on paternal postpartum bonding. The results have shown that paternal mental health is related to parental postpartum bonding directly after delivery.

Clinical Trial Registration: ClinicalTrials.gov Identifier: NCT04118751.

Keywords: bonding, anxiety, stress, postpartum depression, parenting (MeSH), newborns, fatherhood and building early relationships

OPEN ACCESS

Edited by:
Barbara Figueiredo, University of Minho, Portugal

Reviewed by:
Alicja Kalus, Opole University, Poland
Hanna Przybyła-Basista, University of Silesia, Katowice, Poland
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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *12 November 2020*
Accepted: *15 March 2021*
Published: *09 April 2021*

Citation:
Bieleninik Ł, Lutkiewicz K, Jurek P and Bidzan M (2021) Paternal Postpartum Bonding and Its Predictors in the Early Postpartum Period: Cross-Sectional Study in a Polish Cohort. Front. Psychol. 12:628650. doi: 10.3389/fpsyg.2021.628650

INTRODUCTION

Many researchers have examined parental bonding over the last few decades, since the concept was initially described in the 1970s (Klaus and Kennell, 1970, 1976; Klaus et al., 1972). The process of forming a healthy bond between parents and their newborn baby in the early postpartum period is important due to its long-lasting impact on the future parent – infant relationship (Mihelic et al., 2017; Nelson et al., 2019), the child's survival and consequently the child's development (Leckman et al., 2004; Nakano et al., 2019). Here, "maternal – infant bonding" (MIB) is defined as the emotional tie of a mother to her baby, as it gradually unfolds in the first year of a child's life' (Kinsey and Hupcey, 2013, p.7). Bonding development may look differently for mothers and fathers. A paternal – infant bond is often defined as the relationship between a father and his child. It starts to emerge early in pregnancy and further develops becoming more prevalent 2 months after childbirth (Anderson, 1996).

Based on existing knowledge, the postpartum period is considered the most difficult period for first-time fathers (Chin et al., 2011) due to new tasks, new emotions, new role development, and a lack of father-specific resources (Kumar et al., 2018). Society's expectations of a father's contribution in parenting have increased over time (Opondo et al., 2016). The evolution of the paternal role and a lack of father-specific models may make it more challenging to fulfill all of the modern expectations and have a proper understanding of how to be a competent father (Barclay and Lupton, 1999). Thus, first-time fathers may find it challenging to adjust to their new role after childbirth and live up to these new demands. Even in the case of a healthy newborn from full-term pregnancies, they can feel frustrated and uncertain, by not having enough opportunities to strengthen the emotional tie with their baby (Barclay and Lupton, 1999; Premberg et al., 2008), because of the mother's primary-caregiver role. What is more, personal and family changes may increase vulnerability to psychological stress in the early post-partum period (Epifanio et al., 2015). First-time fathers may feel less confident than new mothers with a baby, and may feel excluded in the close relationship that is growing between the mother and her baby. As a consequence, fathers may experience an increased level of stress and anxiety and/or depression, which later can be a risk factor of an impaired paternal bond with the baby.

A father's mental health during the antenatal and postpartum periods is a relatively under-researched topic in comparison with maternal mental health at that time (Ilska and Przybyła-Basista, 2014; Kucharska, 2020; Lutkiewicz et al., 2020). The prevalence of perinatal depression among fathers has been shown to be about 10% at the very beginning of pregnancy increasing to 25% around 6 months after birth (Paulson and Bazemore, 2010). Other research showed that paternal postpartum depression during the first year after childbirth can range between 4 and 25% (Soliday et al., 1999; Kim and Swain, 2007). This prevalence might be underreported due to the use of different measures, various cut-off scores, different measuring time-periods, and various other social and cultural factors. Factors for paternal postpartum depression include negative emotions, financial concerns/instability, balancing work–life demands, older age, low education levels, marital problems (Kumar et al., 2018), and anxiety (Chin et al., 2011; Kowlessar et al., 2015). Some studies claimed that a father's mood and emotional well – being are associated with their partner's mood (Deater-Deckard, 1998; Nishimura and Ohashi, 2010) and that these can influence each other (Paulson and Bazemore, 2010; Vismara et al., 2016). Research has also shown that paternal depression is significantly connected to maternal depression (Pinheiro et al., 2006; Letourneau et al., 2011; Edward et al., 2015; Nishimura et al., 2015).

Parental stress is a bio-psycho-social construct, where demands are placed so high that a parent does not have the available resources to fulfill them (Abidin, 1995). It may be experienced as a feeling of being overwhelmed, uncertainty in the parental role, or a feeling of being unsatisfied (Pasley et al., 2002). Anxiety among fathers also increases as pregnancies progress, and comes to a peak 2 months after birth impacting 11.6–14.2% of fathers (Koh et al., 2015). Research has shown that an increased level of anxiety is related to a decrease in paternal competence (Mercer and Ferketich, 1994). With the evolution of a father's role and societal demands, paternal stress has become more of a common experience in fatherhood (Pasley et al., 2002). Examining the experience of fathers' stress is an area that is overlooked in research. Knowing more about a father's experience of anxiety is important in enhancing parenting self-efficacy and achieving a more satisfying and successful transition to fatherhood. It is necessary to analyze paternal stress after childbirth as stress and anxiety are significant risk factors for depression in men (Vismara et al., 2016). On the other hand, anxiety together with stress and depression among fathers can also be interdependent (Vismara et al., 2016). A study conducted by Wee et al. (2015) among fathers during pregnancy found that high levels of anxiety in early pregnancy is related to high levels of depression and stress in late pregnancy.

Men also go through a process of transition to fatherhood and that the postpartum period is especially a vulnerable time for fathers (Koh et al., 2015). The paternal mental states as well as paternal bonding are crucial during pregnancy and after childbirth as they are connected with the developmental outcomes for children (Ramchandani et al., 2013). For example, parents with depression have a tendency to experience an increase in negative emotions and helplessness, which can translate into a lower quality of interactions with the baby (Kim and Swain, 2007). Findings suggested that a stronger paternal bond is associated with better infant outcomes (Ramchandani et al., 2013). For example, Ramchandani et al. (2013) found that disengagement and a poor connection between fathers and their babies as early as the third month of a baby's life, predict early negative behavioral outcomes in children at the age of one. Low paternal engagement is correlated with higher infant mortality and the poorer well – being of children (Geary, 2000). Thus, health-care professionals should appropriately support first-time fathers in the transition to

fatherhood as a better paternal mental state increases the chance for a more satisfying bond with a child.

Parental postpartum bonding has been studied by many researchers focusing on maternal bonding. However, how fathers' bond with their child and what predictors influence this process is only begging to emerge in research. This study aims to contribute to this growing area of research by exploring the experience of paternal bonding with a newborn child. The purpose of this study was to assess psychological (paternal and maternal) and socio-demographic predictors of paternal postpartum bonding. The following research questions were posed:

1. Whether paternal postpartum bonding is associated with fathers' mental health (anxiety and stress)?
2. Whether paternal postpartum bonding is connected with mothers' mental health (maternal depression, stress, and anxiety) and maternal postpartum bonding?
3. Whether paternal postpartum bonding is associated with being a first-time father, a father's presence at childbirth, paternal age, and education level?

Based on the aforementioned research results, it was possible to hypothesize that fathers with a high level of stress and anxiety are more likely to experience problematic paternal postpartum bonding. It could conceivably be hypothesized that the occurrence in mothers of depression symptoms, a high level of anxiety and stress is also associated with fathers' problematic paternal postpartum bonding. Finally, we assumed that a lack of father's presence at childbirth, lack of experience with having a previous child (being a first-time father), older age, and low education level is associated with problematic paternal bonding in the early postpartum period.

MATERIALS AND METHODS

Study Design

This study was designed as a cross-sectional study, which is part of a larger longitudinal study on families after birth (ClinicalTrials.gov ID: NCT04118751). The procedures of this study were approved by the Research Ethics Board at the University of Gdansk (no 7/2019, date of approval: April 29, 2019).

Population

Enrollment was provided by trained assistants in accordance with predetermined eligibility criteria through medical records of females who gave full-term birth (defined as above 37 weeks of gestation) in the Neonatology, Gynecology, and Obstetrics Unit of the University Clinical Center in Gdansk (Poland). Couples (between the age of 18 and 50 years) were recruited for the study after a woman's delivery and were included after providing a written consent form. Our rationale to the cut-off age limit is because age of parents may affect the bond. The advanced age of parents is related to reproductive health (e.g., risk of infertility, fetal anomalies, pregnancy loss, obstetric complications, and stillbirth), while lower paternal age is linked with the adverse mental health outcomes (e.g., depression, substance abuse, and posttraumatic stress disorder) in the perinatal period (Heath et al., 1995; Pennings, 1995; Hodgkinson et al., 2014; SmithBattle and Freed, 2016).

Trial Procedures

In order to identify fathers, the mothers of newborns hospitalized in the postpartum ward were asked first for their willingness to participate in the project. Trained assistants contacted potential mothers within the first 24 h after giving birth in order to provide an oral explanation of the proposed research project and an informed consent form to sign. Assistants were available at the unit to answer question about the project. It was highlighted that enrolment in the study is voluntary and parents could refuse to participate without giving any reason. No participation in the project had bearing on the medical care parents and their child received at the unit. In addition, parents were informed whom to contact in case on further questions.

Data for this study were prospectively collected in the early postpartum period (1–3 days post-partum) from fathers who were asked to complete paper datasets of anonymous questionnaires regarding their subjective level of stress, anxiety, and bonding with their newborns as well as a socio-demographic questionnaire. A relevant hospital policy in Poland is that a mother with her baby stays at the hospital 2–3 days after delivery. During their stay, fathers of newborns are encouraged and welcomed to visit their children. Since the early post-partum period is a high-risk time for parents' mental health outcomes (especially for first-time fathers), we used parental presence in post-delivery wards to gather unique data on paternal outcomes. In order to maintain confidentiality, paper datasets were secure with participant ID retrieved from their medical card. The ID was unrelated to the subjects' identifiers with one exception – the informed consent form; however, the consent forms were stored in a place accessible only to the project manager, separated from the paper datasets.

Measures

Paternal Postpartum Bonding/Maternal Postpartum Bonding

Postpartum Bonding in mothers and fathers was measured with the Postpartum Bonding Questionnaire (PBQ, Brockington et al., 2006b). This is a self-report questionnaire widely used to evaluate the occurrence of disturbances of bonding formation between a parent and child during the postpartum period. It contains 25 items evaluated on a six-point Likert scale (each item scores between 0 and 5). The sum of scores ranges from 0 to 125. Higher scores indicate problematic bonding (Brockington et al., 2001). The questionnaire is divided into four factors:

1. Factor 1: general factor (includes 12 items) with a cut-off score of 11 (higher scores indicate bonding disorder).
2. Factor 2: rejection and pathological anger (includes seven items) with a cut-off score of 16.

3. Factor 3: anxiety about the infant (includes four items) with a cut-off score of 9.
4. Factor 4: incipient abuse (includes two items) with a cut-off score of 2 (Brockington et al., 2001).

Postpartum Bonding Questionnaire was chosen because it is a world-wide instrument translated and validated into different languages, including German (Reck et al., 2006; van Bussel et al., 2010), Spanish (Garcia-Esteve et al., 2016), Chinese (Siu et al., 2010), Japanese (Kaneko and Honjo, 2014; Suetsugu et al., 2015; Ohashi et al., 2016), and Jordan (Thekrallah et al., 2019). The Cronbach α coefficients of reliability were calculated as 0.85 for the German version (Reck et al., 2006), 0.90 for the Spanish (Garcia-Esteve et al., 2016), and 0.720 for Jordanian mothers (Thekrallah et al., 2019). Translation to Polish was done by the investigator (ŁB) according to World Health Organization recommendations,[1] after obtaining approval from the author of the PBQ (private correspondence from May 29, 2018 until November 27, 2018). Since there was no Polish adaptation of the PQB and at the same time there were inconsistent reports on the reliability and validity of factors 3 and 4 (Brockington et al., 2006a; Wittkowski et al., 2007), an exploratory factor analysis (EFA) was used to identify meaningful factors underlying the Polish version of the scale. Conducting EFA, we used principal component analysis with varimax rotation. Reliability was calculated using Cronbach's alpha for all scale's internal consistency. We reported using the score and its 95% CI. The suitability for EFA was examined by Bartlett's test of sphericity, $\chi^2(276) = 1897.27$, $p < 0.001$, and the Kaiser-Meyer-Olkin measure of sampling adequacy (0.71). The number of factors to be retained was guided by Kaiser's criterion (eigenvalues above 1) and consideration for the amount of variance explained by the factor solution, and that two criteria favored the four-factor structure (62% of the total variance explained using 22 items after excluding those with a factor loading less than 0.3). However, the assignment of items to factors turned out to be different compared to the original version of the tool (see Brockington et al., 2006b). **Supplementary Table S1** in the **Supplementary Material** presents EFA standardized factor loadings based on current study data. Since the factor structure of the Polish version of the tool differs from that shown by the authors of the original version, in further analyses, we used only the overall scale score calculated as the sum of all PBQ's items.

Paternal Anxiety/Maternal Anxiety

Level of anxiety in mothers and fathers was measured with the Generalized Anxiety Disorder (GAD) Assessment (GAD-7, Spitzer et al., 2006). This is a self-report scale widely used to evaluate the severity of generalized anxiety. It contains seven items evaluated at a four-point Likert scale. Responders are asked to answer the following question: "Over the last 2 weeks, how often have you been bothered by the following problems?" (not at all, several days, more than half the days, and nearly every day). The sum of scores ranges from 0 to 21 with the following cut-off points: 5 interpreted as mild levels of anxiety, 10 – moderate; and 15 – strong. GAD-7 differentiates GAD from comorbid depression. Evaluation of psychometric properties showed that GAD-7 is a reliable and valid measure to capture anxiety symptoms in the general population (Löwe et al., 2008; Hinz et al., 2017) as well as in psychiatric patients (Johnson et al., 2019). The Cronbach α coefficients of reliability were calculated as 0.92, while intraclass correlation as 0.83 (Spitzer et al., 2006). To our best knowledge, there has been no study undertaken in order to evaluate the psychometric properties of GAD-7 based on Polish cohort; thus, we followed norms proposed by Spitzer et al. (2006).

Paternal Stress/Maternal Stress

Level of stress in mothers and fathers was measured with the Parental Stress Scale (PSS, Berry and Jones, 1995). This is a self-report scale used to measure the stress level experienced by mothers, fathers, stepparents, and foster parents, as well as to measure parenting stress associated with grandparenting (Louie et al., 2017). Items represent positive (e.g., emotional benefits, personal development) and negative (demands on resources, restrictions) themes of parenthood. PSS contains 18 items evaluated at a five-point Likert scale (strongly disagree, disagree, undecided, agree, and strongly agree) with the sum of scores ranges from 18 to 90. Higher scores indicate a higher level of parental stress (Berry and Jones, 1995). The Cronbach α coefficients of reliability were calculated as 0.83 while inter-item correlation as 0.23 (which was in line with authors expectation; the items focus on variety of examples in terms of broad construct; Berry and Jones, 1995). The scale was translated into five languages and used in eight countries (Australia, Canada, China, India, Ireland, Spain, Malaysia, and United States; Louie et al., 2017). To our knowledge, the scale was not used for clinical research in Poland so far. Translation was done into Polish by the investigator (ŁB) according to World Health Organization recommendations.

Maternal Depressive Symptoms

Maternal depressive symptoms were evaluated with the Edinburgh Postpartum Depression Scale (EPDS; Cox et al., 1987; Polish translation: Bielawska-Batorowicz, 1995). This is a self-report scale used worldwide for screening depression in both women and men during antenatal and postnatal periods. The scale indicates how the parent felt during the previous week. EPDS contains 10 items evaluated at a four-point Likert scale (each question scores between 0 and 3) with the sum of scores ranging from 0 to 30. Higher scores indicate more severe depressive symptoms. Research has reported that EPDS is a reliable and valid measure for use with diverse cultural, geographical, and non-English speaking populations (Department of Health, Government of Western Australia, 2006; McBride et al., 2014). For each translated version, another cut-off score is recommended for optimal sensitivity (Department of Health, Government of Western Australia, 2006). Psychometric properties of the Polish version of the EPDS indicate that the Cronbach

[1]World Health Organization (2020). Available at: https://www.who.int/substance_abuse/research_tools/translation/en/ (Accessed June, 1, 2020).

α coefficients of reliability were calculated as 0.91 while intraclass correlation as 0.95 with the scale's sensitivity of 96% and the specificity was 93% for the cut-off of 13/14 (Kossakowska, 2013).

Other Parental Outcomes

The following socio-demographic information were collected from both parents: age, marital status, education level, and work situation; number of children in the household including a newborn participating in this study.

Other Children Outcomes

The following medical items of children were collected from hospital records: child gender (male/female), birth weight (grams), delivery route (vaginal/caesarean), and final APGAR score (APGAR points).

Statistical Methods Plan

Descriptive statistics were characterized by descriptive methods [mean (SD), median (range), *n* (%)]. Data management and analysis were performed using SPSS, version 26. The statistical plan was divided into three phases.

1. Descriptive data were generated for all variables. In the first step, the Pearson product moment correlation coefficient was used to determine the relationship between paternal postpartum bonding and study variables (paternal anxiety, paternal stress, maternal depression symptoms; maternal postpartum bonding, maternal anxiety, maternal stress).
2. To test the mediating model of paternal anxiety on paternal postpartum bonding *via* paternal stress, we used Model 4 of the PROCESS macro for SPSS (Hayes, 2013). Whereas classic mediation (Baron and Kenny, 1986) has the assumption of normality of sampling distribution, this test assumes a nonparametric distribution and relies on the bootstrap procedure. We used 5,000 bootstrap resamples to generate CIs for the indirect effect of paternal anxiety on paternal postpartum bonding *via* paternal stress [effect = 0.40; Bootstrap lower level 95% CI (LLCI) = 0.21; Bootstrap upper level 95% CI (ULCI) = 0.62].
3. The third set of analyses were linked with predicators of paternal postpartum bonding evaluation. A regression analysis was calculated on the whole group of fathers to examine the relationship between paternal postpartum bonding (explained variable) and only those variables, which were significant ($p < 0.01$) in the first phase. In addition, we added the following explanatory variables: fathers' presence at childbirth, fathers' educational level, fathers' age, and fathers' parental experience (being a first-time father).

RESULTS

The Characteristics of Study Group

Individuals were recruited from November 2019 to March 2020. The sample comprised 131 couples with a mean mothers' age of 30.23 years (range 22–45, *SD* = 3.90) and mean fathers' age of 32.37 years (range 22–50, *SD* = 4.59). **Table 1** shows the socio-demographic characteristics of the sample. The large majority of the sample comprised married couples (75%), with the remaining couples living together, but not married (23%); 2% of the interviewed couples did not answer the question about their marital status.

All of the children were delivered on time (mean age in weeks was 39.71, *SD* = 1.16); 53% of children were vaginal delivery and 47% by caesarean section; the mean weight of the children after birth was 3469.51 g (*SD* = 450.29); 92% of children received the maximum number of points on the Apgar scale. In 28% of cases, fathers were present during childbirth. Among the children of the surveyed couples, 66 were girls and 65 boys. For 56% of couples, it was their first child.

TABLE 1 | Socio-demographic characteristics of the study sample.

Demographic variable	Mothers		Fathers	
	n	%	*n*	%
Education level				
Primary/elementary or less	1	0.8	–	–
Secondary school, but not completed	2	1.5	6	4.6
Secondary school graduate	19	14.5	31	23.7
University/college, but not completed	5	3.8	11	8.4
University degree (Bachelor or equivalent)	22	16.8	22	16.8
University degree (Master or equivalent)	76	58.0	58	44.3
University degree (PhD or equivalent)	3	2.3	3	2.3
Missing	3	2.3	–	–
Work situation				
Full-time employed	93	71.0	91	69.5
Part-time employed	7	5.3	1	0.8
Self-employed	8	6.1	31	23.7
Student full-time	1	0.8	–	–
Student part-time	2	1.5	–	–
Stay-at-home parent	10	7.6	1	0.8
Unemployed and seeking work	3	2.3	1	0.8
Missing	7	5.4	6	4.6

Correlation Between Paternal Bonding and Study Variables

Table 2 reports the means, SDs, Pearson's zero-order intercorrelations, and reliabilities (on the diagonal) of the variables under study. The average intensity of postpartum bonding was measured in the group of fathers and mothers. Both mothers and fathers did not experience problematic postpartum bonding. It can be seen from the data in **Table 2**, the average level of paternal postpartum bonding is 6.63 points (range 0–33; *SD* = 6.68), while the average level of maternal postpartum bonding is 7.95 (range 0–30; *SD* = 6.64). The difference of means is statistically significant ($t = -2.39$, $p = 0.02$, Cohen's $d = 0.20$), however, both mean results do not exceed the norm. Fathers experienced moderate anxiety (*M* = 10.51; *SD* = 3.87) and relatively low level of stress (*M* = 30.79; *SD* = 9.16). Mothers did not experience depression symptoms (*M* = 6.61; *SD* = 4.04), but they experienced moderate anxiety (*M* = 11.85; *SD* = 4.21) and a mild stress (*M* = 32.55; *SD* = 8.42).

As presented in **Table 2**, paternal postpartum bonding was positively related to paternal anxiety (moderate strength) and maternal stress (strong correlation). Furthermore, paternal postpartum bonding was significantly positively correlated with maternal postpartum bonding and maternal stress but there were no significant correlations between paternal postpartum bonding and maternal depression symptoms and maternal anxiety.

Mediating Model of Paternal Anxiety on Paternal Postpartum Bonding *via* Paternal Stress

The rationale to create a mediating model of paternal anxiety on paternal postpartum bonding *via* paternal stress was due to findings from previous studies (e.g., Nima et al., 2013), which showed that in general stress partially mediated the effects of anxiety upon depression. Thus, we expected that parental stress could play a similar role in the relationship between parental anxiety and experiencing problematic postpartum bonding. We found that paternal stress mediates the relationship between paternal anxiety on paternal postpartum bonding. The tested model (**Figure 1**) proved that the path from paternal anxiety to paternal postpartum bonding (taking into account paternal stress in the model) is statistically insignificant. As we expected, paternal anxiety strengthens paternal stress ($b = 0.98$). Further, a high level of paternal stress disrupts paternal postpartum bonding ($b = 0.41$).

Predictors of Paternal Postpartum Bonding

We have not included maternal depression symptoms and anxiety in regression analysis due to a lack of significant correlations with paternal postpartum bonding as demonstrated in the earlier phase of the analysis (**Table 2**). In addition, due to the fact that the relationship of paternal anxiety with paternal postpartum bonding is mediated by paternal stress, paternal anxiety was also excluded from the model.

The results, as shown in **Table 3**, indicate that maternal infant bonding and paternal stress are the only predictors of parental postpartum bonding across all included variables. Maternal stress is not significantly associated with paternal postpartum bonding. Moreover, the regression analysis indicated that there was no association between paternal postpartum bonding and socio-demographic factors, such as a lack of father's presence at childbirth, being a first-time father, older age, and lower education level (**Table 3**).

DISCUSSION

Returning to the research questions posed at the beginning of this study, it is now possible to state that paternal postpartum bonding was positively related to paternal anxiety, maternal postpartum bonding, and maternal stress as expected. In addition, paternal anxiety strengthens paternal stress, and paternal stress mediates the relationship between paternal anxiety and paternal postpartum bonding. Contrary to expectations, this study did not find a significant correlation between postpartum bonding with maternal depression symptoms and maternal anxiety. Surprisingly, none of investigated socio-demographic variables were associated with paternal postpartum bonding. Clinically, the most relevant finding was that maternal infant bonding and paternal stress are the only predictors of parental postpartum bonding across all included variables.

With respect to the first research question, the results have shown that there is a significant positive relationship between a paternal postpartum bonding and fathers' mental health. As expected, fathers with a high level of stress and moderate

TABLE 2 | Means, SDs, and zero-order correlations among study variables.

S.no	Variable	*N*	*M*	*SD*	Range	1	2	3	4	5	6	7
1	Paternal postpartum bonding	131	6.63	6.68	0–33	(0.84)						
2	Paternal anxiety	131	10.51	3.87	6–28	0.34**	(0.88)					
3	Paternal stress	131	30.79	9.16	17–65	0.60**	0.41**	(0.88)				
4	Maternal depression symptoms	126	6.61	4.04	0–22	0.07	0.04	0.08	(0.80)			
5	Maternal postpartum bonding	129	7.95	6.64	0–30	0.45**	0.01	0.23**	0.39**	(0.80)		
6	Maternal anxiety	120	11.85	4.21	1–29	0.13	0.16	0.27**	0.70**	0.28**	(0.85)	
7	Maternal stress	125	32.55	8.42	18–57	0.30**	0.09	0.28**	0.34**	0.59**	0.33**	(0.83)

**$p < 0.01$, two-tailed.

Alpha coefficients are given in brackets on the diagonal.

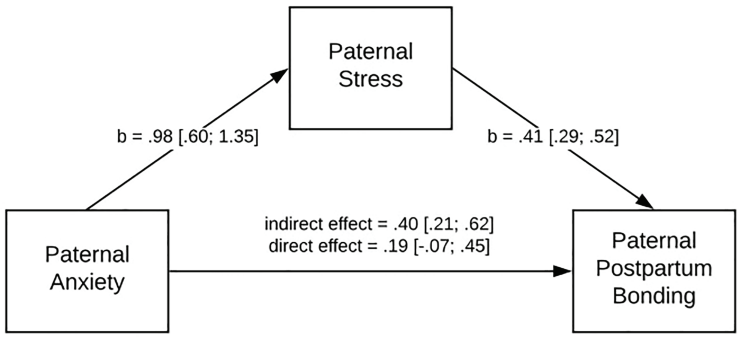

FIGURE 1 | Mediating model of paternal anxiety on paternal postpartum bonding *via* paternal stress.

TABLE 3 | Results of regression analyses for Paternal Postpartum Bonding.

Predictor	*b*	*SE*	*p*	LLCI	ULCI
Fathers' presence at childbirth	0.06	0.59	0.91	−1.18	1.23
Fathers' educational level	0.58	0.33	0.08	−0.12	1.64
Fathers' age	0.08	0.10	0.43	−0.12	0.27
Fathers' parental experience	−0.12	0.96	0.90	−2.01	1.98
Paternal Stress	0.36	0.08	< 0.01	0.22	0.52
Maternal postpartum bonding	0.32	0.10	< 0.01	0.13	0.51
Maternal stress	−0.03	0.07	0.68	−0.16	0.11

b, unstandardized coefficient; SE, standard error; p, significant; LLCI, lower level 95% CI; and ULCI, upper level 95% CI.

anxiety are more likely to experience problematic paternal postpartum bonding. Our results are consistent with other studies, where stress was negatively associated with the parental bonding process (Epifanio et al., 2015; McNamara et al., 2019) and anxiety as a risk factor for a problematic parent – child relationship and subsequently child development (Kim and Swain, 2007). In addition, some of other studies demonstrated that anxiety among fathers is also a risk factor for paternal depression (Matthey et al., 2003). However, in our study, paternal depression was beyond the scope of this project. The level of anxiety did not differ substantially – despite the demonstrated statistical significance – in mothers and fathers under this investigation. However, other research has showed that in comparison with mothers, fathers tend to have lower levels of anxiety in postpartum period (Matthey et al., 2003; Candelori et al., 2015). Nevertheless, at 3 months postpartum, paternal levels of anxiety were on a similar level as maternal anxiety (Figueiredo and Conde, 2011; Koh et al., 2015). Further in the results analysis, we conducted the mediation model, in which we examined the relationship between paternal stress, anxiety, and parental postpartum bonding. We found that paternal stress mediates the relationship between paternal anxiety and paternal postpartum bonding. In our study, the level of anxiety experienced by fathers strengthens the experience of stress, and a high level of paternal stress amplifies problematic paternal bonding with a newborn baby. This result is in line with the results obtained by Wee et al. (2015). In their study on expecting fathers, high levels of anxiety in early pregnancy among fathers were associated with high levels of paternal stress and depression.

This study set out with the second aim of assessing whether paternal postpartum bonding is connected with mothers' outcomes as mental health (stress, anxiety, and depression) and maternal postpartum bonding. The current study found that paternal postpartum bonding was significantly positively correlated with maternal postpartum bonding and maternal stress as hypothesized. It is well documented that the paternal and maternal mental states are associated with each other (Dudley et al., 2001). This issue is pivotal because when both parents experience mental health difficulties, a baby's development may be severely disrupted (Paulson et al., 2006). Further, we conducted the regression analysis, which indicated that maternal postpartum bonding and paternal stress are the only predictors of paternal postpartum bonding. In terms of these outcomes, our results are in line with other research (e.g., Epifanio et al., 2015). This differs from the findings presented by e.g., Nishigori et al. (2020), who proved that father-to-infant bonding failure was associated with maternal-to-infant bonding failure, maternal distress during pregnancy, and a father's depressive symptoms during the postpartum period. In contrast to earlier findings, however, no significant correlation between paternal postpartum bonding and maternal depressive symptoms or anxiety was observed in our study, which means that paternal postpartum bonding did not correspond with depression or anxiety experienced by mothers. This result may be explained by the fact that mothers included in this project did not experience depression symptoms in postnatal period (they received scores below the cut-off points of 13 in EPDS indicating depressive symptoms). Current results are likely to also be related to a newborn's condition directly after delivery (92% of them received 10 points on Apgar scale with the birth normal weight above 2.5 kg). All babies were born between 38 and 41 weeks of gestation; and what is commonly known mothers of premature birth are linked to worse mental health (Cook et al., 2018; de Paula Eduardo et al., 2019). What is interesting is that included mothers experienced moderate anxiety, which was not connected with parental postpartum bonding. A possible explanation for this might be that there is overlap between stress and anxiety, and they affect each other.

The present study also determined whether paternal postpartum bonding is associated with socio-demographic variables. Contrary to expectations, we found that a lack father's attendance during childbirth, lack of experience with having previous child (being a first-time father), older age, and low education level were not significantly associated with paternal postpartum bonding. The findings of the current study do not support the previous research. A study conducted by Aslan et al. (2017) reported that the paternal education level and occupation were significantly related to a father's involvement in taking care of the child. Fathers with university level education had a higher engagement in child – rearing above expected values. Although, these results differ from this data, they are consistent with others. In the same study, a father's age, economic status, duration of marriage, number of children, attending at childbirth, or education were not correlated with participation in infant care (Aslan et al., 2017).

Implication for Clinical Practice

The study results have important clinical implications by raising the significance for pre-screening paternal and maternal mental health in the early post-partum period to provide additional support for risk groups. This study adds to the growing body of literature showing that the early postpartum period is a vulnerable time for men. Our results have shown that fathers of a healthy newborn from full-term pregnancies are also an at-risk group of higher-level anxiety. Paternal anxiety and maternal postpartum bonding are predictors toward a problematic paternal–infant bonding. While it is essential for mothers and their babies to have a good relationship, it is also important for fathers. Growing a deep and positive paternal connection with their infants form the very beginning is important due to due to long-lasting impact of bonding on child's psychosocial and developmental outcomes. The quality of the paternal involvement in child – bearing is crucial for a child's cognitive, emotional, and social development during the first years and likely beyond (Ramchandani et al., 2005). What is more, studies examining paternal infant bonding found that fathers who are given more opportunities to engage in taking care of the baby can become just as nurturing parents as mothers (Kim and Swain, 2007). Thus, in research, more focus on fathers' experiences during the antenatal and postpartum periods is needed to expand the knowledge about paternal – infant bonding and also risk factors that may cause disturbances in the bonding process. Hospital policy should pay more attention to fathers of newborns and encouraged them to engage in taking care of children. Paternal care is crucial for successful transition to fatherhood and increases self-efficiently in taking up a satisfactory parental role. Health care professional should support fathers as better parental outcomes positively impact paternal infant bonding during the first days of fatherhood. Specific interventions aimed at the promotion of early paternal postpartum bonding are needed.

Implication for Further Research

This research has thrown up many questions that need further investigation. It would be interesting to assess the trajectory of bonding over time, because studies reported that adjustment to fatherhood was connected to various variables at different times in the perinatal and postnatal periods (Matthey et al., 2000). Thus, a prospective cohort study with a longitudinal study design would be valuable. In addition, more research is required to determine how paternal/maternal mental health and socio-demographic factors affect paternal bonding is a cross-national study.

Limitation

The reader should bear in mind the limitations of this study to make appropriate interpretation of the study results. The generalization of this data is problematic because the study was conducted in one unit including a small sample size. This study is unable to encompass the entire issue due to the fact that statistical analysis applies to fathers of newborns from single pregnancies, healthy babies born full-time with normal birth weight. It is important to acknowledge that using self-reports increases the risk of bias in comparison with clinically observed outcomes with unblinded designs. However, due to a nature of undertaken subject, cross-sectional study seems to be the most efficient and sensitive aspect of data collection. The results of the study should be interpreted with caution because the measurement tools (PBQ and PSS questionnaires) may require further validation studies.

Conclusion

This study has identified that paternal postpartum bonding was positively related to paternal anxiety and maternal stress, maternal postpartum bonding, and maternal stress. The second major finding was that maternal infant bonding and paternal stress are the only predictors of parental postpartum bonding across all included variables. The current findings add to a growing body of literature on paternal postpartum bonding. The key strength of this study was targeting fathers who belong to an untested group in this topic. While it is essential for mothers and their babies to have a good relationship, it is also important for fathers to grow a deep connection with their babies form the very beginnings, due to long-lasting impact of bonding on child's psychosocial and mental development (Ramchandani et al., 2005). The results highlight the need for interventions concentrating on paternal postpartum bonding and parental mental health in order to help fathers grow a positive bond with their child.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Research Ethics Board at the University of

Gdansk (no 7/2019, date of approval: April 29, 2019). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

ŁB, MB, and KL: conceptualization. PJ: formal analysis. ŁB and MB: investigation, project administration, and supervision. PJ, ŁB, MB, and KL: methodology. ŁB, KL, and PJ: writing – original draft preparation. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.628650/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 28 May 2021
doi: 10.3389/fpsyg.2021.672174

Parent and Peer Attachments in Adolescence and Paternal Postpartum Mental Health: Findings From the ATP Generation 3 Study

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OPEN ACCESS

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *25 February 2021*
Accepted: *30 April 2021*
Published: *28 May 2021*

Citation:
Macdonald JA, Greenwood CJ, Letcher P, Spry EA, Mansour K, McIntosh JE, Thomson KC, Deane C, Biden EJ, Edwards B, Hutchinson D, Cleary J, Toumbourou JW, Sanson AV and Olsson CA (2021) Parent and Peer Attachments in Adolescence and Paternal Postpartum Mental Health: Findings From the ATP Generation 3 Study. Front. Psychol. 12:672174. doi: 10.3389/fpsyg.2021.672174

Background: When adolescent boys experience close, secure relationships with their parents and peers, the implications are potentially far reaching, including lower levels of mental health problems in adolescence and young adulthood. Here we use rare prospective intergenerational data to extend our understanding of the impact of adolescent attachments on subsequent postpartum mental health problems in early fatherhood.

Methods: At age 17–18 years, we used an abbreviated Inventory of Parent and Peer Attachment to assess trust, communication, and alienation reported by 270 male participants in their relationships with mothers, fathers, and peers. More than a decade later, we assessed the adult males, now fathers, at 12 months postpartum ($N = 409$ infant offspring) for symptoms of depression, anxiety, and stress. Logistic regression was used to examine the extent to which attachment dimensions predicted paternal postpartum mental health, adjusting for potential confounding, and with assessment for interactions between parent and peer attachments.

Results: Trust in mothers and peers, and good communication with fathers during adolescence, were associated with 5 to 7 percentage point reductions in postpartum mental health symptoms in early fatherhood. Weak evidence of parent-peer interactions suggested secure attachments with either parent or peer may compensate for an insecure attachment with the other.

Conclusions: Our results suggest that fostering trust and communication in relationships that adolescent boys have with parents and peers may have substantial effects on rates of paternal postpartum mental health problems. The protective benefits may be preventative in intergenerational cycles of risk for mental health problems.

Keywords: father, mental health, parents, peers, relationship, postpartum, longitudinal, cohort studies

INTRODUCTION

Symptoms of common mental health problems (depression and anxiety) are reported by ∼10 per cent of fathers of infant children (Giallo et al., 2013; Cameron et al., 2016; Leach et al., 2016; Glasser and Lerner-Geva, 2019). Public health ramifications extend to partners, usually mothers, with reduced levels of postnatal support (Pilkington et al., 2015), and heightened probability of their own mental health problems (Paulson et al., 2010, 2016). Intergenerationally, children of depressed or anxious fathers are also at greater risk of behavioural, social, and emotional problems (Gentile and Fusco, 2017). Compared to mothers, fewer health services screen and treat paternal postpartum mental health problems and considerable barriers exist to paternal support at levels of both the individual (e.g., masculine stoicism; Mansfield et al., 2003; Oliffe and Phillips, 2008) and the health system (e.g., maternal-centric culture; Panter-Brick et al., 2014). In this context, there is a critical need to identify targets for prevention of postpartum mental health problems in fathers. Understanding factors in the developmental history of postpartum mental health problems can also guide treatment options and improve outcomes (Goodman and Dimidjian, 2012).

Emerging evidence from prospective longitudinal cohort studies points to the origins of paternal mental health problems typically existing prior to offspring conception (Thomson et al., 2020). In one sample of expectant fathers with partners in the third trimester of pregnancy ($N = 295$ pregnancies to 214 men), 68% prospectively reported a preconception history of common mental health disorders (Spry et al., 2018). Further, Thomson et al. (2020) reported that 83% of fathers who exhibited depressive symptoms at 12 months postpartum had a history of preconception mental health problems in adolescence and young adulthood. These studies indicate pathways of homotypic continuity in men's symptoms of mental health problems and suggest that prevention efforts should be focused on risk mitigation prior to offspring conception.

However, there is a lack of prospective research examining the preconception contexts associated with paternal postpartum mental health problems. Given that histories of mental illness are not always apparent in those with postpartum mental health problems (Patton et al., 2015; Thomson et al., 2020), and where they do exist, that a prior history does not fully account for the variance in postpartum symptoms, there is a need to extend investigations into other formative developmental domains. One of the most aetiologically relevant of these is the interpersonal domain. In particular, attachment theory, and evidence from retrospective studies, suggest that secure relationships with parents and peers prior to adulthood forge protective foundations that buffer against postpartum mental health risk (Allen and Miga, 2010). Conversely, insecure preconception parent and peer relationships are likely implicated in subsequent postpartum psychological risk (Lee and Hankin, 2009; Mikulincer and Shaver, 2012; McDougall and Vaillancourt, 2015).

In adolescence and young adulthood, the measurement of parent and peer attachment relationships commonly include the dimensions of mutual trust (i.e., mutual understanding in the relationship), quality of communication (i.e., perceptions that others are sensitive and responsive to emotional needs and disclosures), and degree of anger and alienation (i.e., a sense of isolation and detachment) (Gorrese and Ruggieri, 2012). These are captured in the Inventory of Parent and Peer Attachment (IPPA; Armsden and Greenberg, 1987), a self-report measure of the young person's relationships with their mother, father, and peers. The dimensions align to core features of 'internal working models' of attachment that indicate the availability of others in times of need. The evidence from cross-sectional and longitudinal studies with outcomes in adolescence or young adulthood (i.e., prior to next-generation conception), is that trust, communication, and alienation with parents and peers are associated with depression and anxiety (Agerup et al., 2015; Gorrese, 2016). Longitudinal studies with preconception assessments are yet to examine whether these associations extend into the postnatal period when there is potential for intergenerational effects on family functioning and child development. Moreover, this line of enquiry is yet to cast a lens on fathers.

The lack of research on fathers is not surprising given a dominant focus on developmental pathways to parenthood in women, for whom parental caregiving roles are typically socialised in deeply embedded, gender-based interactions (Wood and Eagly, 2012; Eagly and Wood, 2016). In general, there is considerably less developmental preparation of males for fatherhood (Baldwin et al., 2018). Men without children often report being uncertain about what future fatherhood is likely to entail in terms of both pragmatic functions and emotional adjustment (Kings et al., 2017). Men with children often report having entered fatherhood lacking critical insights into their partner's and children's needs and into the extent of psychological upheaval that the new role would entail (Darwin et al., 2017; Baldwin et al., 2018). They also report limited acknowledgement and a lack of support from clinical and community support services (Baldwin et al., 2018, 2019) often being told that, in the postpartum period, their needs are comparatively unimportant (Baldwin et al., 2018; Pfitzner et al., 2018). This results in men's minimisation of symptoms and diversion of attention away from their own psychological vulnerability (Darwin et al., 2017; Burgess and Goldman, 2018). The vastly different gender-based, developmental and postpartum experiences related to preparation for and engagement in parenting may manifest in distinct pathways of risk for postpartum mental health vulnerability.

In one retrospective study with assessments taken postpartum, psychologically distressed fathers, compared to non-distressed fathers, reported lower care and higher overprotection (psychological control) from their own fathers and mothers up to age 16 years (Boyce et al., 2007). Retrospective postpartum assessments may be subject to recollection biases and may be particularly influenced by current psychological distress (Bryant et al., 1989; Amato, 1991; Pless and Pless, 1995). To our knowledge there is no prospective evidence of these relationships as assessed with the IPPA, although multi-generational, longitudinal studies do provide evidence that related constructs such as neglect and harsh parenting experienced during

childhood and adolescence are linked to subsequent risk for mental health problems when parenting the next generation (Greene et al., 2020; Neppl et al., 2020).

Also lacking are prospective studies of how preconception affiliative relations (i.e., friendships with peers) may increase risk or protection for mental health during the postpartum period. Positive relationships with peers prior to transitioning into parenthood indicate normative psychological adjustment (Laible et al., 2000, 2004; Laible, 2007). Wilkinson (2004) contends that peer attachments inform the evaluation of the self and the construction of identity, which when deficient heighten risk for mental health problems. In new parents, a history of close and available relationships with peers may signal positive identity development and the availability of a broader protective network for support during major life events and transitions such as early parenthood (Bäckström et al., 2020).

It is also possible that the qualities of parent and peer relationships may interact to influence subsequent mental health and well-being. One hypothesis suggests that peer relationships represent an extension of family attachments whereby internal working models of parent availability and sensitivity inform representations of others, including peers (Bowlby, 1969). Gorrese and Ruggieri (2012) found supporting evidence for this but noted patterns of trust, communication and alienation in peer relationships were more similar to mother than father relationships. They argued this was potentially because mothers were more likely to be the primary attachment figure (Gorrese and Ruggieri, 2012). An alternative model suggests that qualities of either peer or parent relationships in adolescence may compensate for unmet needs (Wilkinson, 2004) or fulfil new developmental needs, particularly approaching the transition to adulthood (Buist et al., 2002; Arnett, 2004). How parent and peer relationships interact may inform subsequent risk for mental health problems across the transition to fatherhood; however, this has yet to be investigated. The qualities of each may compound or create a buffer against the influence of the other on future psychological risk.

The aim of this paper is to gain insights into preconception predictors of risk for paternal postpartum mental health problems that may represent prevention targets or inform treatment approaches. We draw on rare longitudinal data of males spanning late adolescence to 1 year after the birth of their offspring. We assess communication, trust and alienation in relationships with mothers, fathers and peers (at 17–18 years) and examine associations with mental health symptoms of depression, anxiety, and stress that are assessed more than a decade later, at 1 year postpartum. We further examine the inter-relationships between parent and peer histories on postpartum mental health to understand if a deficit in one might be counteracted by the protective nature of the other or whether there are compounding effects of poor relationships with both.

METHODS

Participants

Participants were from the Australian Temperament Project (ATP), a 16-wave longitudinal study tracking the psychosocial development of young people from infancy to adulthood. The baseline sample consisted of 2,443 infants aged between 4 and 8 months (Generation 2; G2) and their parents (Generation 1; G1), recruited in 1983 from urban and rural areas and representative of the state of Victoria, Australia. Subsequently, families have been invited to participate via mail surveys approximately every 2 years until 19–20 years and every 4 years thereafter (Vassallo and Sanson, 2013).

The ongoing, prospective ATP Generation 3 (G3) study commenced when G2 participants were aged 29–35 years, with recruitment of G3 infant offspring. Identification of pregnancies occurred via participant email or phone every 6 months between 2012 and 2018. Telephone or web-based surveys were conducted with parents at the third trimester of pregnancy, and at 2 months and 1 year postpartum. The present study used data collected from G2 cohort participants at the 1 year postpartum interview for each of their G3 children. To be included in the current study, G2 participants needed to have provided data at 17–18 years on relationships with G1 parents and peers or at 1 year postpartum on their own mental health symptoms. The resulting sample size was 270 G2 fathers with 409 G3 children.

ATP Generation 3 Study protocols have been approved by the Royal Children's Hospital Human Research Ethics Committee. Prior ATP wave study protocols were variously approved by human research ethics committees at the University of Melbourne, the Australian Institute of Family Studies and/or the Royal Children's Hospital, Melbourne.

Measures

Mental Health Outcomes

G2 participants completed the short-form Depression Anxiety and Stress Scale (DASS-21) (Lovibond and Lovibond, 1995; Antony et al., 1998) at 1 year postpartum, which measured symptoms of depression (7-items, [$\alpha = 0.83$], e.g., "couldn't seem to experience any positive feeling at all"), anxiety (7-items, [$\alpha = 0.71$], e.g., "I was aware of dryness in my mouth"), and stress (7-items, [$\alpha = 0.84$], e.g., "I found it hard to wind down"). Responses to all items were given on a 4-point scale with 1 = "not at all," 2 = "to some degree, or some of the time," 3 = "to a considerable degree, or a good part of the time," and 4 = "very much, or most of the time." Mean scores were calculated so that high scores represented increased symptoms. Given the low prevalence of elevated mental health symptoms, thresholds of $\geq$5, $\geq$4, and $\geq$8 were used to identify mild to severe symptoms of depression, anxiety, and stress, respectively (Lovibond and Lovibond, 1995).

Relationship Exposures

G2 participants completed a brief, self-reported version of the Inventory of Parent and Peer Attachment (Armsden and Greenberg, 1987) at 17–18 years, which measured degree of mutual trust (5-items parents, [$\alpha_{mother} = 0.81$, $\alpha_{father} = 0.85$, $\alpha_{peer} = 0.80$], 4-items peers, e.g., "Respect my feelings"), quality of communication (4-items parents/peers, [$\alpha_{mother} = 0.82$, $\alpha_{father} = 0.83$, $\alpha_{peer} = 0.84$], e.g., "I tell him/her/them about my problems and troubles"), and degree of alienation (3-items parents, [$\alpha_{mother} = 0.63$, $\alpha_{father} = 0.66$, $\alpha_{peer} = 0.65$], 4-items peers, e.g., "I get upset more than she/he/they know(s)

about"). Questions were answered about the relationships each with the participant's mother and father (step-parent if deemed as most important by the participant), and the participant's peers. Responses to all items were given on a 4-point scale with 1 = "almost always/always," 2 = "often," 3 = "seldom," and 4 = "never/almost never." Mean scores were calculated so that high scores represented higher levels on each respective dimension of trust, communication, and alienation. Validity of IPPA short forms has been demonstrated in prior studies (Laible et al., 2000, 2004; Buist et al., 2008).

Potential Confounding Factors

Potential confounders were selected up to the time of exposure and included G1 parent family background characteristics of country of birth (either parent not born in Australia), separation/divorce (experienced separation or divorce) and low parental education (< year 12) up until the end of G2 adolescence (ages 0–18 years). We also included G2 participant anti-social behaviour (2 behaviours at least once or 1 behaviour more frequently) across ages 13–18 years (Edwards et al., 2019), and G2 endorsement of elevated depression or anxiety symptoms prior to age 17–18 years.

Statistical Analysis

All analyses were conducted in Stata v15 (StataCorp, 2017). Generalised estimating equations (GEEs) with an exchangeable working correlation structure (to account for within family clustering) were used to estimate a series of logistic regression analyses examining associations between adolescent relationship quality and elevated mental health at 1 year postpartum. Elevated mental health was treated as a multivariate outcome (i.e., depression, anxiety, and stress outcomes analysed simultaneously). First, elevated mental health was regressed onto each relationship quality exposure separately. Analyses were then repeated by including an interaction between relationship quality exposure and a variable denoting the type of mental health outcome (e.g., depression, anxiety, or stress) to determine if associations were similar across all outcome types. Second, elevated mental health was regressed onto all three relationship quality exposures for each relationship source (i.e., mother, father, peer). Finally, the mother and father models were repeated by including an interaction term between each parent and peer relationship quality (e.g., mother trust X peer trust; father communication X peer communication). All models were adjusted for potential confounding factors.

Multiple imputation was used to handle missing data in the inferential analyses. Twenty complete datasets were imputed, based on a multivariate normal model (Lee and Carlin, 2010). Binary variables were imputed as continuous variables and then back transformed with adaptive rounding following imputation (Bernaards et al., 2007). Estimates were obtained by pooling results across the 20 imputed datasets using Rubin's rules (Rubin, 1987).

RESULTS

To assess bias due to attrition, we compared G2 male participants screened for G3 study eligibility to all G2 male participants on baseline characteristics (G1 education, G1 country of birth, G2 difficult temperament, and G2 behaviour problems) measured at commencement of the ATP in 1983 (G2 age 4–8 months old). We found evidence for some selective loss of participants whose G1 parents were not born in Australia and had lower levels of education, specifically with highest achievement being high school completion or below. Those who participated in the G3 study were broadly representative of those eligible to participate on baseline characteristics.

Descriptives

Descriptives for all analytic variables are presented in **Table 1**.

Postpartum Mental Health and Associations With Parent and Peer Relationships

Results from the GEE analyses, in which elevated 1 year postpartum mental health problems (depression, anxiety, and stress) were regressed onto late adolescent relationship exposures, are presented in **Table 2**. After adjustment for potential confounding factors, the strongest associations were observed for father communication and both mother and peer trust (OR range 0.60–0.62). There was no evidence that relationship quality associations differed across mental health outcome type (depression, anxiety, and stress).

Each relationship type (with mother, father, peer) was then examined by simultaneously adjusting for all relationship qualities. To help quantify these associations, the estimated prevalence of elevated symptoms of mental health problems are presented at low (−1 SD) and high (+1 SD) levels of relationship quality. For G2 relationships with G1 mothers, increases in trust (OR = 0.55; 95% CI = 0.38, 0.79) were associated with a decrease in the odds of elevated mental health problems (low trust = 10%, high trust = 3%). For G2 relationships with G1 fathers, increases in communication (OR = 0.62; 95% CI = 0.40, 0.98) were associated with a decrease in the odds of elevated mental health problems (low communication = 9%, high communication = 4%). For relationships with peers, increases in trust (OR = 0.66; 95% CI = 0.44, 0.99) were associated with a decrease in the odds of elevated mental health problems (low trust = 9%, high trust = 4%).

The analyses did not provide evidence for interactions between parent (mother or father) and peer trust (mother $p = 0.344$, father $p = 0.453$), and evidence of interactions was weak for both communication (mother $p = 0.138$, father $p = 0.057$), and alienation (mother $p = 0.078$, father $p = 0.146$). **Figure 1** is a visual representation of the interactions presenting estimated percentages of people with elevated symptoms of mental health problems by levels of each of the parent and peer relationship factors. In these analyses, three patterns were apparent. The most prominent was the presence of elevated symptoms of mental health problems when levels of trust, communication, and alienation were problematic in relationships with both

TABLE 1 | Descriptive statistics for outcome, exposure, and potential confounding factors in the unimputed data ($n = 270$ men with 409 children).

	n (cases)	%	95% CI	% missing
Mental Health Symptoms[a]				
Depression	26	9%	(6, 12%)	27%
Anxiety	16	5%	(3, 9%)	27%
Stress	20	7%	(4, 10%)	29%
	m	**SD**	**95% CI**	**% missing**
Mother Relationships[b]				
Trust	3.41	0.47	(3.35, 3.47)	19%
Communication	2.85	0.61	(2.77, 2.93)	19%
Alienation	1.98	0.58	(1.90, 2.06)	20%
Father Relationships[b]				
Trust	3.27	0.53	(3.20, 3.34)	19%
Communication	2.42	0.64	(2.34, 2.51)	19%
Alienation	2.12	0.60	(2.04, 2.20)	21%
Peer Relationships[b]				
Trust	2.98	0.30	(2.94, 3.02)	18%
Communication	2.61	0.61	(2.53, 2.69)	18%
Alienation	1.75	0.46	(1.69, 1.81)	18%
	***n* (cases)**	**%**	**95% CI**	**% missing**
Potential confounding factors[b]				
G1 separation	47	18%	(14, 23%)	2%
G1 non-Australian country of birth	77	30%	(25, 36%)	4%
G1 low education	53	20%	(15, 25%)	0%
G2 mental health problems	48	20%	(15, 25%)	11%
G2 delinquency	138	55%	(49, 62%)	8%

[a]*Assessed in G2 participants at 1-year postpartum for each G3 child,* [b]*Assessed in G2 participants at 17–18 years.*

parents and peers. The second contrasting pattern was apparent for communication and alienation whereby having extremely positive relationships with both parents and peers, was associated with elevated symptoms of mental health problems. The third pattern, also for communication and alienation, suggests that the prevalence of mental health problems was lowest when levels were discrepant between parent and peers (i.e., high for parents and low for peers or vice versa).

DISCUSSION

Findings from this study address a key gap in knowledge about preconception determinants of father postpartum mental health problems. We found that characteristics of adolescent male relationships with mothers, fathers, and peers were associated with subsequent risk for mental health problems once young men became fathers. Specifically, trusting adolescent relationships with mothers and peers, and good communication with fathers, were all associated with reduced risk for mental health problems in early fatherhood, more than a decade later. The associations were similar across depression, anxiety, and stress outcomes. There was additionally some weak evidence of interactions between parent and peer communication and alienation. The prevalence of elevated mental health symptoms was highest when relationships were poor with both parents and peers suggesting possible compounding effects of risk, but lowest when the relationship was poor with either parent or peer but positive with the other, suggesting possible compensatory effects.

Trust is a core feature of secure attachments across the life course and a particularly key factor in an emerging "self-concept," or sense of identity, across the transition from adolescence to adulthood (Smetana, 2010; O'Connor et al., 2011). We found that in the mother-son relationship, diminished trust during adolescence was the most important of the three IPPA subscales in predicting later mental health problems during early fatherhood. In our fully adjusted analyses, 10% of males who experienced low levels of maternal trust in late adolescence were at risk for subsequent postpartum mental health problems, compared to 4% of males who experienced high maternal trust. In the attachment framework, a pattern of trust in early caregiving relationships creates an internalised "secure base" from which the dependent child attains confidence to explore and develop, particularly under challenging circumstances (Cassidy, 2008).

The IPPA trust scale incorporates questions about mutual feelings of acceptance, respect, and trust in judgement. Developmentally, as with secure attachment classifications, these indicators may signal the experience of parental support for autonomy in late adolescence, and a confidence in the young person's readiness to transition to adulthood (Allen and Miga,

TABLE 2 | Regression models predicting elevated mental health symptoms (depression, anxiety, and stress).

	Separate models			Simultaneously adjusted models		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
G1 Mother						
Trust	0.60	(0.44, 0.82)	0.002	0.55	(0.38, 0.79)	0.001
Communication	0.72	(0.49, 1.06)	0.095	0.89	(0.56, 1.39)	0.596
Alienation	1.12	(0.75, 1.66)	0.585	0.73	(0.47, 1.15)	0.172
G1 Father						
Trust	0.72	(0.49, 1.05)	0.091	0.84	(0.53, 1.34)	0.465
Communication	0.60	(0.41, 0.88)	0.010	0.62	(0.40, 0.98)	0.039
Alienation	1.22	(0.80, 1.87)	0.358	0.88	(0.55, 1.43)	0.614
Peer						
Trust	0.62	(0.44, 0.88)	0.008	0.66	(0.44, 0.99)	0.044
Communication	0.71	(0.50, 1.02)	0.061	0.87	(0.59, 1.27)	0.464
Alienation	1.25	(0.84, 1.85)	0.272	1.00	(0.66, 1.53)	0.994

Separate models (k = 9) assess associations between attachment construct for each source relationship individually. Simultaneously Adjusted models (k = 3) include all 3 attachment constructs for each source relationship in each regression. Both models adjusted for G1 country of birth, separation/divorce, and education; G2 anti-social behaviour, and elevated depression or anxiety symptoms during adolescence.

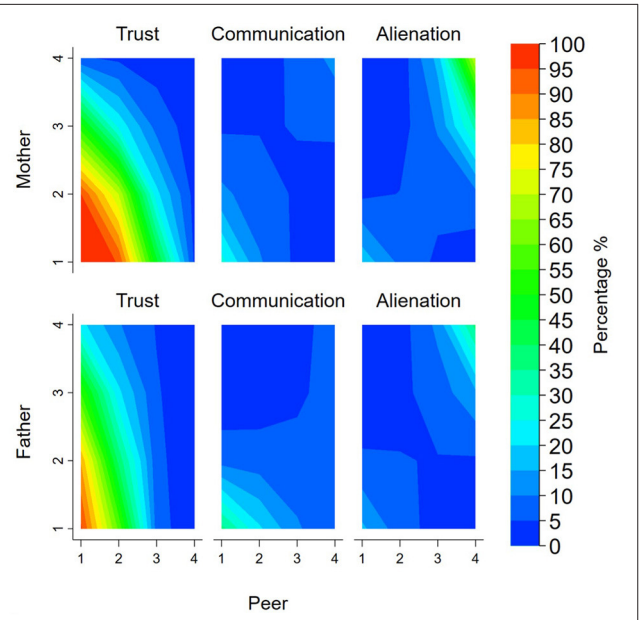

FIGURE 1 | Contour plots presenting the percentage of people with elevated symptoms of mental health problems for the interaction between parent and peer relationships. Note: Colours represented percentage of people with elevated symptoms of mental health problems (blue = low percentage; green = middle percentage; red = high percentage). Peer and parent relationships presented as unstandardised scores (range 1–4).

2010; Soenens and Vansteenkiste, 2010). Prior research has demonstrated the protective nature of parent trust for adolescent mental health (Gorrese, 2016). We extend on that literature by demonstrating that trust specifically in the mother-son relationship may forge foundations of good mental health that remains apparent for more than a decade. Most importantly this protective relationship exists into early fatherhood, when it may buffer the next generation against risks that emerge from paternal mental health problems.

It is possible that because mothers are typically primary caregivers, the experience of trust within the adolescent mother-son relationship may be of particular importance once men become caregivers of their own children. This may be intensified in the context of contemporary attitudes and beliefs about fatherhood in which many men report a desire to be nurturant, emotionally involved caregivers, in a manner more resembling the care they experienced from their mothers than fathers (Kings et al., 2017). Across the transition from care receiver to caregiver, trust in the relationship with one's own primary caregiver has the capacity to foster self-regulation and care for others (Scharf and Goldner, 2018). Aligned to this is prospective research with females that shows that during adolescence, the experience of maternal but not paternal psychological control—a construct aligned to low trust—is associated with impairments in the emotional bonds formed with next generation infants in the first year postpartum (Macdonald et al., 2018). The current study, along with the prior research, combine to suggest that regardless of gender, a history of trust with one's mother, or possibly the primary attachment figure during adolescence has implications for later emotional functioning in the postpartum period of parenthood.

Furthermore, we found that for peer relationships in adolescence, trust was also the most important of the three IPPA factors in predicting later mental health problems during early fatherhood. Adolescent males who reported high, compared to low, trust in their peer relationships had substantially reduced risk of postpartum mental health problems. In fully adjusted analyses, 9% of those who experienced low trust in peers during adolescence were at subsequent risk for postpartum mental health problems, compared to 4% for those with high peer trust. These findings align with meta-analysed results (k = 7) supporting a risk association between peer trust and depression

(−0.22, $p < 0.001$) reported by Gorrese (2016). However, outcomes in that meta-analysis were restricted to adolescence. Our results show that effects persist over much longer periods of time, into the postpartum period. Meta-analyses have also found that adolescent males report lower trust in relationships with peers than females (Gorrese and Ruggieri, 2012). This suggests that not only are interventions on trust in relationships that target adolescent males particularly important, they may also have intergenerational benefits. That trust in relationships with both mothers and peers were predictive of men's postpartum mental health may indicate generalisation of working models of trust from the primary attachment figure to peers. This possibility aligns with attachment theory and supports the proposition that secure representations from both original and subsequent attachment relationships are important in promoting effective emotion regulation (Bowlby, 1973, 1979; Furman et al., 2002).

The pattern of results we observed for relationships that adolescent boys had with their fathers was different. Here we found that communication was the more important of the three IPPA subscales. When quality of father communication was low, the rate of paternal postpartum mental health risk was 9.5%, compared to 4% when communication was high. The communication subscale indicates the degree of encouragement of and mutuality in sharing of opinions, and the nature of the parents' intuitive communication, especially in challenging affective contexts. As such, high endorsement of these items is a proxy for the degree to which the father was experienced as a "safe haven" for the boy during adolescent development (Crowell et al., 2008). Low levels of personal disclosure between fathers and sons are characteristic of socialised emotional distancing that is a feature of dominant forms of masculinity (Emslie et al., 2006). Rigid adherence by men to restrictive masculine values has been linked to elevated risk for mental health problems (Gerdes and Levant, 2017). Similarly, in the parenting literature, emotion-dismissing behaviours that cut-off a child's communication about problems also heightens risk of poor social and emotional outcomes (Kehoe et al., 2014). Our results appear to indicate multi-generational effects of such emotional distancing. Here, when Generation 1 fathers were reported to be unaware of their sons' troubles or could not be depended upon to hear out a son's difficulties, there was substantially increased risk for postpartum mental health problems.

We also assessed interactions between mothers and peers, and fathers and peers, for each of the factors of trust, communication, and alienation. This allowed us to assess whether positive qualities of the relationship with one might compensate for negative qualities with the other and whether negative relationships with both compounded risk for subsequent paternal mental health problems. In light of our low-powered environment (small sample), there was weak evidence to support an interaction between parent and peer levels of communication and alienation, suggesting patterns of a compensatory effect. Surprisingly, however, symptoms of mental health problems were least prevalent when parent and peer levels were discrepant; whereas, when levels were positive for both parent and peer relationships, an increase in the prevalence of mental health problems was observed. As noted above, inferences about interactions should be interpreted with caution because the available sample precluded well-powered evaluations. However, if replicated, strengthening of alternative relationships when key attachment supports fail may play a role in preventing postnatal distress in men, in line with the proposition that at least a single source of attachment security is essential (Bowlby, 1973).

Additionally, a possible explanation for the comparatively higher level of postpartum mental health risk observed among those with extreme positive levels (high communication or low alienation) from both parents and peers may be indicative of effects of idealised rather than realistic appraisals of relationships. Prior studies suggest a normative curvilinear trajectory of adolescent to young adult self-reported relationship quality with parents. This is characterised by a decline in reported relationship quality typical in late adolescence, presenting as a transient dip between reports of high quality relationships in early adolescence and then again in young adulthood (Wintre et al., 1995; Koepke and Denissen, 2012). This trajectory arguably supports the developmental process of autonomy and individuation (Koepke and Denissen, 2012). Similarly, while adolescence is a period of strengthening relationships with peers, some adolescents report being enmeshed in peer relationships indicating immaturity and a lack of emotional independence (Mayseless and Scharf, 2009). While speculative, it is possible that in our study extreme positive self-reports of relationships in late adolescence may indicate a level of dependency and failure or delay to progress in normative developmental processes (Koepke and Denissen, 2012). This potential mechanism in the development of some fathers' postpartum mental health problems is worthy of future investigation using specific measures of dependence or enmeshment and a multi-informant design.

IMPLICATIONS

Relationship functioning is modifiable (Fonagy et al., 2015). Past research supports the implementation of prevention programs that target relationships with parents and peers to improve proximal mental health outcomes for adolescents (Catalano et al., 2004; Kehoe et al., 2014; Rose et al., 2014). Our research provides early evidence to support the possibility that such programs may produce mental health benefits years later into the next generation of family life. Existing universal and targeted services and programs delivered in school and community settings rarely focus on parent and peer attachment (Werner-Seidler et al., 2017). However, many of those based on the cognitive-behavioural model include components which may improve interpersonal relationships (e.g., social skills; conflict resolution) (Dray et al., 2017). Furthermore, there are some promising results from programs which include a focus on building healthy attachments (Rose et al., 2014); these may be especially impactful if they incorporate parent involvement (Catalano et al., 2004). Community-based parenting programs designed to teach parents skills in responding to emotions and foster closer parent-adolescent connection have also demonstrated positive effects for both parents and adolescents (Havighurst et al., 2013, 2019;

Toumbourou et al., 2013; Kehoe et al., 2014). Additionally, attachment-based treatments for adolescents are increasing and could help to inform universal programs (Kobak et al., 2015).

Prevention targets for men are of particular importance in a context where formal perinatal supports within health services are focused predominantly on mothers and infants (Panter-Brick et al., 2014; Allport et al., 2019; Hodgson et al., 2021). Of note are growing calls for gender-specific programs for males during adolescence when a divergence in mental health outcomes, gender-based identities, behavioural risks, and barriers to support, start to become pronounced (Patton et al., 2018; Rice et al., 2018). Our research suggests that adolescent boys might benefit differentially from different components of relationships (i.e., trust in peers and mothers and communication with fathers). Additionally, given evidence that male mental health problems, including paternal depression, often present with increased levels of anger (Macdonald et al., 2020), a focus on male-specific preventative targets may also have flow on effects for partners and children if they improve family harmony and reduce conflict.

STRENGTHS AND LIMITATIONS

A strength of this study is the focus on pathways to paternal mental health. The imbalance in literature favouring investigation of psychological functioning of mothers is slowly being addressed; however, we present here one of the few studies that has prospectively addressed factors that might be appropriate targets for prevention of paternal postpartum mental health problems. Our longitudinal study design allowed us to identify characteristics of relationships that potentially shape the futures of adolescent boys into adulthood and fatherhood. However, limitations of longitudinal studies such as ours include missing data and biases that may be associated with non-responses. Within the achieved sample, levels of missing data were low and addressed using multiple imputation. Nonetheless as with all longitudinal studies, some bias due to differential attrition is likely. While the participating G2s in our sample were broadly similar to those eligible on baseline characteristics, compared to the original sample, families retained in the study were more often born in Australia and had higher education levels. Future research could investigate these associations in specific population groups.

Our study may also be limited by the use of self-reports, which are subject to social desirability biases (van de Mortel, 2008) and mood states (Fergusson et al., 1993; Robinson and Clore, 2002). While inclusion of observational measures and other informants is warranted in future research, our findings nonetheless align with prior research demonstrating the value and substantial predictive utility of adolescents' own perceptions of their parental and peer relationships (Chen et al., 2019a,b). Future research would also benefit from investigating associations between preconception parent and peer relationships and later clinical diagnoses of mental health problems, although non-clinical levels of depression and anxiety are associated with poor psychosocial functioning (Gotlib et al., 1995; Letcher et al., 2012).

We adjusted for key demographic variables and prior levels of the outcome, which can account not only for reverse causation but also confounding by other common causes of exposure and outcome (VanderWeele, 2013). As with all observational studies, though, potential for unmeasured confounding remains. Future studies should explore the potential causal nature of these associations using alternative designs (Thapar and Rutter, 2019). There are, additionally, proximal factors that may be relevant to paternal mental health include parity, multiple births, and perinatal outcomes such as gestational age and infant health. We did not include these in our analyses because they are potentially mediating mechanisms on the causal pathways of the associations we tested, and their inclusion may have concealed total effects. Nevertheless, future research, with larger samples, could explore their contribution to associations between preconception relationships and paternal mental health outcomes.

CONCLUSION

Supporting the positive development of boys into fatherhood requires careful investment in the quality of their attachment relationships with mothers, fathers, and peers over time. Prior research has established the importance of trust and communication in parent and peer relationships during adolescence (Gorrese and Ruggieri, 2012; Gorrese, 2016). Here, we provide evidence suggesting enduring effects, such that boys who experienced trust with their mothers and peers and positive communication with their fathers were at substantially reduced risk of postpartum mental health problems more than a decade later. Our finding that different factors in relationships with mothers and fathers were differentially related to mental health outcomes may be particularly relevant as momentum grows for gender-specific programs that support the social and emotional development of adolescent males (Patton et al., 2018; Rice et al., 2018). Supporting young males to resolve issues that may impede development of trust in peer relationships may also have far-reaching benefits into fatherhood. Relationships that build trust, and that are based on good communication, may not only strengthen boys' social and emotional development in their adolescent years, they may also build the foundations for better mental health that, our findings suggest, endure into fatherhood.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because ethics approvals do not permit the data to be made publicly available due to limitations of participant consent and concerns regarding potential re-identifiability. Requests to access the datasets should be directed to https://lifecourse.melbournechildrens.com/data-access/ where submissions can be made using our institutional data access protocols.

ETHICS STATEMENT

Ethics approvals for data collection in the multiple waves of the ATP and its Generation 3 study were variously granted by the human research ethics committees of the Royal Children's Hospital in Melbourne, the University of Melbourne, and/or

the Australian Institute of Family Studies. ATPG3 participants provided written informed consent to participate in the study.

AUTHOR CONTRIBUTIONS

JAM, CO, CG, PL, and ES: conceptualisation and study design. CG: statistical analyses. CO, PL, AS, JAM, CG, DH, JT, BE, and JEM: ATP cohort experts. JAM, PL, ES, KM, JEM, KT, CD, EB, and JC: literature review. JAM, CG, CO, PL, ES, and KT: interpretation of results. JAM, PL, ES, and CG: drafting of original introduction and conclusion, and drafting of original methods and results. All authors: critical revision of manuscript and final acceptance of manuscript.

FUNDING

Data collection for the ATP study was supported primarily through Australian grants from the Melbourne Royal Children's Hospital Research Foundation, the National Health and Medical Research Council (NHMRC) of Australia, the Australian Research Council (ARC), and the Australian Institute of Family Studies. Funding for this work was supported by grants from the ARC (DP130101459, DP160103160, and DP180102447) and the NHMRC (APP1082406). CO and DH were supported by NHMRC investigator grants (APP1175086 and APP1197488). JAM was supported by a Deakin University, Faculty of Health, mid-career research fellowship.

ACKNOWLEDGMENTS

The ATP and Generation 3 studies are located at The Royal Children's Hospital Melbourne and are a collaboration between Deakin University, The University of Melbourne, the Australian Institute of Family Studies, The University of New South Wales, The University of Otago (New Zealand), and the Royal Children's Hospital (further information available at www.melbournechildrens.com/atp). The views expressed in this paper are those of the authors and may not reflect those of their organisational affiliations, nor of other collaborating individuals or organisations. We acknowledge all collaborators who have contributed to the ATP, especially Prof. Margot Prior, Prof. Frank Oberklaid, and Dr. Diana Smart. We are grateful to all study research team members involved in data collection and management, in particular Generation 3 Project Manager, Mrs. Sophie Barker. We would also like to sincerely thank the participating families for their time and invaluable contribution to the study.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 04 June 2021
doi: 10.3389/fpsyg.2021.668028

Paternal Leave and Father-Infant Bonding: Findings From the Population-Based Cohort Study DREAM

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Background: Father-infant bonding is important for child development. Yet, in contrast to mother-infant bonding, little is known about factors that might facilitate father-infant bonding. With new generations of fathers being more involved in childcare, this study aims to examine the impact of paternal leave duration on father-infant bonding, and whether this relation is mediated by the amount of time fathers actively spend on childcare.

Methods: Data of $n = 637$ fathers were derived from the German population-based cohort study "Dresden Study on Parenting, Work, and Mental Health" (DREAM). Mediation analyses were conducted. Duration of paternal leave (predictor), weekly hours spent on childcare (mediator), and father-infant bonding (outcome) were measured at 14 months postpartum. The potential confounders current status of paternal leave, part-time work during paternal leave, duration of solo paternal leave, age, education, and partnership satisfaction were included in a second mediation analysis.

Results: Without considering confounders, duration of paternal leave positively predicted father-infant bonding through weekly hours spent on childcare. When adding confounders to the model, this indirect path did not stay significant. Moreover, in the adjusted model and on the direct path duration of paternal leave negatively predicted father-infant bonding. Additionally, partnership satisfaction positively predicted father-infant bonding. Some study variables were significantly associated with the mediator. Longer duration of paternal leave, currently being on paternal leave, younger age, and lower educational level predicted more weekly hours spent on childcare.

Conclusions: Duration of paternal leave not being a stable predictor for father-infant bonding suggests that fathers, who do not have the opportunity to take long periods of paternal leave, can still form strong bonds with their infants. Other factors, for example partnership satisfaction, which might represent fathers' underlying capacity to bond, might be more crucial for father-infant bonding. At the same time, results should not be interpreted in a way that father involvement (e.g., paternal leave/time spent) does

OPEN ACCESS

Edited by:
Ana Conde, Portucalense University, Portugal

Reviewed by:
Simona De Stasio, Libera Università Maria SS. Assunta, Italy
Theano Kokkinaki, University of Crete, Greece

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *15 February 2021*
Accepted: *30 April 2021*
Published: *04 June 2021*

Citation:
Schaber R, Kopp M, Zähringer A, Mack JT, Kress V and Garthus-Niegel S (2021) Paternal Leave and Father-Infant Bonding: Findings From the Population-Based Cohort Study DREAM. Front. Psychol. 12:668028. doi: 10.3389/fpsyg.2021.668028

not matter for children's development. The finding that longer duration of paternal leave increases weekly hours spent on childcare supports the idea that facilitating father involvement can be achieved by paternal leave incentives such as non-transferable father months.

Keywords: paternal leave, solo paternal leave, childcare, father-infant bonding, partnership satisfaction, mediation analysis, DREAM study

INTRODUCTION

Parent-infant bonding has been argued to be "the central and most important psychological process of the puerperium" (Brockington et al., 2006, p. 243). Bonding is the parent's emotional tie or love toward their child, not to be confused with parent involvement or children's attachment (Kinsey and Hupcey, 2013). Parent-infant bonding is considered to be the necessary basis for positive parenting behaviors (Condon, 1993; Condon and Corkindale, 1998). It is not surprising thus, that several studies find support for the importance of parent-infant bonding in child development (Yalçin et al., 2010; Mason et al., 2011; Fuchs et al., 2016; de Cock et al., 2017). Therefore, research on factors that can strengthen parent-infant bonding is needed. While factors promoting or hindering mother-infant bonding have been researched to some extent (for overview, see Kinsey and Hupcey, 2013), much less is known about factors predicting father-infant bonding (Scism and Cobb, 2017).

In his process model of parenting, Belsky (1984) suggested three domains of competent parenting, which might also influence the father-infant bond: personal psychological resources of parents, contextual sources of stress and support, and characteristics of the child. The newly emerging body of literature on father-infant bonding has already identified some factors associated with father-infant bonding which can be integrated into the domains of the model (as previously done by de Cock et al., 2016; Wynter et al., 2016). Concerning **fathers' characteristics** (i.e., personal resources), being a younger father (Hall et al., 2015) and having a lower educational level (Hall et al., 2015; de Cock et al., 2016) were associated with higher bonding. Regarding personality traits, higher levels of extraversion, conscientiousness, agreeableness, and emotional stability were all associated with higher levels of father-infant bonding (de Cock et al., 2016). Moreover, having lower levels of personality traits entailing a vulnerability to postnatal depression (e.g., sensitivity to the opinions of others), was associated with higher levels of father-infant bonding (Wynter et al., 2016). Fathers' perceived care by their own parents also influenced father-infant bonding positively (Hall et al., 2015). Depression in fathers was associated with lower father-infant bonding in multiple studies (Parfitt et al., 2014; Kerstis et al., 2016; Wynter et al., 2016; Nishigori et al., 2020). Concerning **contextual factors**, partner support and quality of relationship were positively associated with father-infant bonding in multiple studies (Condon et al., 2013; de Cock et al., 2016; Kerstis et al., 2016; Wynter et al., 2016; Nishigori et al., 2020), only Parfitt et al. (2014) found some mixed results at different measurement points. In couples, higher levels of mother-infant bonding were associated with higher levels of father-infant bonding (Nishigori et al., 2020), and depression in mothers was associated with lower father-infant bonding (Kerstis et al., 2016). Parenting stress was associated with lower levels of bonding (de Cock et al., 2016), which seems consistent with the finding that a difficult **child** temperament was also associated with lower levels of bonding (Condon et al., 2013; Parfitt et al., 2014; de Cock et al., 2016). Concerning parity, de Cock et al. (2016) found higher bonding levels in primiparous fathers. Multiple studies show that father-infant bonding levels stay relatively stable over different measurement points (Condon et al., 2013; Parfitt et al., 2014; Hall et al., 2015; de Cock et al., 2016).

Since Belsky (1984) has developed the model of competent parenting, an important new contextual aspect of fathering has emerged. Fathers are becoming more and more involved in child-care and parental leave reforms with special incentives for fathers to stay at home are being passed in OECD countries (Castro-García and Pazos-Moran, 2016; Gauthier and Bartova, 2018). Following the last parental leave reform in Germany, every mother and father has the right to take parental leave for a maximum of 3 years. Of these 3 years, the couples can receive parental allowance for 12 months, which can be stretched to 14 months if both parents undertake at least 2 months (non-transferable partner months; BMFSFJ, 2020). Since the reform, the proportion of fathers taking paternal leave has risen, even though slowly and from a very low level, but steadily (Samtleben et al., 2019; Statistisches Bundesamt [Desatis], 2020). Despite these current social developments, it has not been researched how paternal leave and spending time with the child influence father-infant bonding. The present study aims to close this gap in the literature.

Even though, to the best of our knowledge, the association between time and father-infant bonding has not been researched before, there are some indications in the literature, that spending (more) time with the newborn may foster father-infant bonding. One explanation for higher levels of bonding in primiparous fathers could be a greater amount of time spent with a single child in comparison to fathers whose available time has to be divided between multiple children (de Cock et al., 2016). This idea is supported by the finding that mother-infant bonding levels were higher in comparison to father-infant bonding (Hall et al., 2015; de Cock et al., 2016), which may indicate that time is an important factor, as mothers typically spend more time with their infant than fathers. Fathers themselves seem to believe that spending sufficient time with a child is an indispensable factor for forging an intimate bond (Brady et al., 2016). Moreover, children whose fathers took paternal leave (Petts et al., 2020) and were more involved in childcare until age one (Jessee

and Adamsons, 2018) report better father-child relationships at age nine compared to children who experienced less father involvement during their 1st year of life. On the basis of these indications, we hypothesize that spending (more) time with the newborn will positively influence father-infant bonding.

Taking paternal leave and spending time with the child are closely related. According to an explorative German survey, fathers who have been intensively involved in childcare and family activities during the child's 1st months of life intend to continue their active involvement in the family to maintain the intimate relationship with their child (Pfahl and Reuyss, 2010). In fact, one quarter of German fathers who took paternal leave (vs. who did not) were shown to have reduced their working hours after their paternal leave (Hobler and Pfahl, 2015). Furthermore, German fathers who took paternal leave had a higher involvement in childcare tasks after their paternal leave ended (Bünning, 2015). Similar results of fathers who took paternal leave being more involved in childcare activities later have been found in U.S., U.K., and Spanish populations (Tanaka and Waldfogel, 2007; Romero-Balsas, 2015; Pragg and Knoester, 2017). Concerning the duration of paternal leave, studies are more inconsistent. While some studies could not find an association between duration of paternal leave and involvement in childcare (Bünning, 2015), others found that longer periods of paternal leave result in higher levels of childcare involvement (Pragg and Knoester, 2017). On the basis of these indications, we hypothesize that taking paternal leave (irrelevant of duration) and in some cases taking longer periods of paternal leave increases the amount of time fathers spend on childcare later.

Combining these results, we hypothesize that spending more time with the child may predict higher levels of father-infant bonding. Fathers have the opportunity to spend time with their children during paternal leave, which in turn might influence the number of hours spent with the child after paternal leave. Therefore, we hypothesize a mediated relationship between *X* (duration of paternal leave) and *Y* (father-infant bonding) through *M* (weekly hours spent on childcare).

When researching this relation, some specifications of paternal leave have to be considered as confounding factors, including current status of paternal leave, part-time work during paternal leave, and solo paternal leave. If the father is currently on paternal leave, he will most likely spend more hours actively engaging with his child in comparison to if he is not on paternal leave and has a standard full-time workday of 8 h, during which he commonly does not spend the majority of the day with his child. Concerning part-time work during paternal leave, in Germany it is possible to work up to 30 h while being on paternal leave and receiving parental allowance (BMFSFJ, 2020). Fathers choosing this option will have less opportunity to spend time with their children. Taking solo paternal leave lies at the other end of the spectrum: Some parents decide to stagger parental leave. Taking solo paternal leave could give fathers more opportunity to actively engage with their children, as the mother will commonly not be at home during her work hours. The construct of solo paternal leave is still fairly unexplored. While Bünning (2015) did not find solo paternal leave to have a significant additional influence on time spent on childcare after the end of paternal leave, data from an Australian qualitative study indicate that solo caring fathers feel more attached and close to their children than fathers who did not take solo paternal leave (Wilson and Prior, 2010).

Further confounders that might influence the postulated mediation are fathers' age, education, and partnership satisfaction. All three have previously been shown to be related to father-infant bonding (see paragraph 2; Condon et al., 2013; Hall et al., 2015; de Cock et al., 2016; Kerstis et al., 2016; Wynter et al., 2016; Nishigori et al., 2020) and they might also be associated to duration of paternal leave and hours spent on childcare. Younger German men agree more often than older men that fathers should reduce their work while their children are small (Wippermann, 2017), and new generations of German fathers wish to be more involved in childcare than previous ones (Juncke et al., 2018). Regarding education, a higher educational level was associated with taking longer periods of parental leave in some studies (Lappegard, 2008), while others yielded mixed results (Sundström and Duvander, 2002) or no association at all (Geisler and Kreyenfeld, 2011). Partnership satisfaction 9 months postpartum is positively associated with paternal leave (Petts and Knoester, 2019). In addition, irrespective of whether paternal leave is taken or not, fathers' active involvement in the 1st years of parenthood is positively associated with relationship quality (McClain and Brown, 2017).

Contrary to most previous literature in the field researching mother-infant bonding, the present study focuses on factors potentially related to father-infant bonding. A positive relation between duration of paternal leave and father-infant bonding at the child's age of 14 months is assumed. Further, it is hypothesized that this relation is mediated by the time fathers actively spend on childcare. Potential confounders, i.e., current status of paternal leave, part-time work during paternal leave, solo paternal leave, age, education, and partnership satisfaction are included (**Figure 1**).

MATERIALS AND METHODS

Study Design and Sample

The present study is part of the Dresden Study on Parenting, Work, and Mental Health ("**DR**esdner Studie zu **E**lternschaft, **A**rbeit und **M**entaler Gesundheit," **DREAM**), a longitudinal multi-method cohort study of a community sample. Expectant mothers and their partners were recruited during pregnancy mostly at information events of obstetrical clinics and birth preparation courses in and around the city of Dresden, Germany. The aim of the DREAM study is "to prospectively investigate the relationship between parental work participation, role distribution, stress factors, and their effects on perinatal outcomes and long-term family mental and somatic health [. . .]" (Kress et al., 2019, p. 1). Participants complete various questionnaires at six measurement points: during pregnancy (T1), 8 weeks after the anticipated birth date (T2), 14 months (T3), 2 years (T4), 3 years (T5), and 4.5 years (T6) after the actual

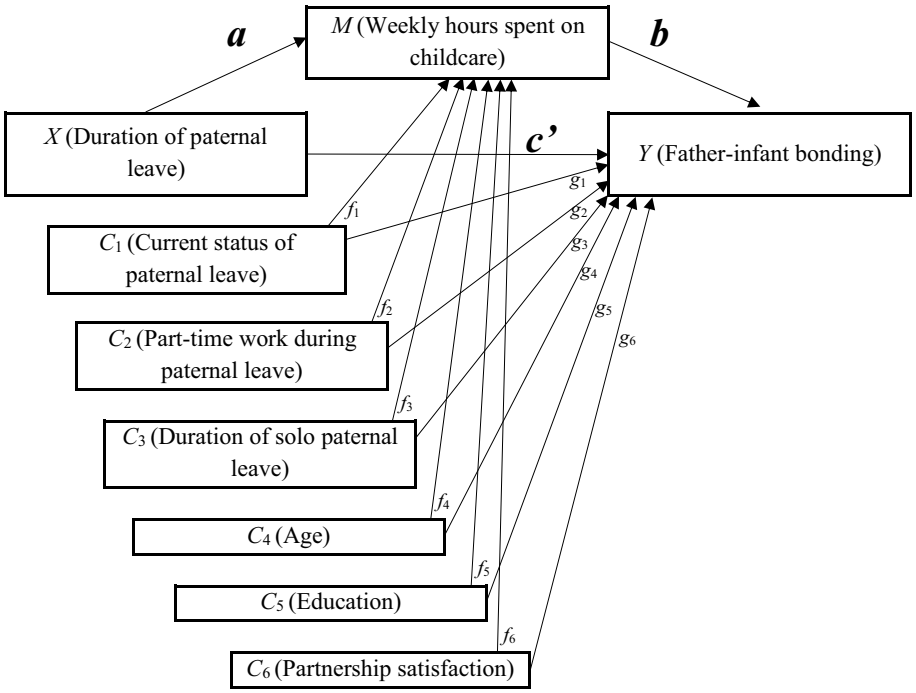

FIGURE 1 | The hypothesized association between duration of paternal leave and father-infant bonding through weekly hours spent on childcare, including six potential confounders. *X*, predictor variable; *M*, mediator variable; *Y*, outcome variable; C_{1-6}, confounders; *a*, effect of *X* on *M*; *b*, effect of *M* on *Y*; *ab*, indirect effect of *X* on *Y*; *c'*, direct effect of *X* on *Y*, estimates the difference between *X* and *Y* holding *M* constant; f_{1-6}, effects of C_{1-6} on *M*; g_{1-6}, effects of C_{1-6} on *Y*.

birth date. Further details regarding the study design of DREAM are described in the study protocol (Kress et al., 2019).

The present paper investigates data from participating fathers having completed T1, T2, and T3. As presented in **Figure 2**, the number of eligible participants for the present study consists of $N = 1,601$ expectant fathers of which $n = 1,575$ had completed the T1 questionnaire at the time of data extraction on the 3rd of December 2020 (prospective data collection ongoing). Inclusion criteria were the timely completion of T2 and T3. Further, $n = 22$ (3.0%) participants were excluded due to factors such as having had twins or multiples, not being the biological father, parents being separated, and infants living separated from their parents, all measured at T3. Some T3 questions relevant for the present study had to be revised after the pilot phase, therefore $n = 66$ (8.8%) participants who had answered the first version of questions were excluded. Further, as this study investigates the duration of paternal leave, $n = 24$ (3.2%) students and unemployed participants who had not been entitled to parental leave were excluded at T3. Exclusion criteria did not entail any health measures, as we aimed to leave the sample as diverse as possible, to be able to generalize the results to the community. The final sample consisted of $n = 637$ fathers.

Instruments

Study data were collected and managed using Research Electronic Data Capture (REDCap), a secure, web-based software platform designed to support data capture for research studies, hosted at "Koordinierungszentrum für Klinische Studien" at the Faculty of Medicine of the Technische Universität Dresden (Harris et al., 2009, 2019).

Father-infant bonding was measured at T3 with the validated German version of the Postpartum Bonding Questionnaire (PBQ; Brockington et al., 2001; Reck et al., 2006), a self-rating instrument consisting of 25 items. The participants are instructed to think about the most difficult time with their child and rate the items (e.g., "I feel angry with my baby" or "I feel close to my baby" [reversed]) on a 6-point Likert scale ranging from 0 (*never*) to 5 (*always*). In the original version of the PBQ, higher scores (ranging from 0 to 125) indicate more bonding problems. For the present study, the items were reversed so that higher scores indicate a higher level of father-infant bonding. Therefore, in the presented data, a score of 99 or less is the clinical cut-off point for the identification of a possible bonding disorder (Brockington et al., 2006). In the present study the reliability of the PBQ was excellent (Cronbach's $\alpha = 0.86$).

Duration of paternal leave is the sum duration (number of months) of all fathers' self-reported paternal leave periods from childbirth up to the date of completing the questionnaire, around 14 months postpartum. At T3, fathers answered retrospective questions about their parental leave (own and partner's) including duration, number of periods, beginning, and end of parental leave periods.

Weekly hours spent on childcare represents the number of hours per week, fathers actively engage in childcare activities

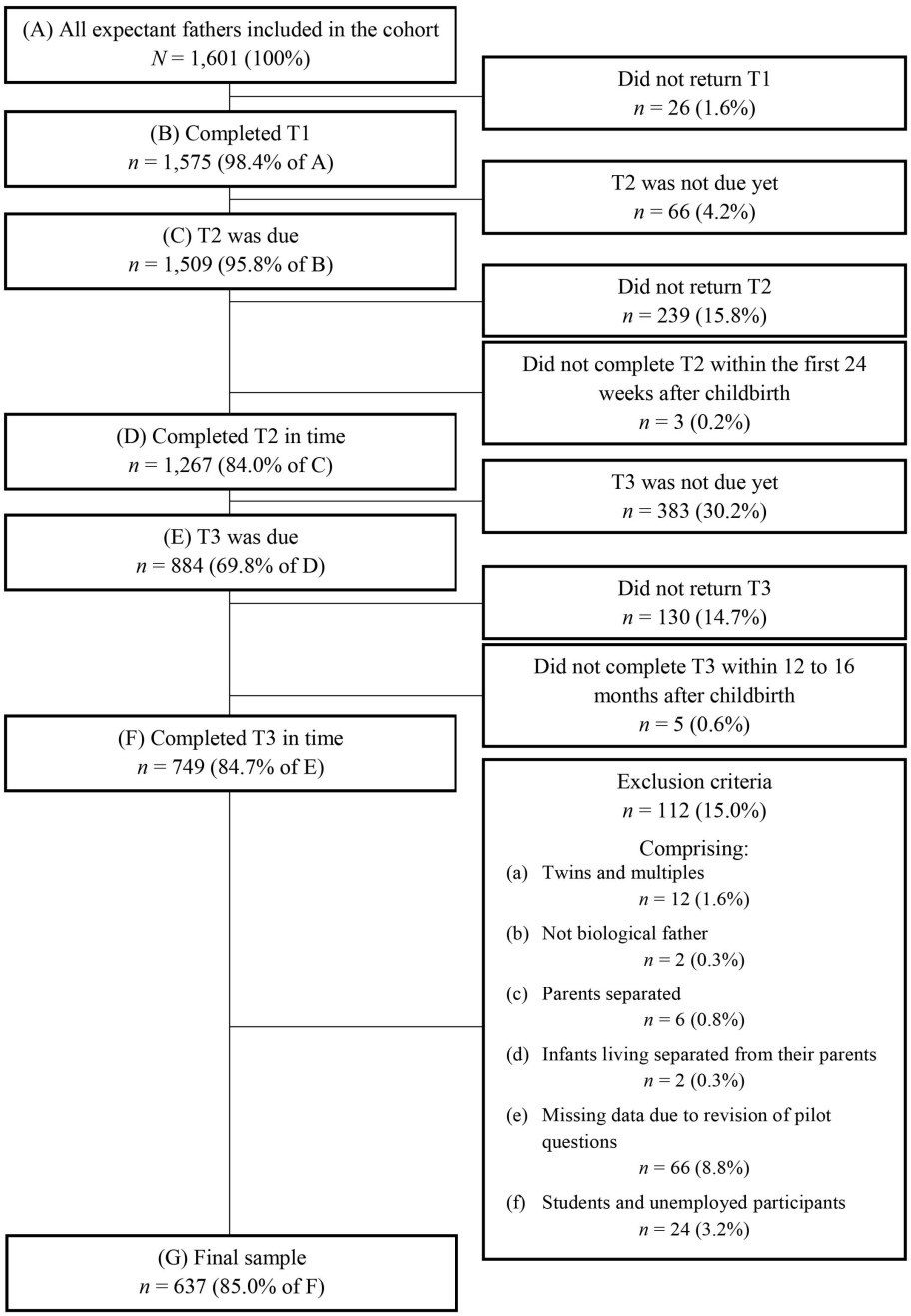

FIGURE 2 | Flowchart of retention rate and exclusion criteria resulting in final sample. T1, during pregnancy; T2, around 8 weeks after anticipated birth date; T3, around 14 months after actual birth date. Data from 3rd of December 2020 (prospective data collection ongoing).

such as feeding, putting to bed, dressing, organizing chaperones, playing, or talking at T3. To estimate the weekly hours, several questions based on the 1997 National Study of the Changing Workforce were used (Hall and MacDermid, 2009). The first item used in the present study aims to detect fathers' average number of days of gainful employment per week. Subsequently, fathers had to estimate how many hours per day they spend on childcare activities on (a) a day of gainful employment (workday) and (b) a day without gainful employment (work-free day). If participants were currently on paternal leave, they only answered part b. By multiplying the hours spend on childcare with the corresponding number of work- and work-free days, the number of hours per week was calculated.

Current status of paternal leave was assessed by fathers' self-report, with 0 indicating fathers have *never been or already*

finished paternal leave and 1 indicating fathers are *currently on paternal leave* at T3.

Part-time work during paternal leave was assessed by fathers' self-report at T3, with 0 indicating *no part-time work during paternal leave* and 1 indicating *part-time work during paternal leave*.

Duration of solo paternal leave is the sum of all paternal leave periods in months that the father took on his own, i.e., not parallel to maternal leave. In other words, the number of months the father stayed at home with the child, while the mother was working. Duration of solo paternal leave was, as duration of paternal leave, determined by the retrospective questions about the fathers' own and their partners' parental leave periods until T3.

Age and education were measured at T1. Age was measured in years. Education was measured with the question "Which vocational training qualifications do you have?" based on the German National Cohort Consortium (2014). Answers were categorized into 0 (*no university degree*) and 1 (*university degree*).

Partnership satisfaction was measured at T2 using the validated German short version of the Partnership Questionnaire (PFB-K; Kliem et al., 2012). The PFB-K is a self-rating instrument consisting of nine items (e.g., "We talk to each other for at least half an hour in the evening" or "She blames me when something has gone wrong" [reversed]). Response categories range from 0 (*never/very rare*) to 3 (*very often*) with a sum score of 27 indicating the highest level of partnership satisfaction. In the present study the reliability of the PFB-K was good (Cronbach's $\alpha = 0.77$).

Statistical Analyses

All statistical analyses were conducted by using IBM SPSS Statistics 26 (IBM Corp, 2019). In case of missing values for items of a sum score, those were substituted with the participant's mean value if no more than 20% of items were missing on this scale. Before conducting descriptive analyses, non-plausible values were set to missing (e.g., if participants claimed to work more than 7 days per week or to spend more than 16 h per day on childcare activities such as feeding, putting to bed, dressing, organizing chaperones, playing, or talking). Before conducting the main analyses, outliers and extreme values outside of the bounds [$Q_1 - 1.5 * IQR$; $Q_3 + 1.5 * IQR$] were excluded. After exclusion of outliers and extreme values, the main assumptions of the linear model, including linearity, independent errors, homoscedasticity, normally distributed errors, and no multicollinearity were tested and could be confirmed (Hayes, 2018). Due to the exclusion of outliers and extreme values and some missing data, *n* varied between the different analyses.

To acquire information on the sociodemographic characteristics of the sample and all study variables, descriptive data analyses were carried out. The relationships between predictors, confounders, and outcome were examined by using Pearson's correlation. To investigate the postulated mediation (*X*, duration of paternal leave on *Y*, father-infant bonding through *M*, weekly hours spent on childcare) two simple mediation analyses (first without, second with consideration of six potential confounders) were carried out using the SPSS modeling tool PROCESS v3.5 macro by Hayes (2018). The tool uses ordinary least squares regression, yielding unstandardized path coefficients for total (*c*), direct (*c'*), and indirect effects (*ab*). For the present mediation, heteroscedasticity consistent standard errors (HC3) according to Davidson and MacKinnon (1993) were employed. BCa-Bootstrapping with 5,000 samples was applied to compute the confidence intervals and inferential statistics. Effects are significant if the confidence interval does not include zero (Hayes, 2018). To have an orientation concerning the power of the mediation, the simulation-based calculations of Fritz and MacKinnon (2007) were considered. For the individual regression models of the mediation, *post hoc* power analyses were conducted with G*Power 3 (Faul et al., 2007).

Ethical Statement

The DREAM study was approved by the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (No: EK 278062015). All participants received written information about the aims and procedures of the study during recruitment. They were informed about pseudonymization of their data and their right to withdraw from the study at any time. All participants signed a declaration of consent.

RESULTS

Descriptive Statistics

The characteristics of the final sample are presented in **Table 1**. The majority of participants were born in Germany (98.0%, $n = 622$), had a university degree (57.5%, $n = 362$), and a full-time employment (77.0%, $n = 466$) at measurement point T1. The duration of paternal leave, fathers had taken until T3, ranged from 0 to 15 months ($M = 2.4$, $SD = 2.4$). A possible bonding disorder with bonding scores below the clinical cut-off point (Brockington et al., 2006) was identified for 7.6% ($n = 46$) of fathers. Intercorrelations between all study variables are presented in **Table 2**. The largest correlation was between duration of solo paternal leave and current status of paternal leave [$r_{(472)} = 0.33$, $p < 0.001$], meaning that there were no large correlation coefficients, i.e., $r \geq 0.5$ between the study variables.

Dropout Analyses

Dropout analyses were conducted for sociodemographic characteristics and partnership satisfaction of the completer group vs. the non-completer group. Completers were more often born in Germany (98.0 vs. 95.1%; Fisher's exact test, $p = 0.025$), and more often had a university degree [57.5% vs. 39.3%; $\chi^2(1, n = 874) = 23.14$, $p < 0.001$]. Moreover, completers more often had a higher partnership satisfaction ($U = 20215.50$, $Z = -2.15$, $p = 0.032$). There were no significant differences between completers and non-completers regarding age, parity, and employment status at T1 (tables on request).

Mediation Analyses

To analyze whether there is a mediated association between duration of paternal leave and father-infant bonding, two simple mediation analyses were performed. They are presented in

TABLE 1 | Sample description.

Sample characteristics	Total ($n = 637$)	
	n^a (%^{b})	M ± SD (range)
Age in years (T1)		32.3 ± 4.7 (20–48)
Week of partners pregnancy (T1)		30.6 ± 6.2 (8–41)
Country of birth (T1)		
Germany	622 (98.0)	
Other	13 (2.0)	
Education (T1)		
No university degree	268 (42.5)	
University degree	362 (57.5)	
Parity (T1)		
Primiparous	486 (77.9)	
Multiparous	138 (22.1)	
Employment status (T1)[c]		
Full-time employed	545 (85.8)	
Part-time employed	52 (8.2)	
Marginally employed	15 (2.4)	
Others[d]	56 (8.8)	
Infant age in weeks (T2)		9.1 ± 2.3 (4–21)
Partnership satisfaction (T2; 0–27)[e]		19.8 ± 4.0 (6–27)
Infant age in months (T3)		13.9 ± 0.5 (12–16)
Employment status (T3)[c]		
Full-time employed	466 (77.0)	
Part-time employed	95 (15.7)	
Marginally employed	9 (1.5)	
Others[f]	0 (0)	
Father-infant bonding (T3; 0–125)[g]		111.9 ± 8.1 (81–125)
Duration of paternal leave in months (T3)[h]		2.4 ± 2.4 (0–15)
Weekly hours spent on childcare (T3)		28.0 ± 13.1 (5–112)
Current status of paternal leave (T3)		
Never been or already finished paternal leave	504 (82.4)	
Currently on paternal leave	108 (17.6)	
Part-time work during paternal leave (T3)		
No part-time work during paternal leave	422 (83.2)	
Part-time work during paternal leave	85 (16.8)	
Duration of solo paternal leave in months (T3)[i]		0.7 ± 1.5 (0–12)

T1, Measurement point during pregnancy; T2, Measurement point around 8 weeks after the anticipated birth date; T3, Measurement point around 14 months after the actual birth date.

[a]n *slightly varies due to missing data of some participants.* [b]*Valid percent.* [c]*Multiple answers allowed.* [d]*Including irregular employment, apprenticeship, student, unemployed, and others.* [e]*Short version of the Partnership Questionnaire ("Kurzform des Partnerschaftsfragebogens", PFB-K).* [f]*Including irregular employment, apprenticeship, and others (not including students and unemployed participants who were excluded as they are not entitled to parental leave).* [g]*Postpartum Bonding Questionnaire (PBQ); reversed items so that higher scores indicate a higher level of father-infant bonding.* [h]*Sum of all paternal leave periods until T3.* [i]*Sum of all paternal leave periods that the father took on his own, i.e., not parallel to maternal leave, until T3.*

Table 3 (without confounders) and **Table 4** (controlling for potential confounders). Due to the exclusion of outliers and extreme values as well as some missing data, *n* varied depending on the used variables. The current state of research on mediation analysis states that a significant total effect (*c*, without considering the mediator) is no essential precondition for a mediation analysis. The direct (*c'*) and indirect effects (*ab*) should be interpreted without this preliminary step (Zhao et al., 2010; Rucker et al., 2011).

Without considering the confounders, *X* (duration of paternal leave) significantly positively predicted *M* (weekly hours spent on childcare; path *a*, $B = 0.996$, $p = 0.007$), which in turn significantly positively predicted *Y* (father-infant bonding; path *b*, $B = 0.074$, $p = 0.010$). The indirect effect of *X* on *Y* was significant, $ab = 0.073$, BCa 95% CI [0.008, 0.167]. The completely standardized indirect effect was 0.034. Considering power, according to a simulation-based calculation of Fritz and MacKinnon (2007), the sample size of this mediation ($n = 513$) was large enough to be able to find even small mediated effects present in the population with sufficient probability.

When considering the confounders, *X* (duration of paternal leave) still significantly positively predicted *M* (weekly hours spent on childcare; path *a*, $B = 1.258$, $p = 0.022$). However, *M* (weekly hours spent on childcare) did not predict *Y* (father-infant bonding) anymore (path *b*, $B = 0.059$, $p = 0.090$). Moreover, the indirect effect of *X* on *Y* was not significant anymore, $ab = 0.075$, BCa 95% CI [−0.010, 0.216]. Looking at the direct path, *X* (duration of paternal leave) now significantly negatively predicted *Y* (father-infant bonding; path *c'*, $B = -0.700$, $p = 0.048$). Considering power, the sample size of this adjusted mediation ($n = 381$) was large enough to be able to find combinations of medium-medium as well as medium-large effects on paths *a* and *b* (Fritz and MacKinnon, 2007).

Looking at the individual regression models of the adjusted mediation analysis (**Table 4**), the individual regression for father-infant bonding (*M* and C_{1-6} on *Y*) explained a significant proportion of variance, $R^2 = 0.053$, $F_{(8, 372)} = 2.073$, $p = 0.038$. The effect size of $f^2 = 0.06$ was between small and medium. There was only one significant association between the confounders (partnership satisfaction) and *Y* (father-infant bonding). The individual regression model for weekly hours spent on childcare (*X* and C_{1-6} on *M*) explained a significant proportion of variance, $R^2 = 0.132$, $F_{(7, 373)} = 6.158$, $p < 0.001$. The effect size of $f^2 = 0.15$ was medium. There were some significant associations between the confounders (current status of paternal leave, age, education) and *M* (weekly hours spent on childcare). *Post hoc* power analyses revealed a power of 1.00 for both individual regressions, which was adequate, i.e., above 0.80.

DISCUSSION

Summary of Findings

The present study aimed to examine the association between duration of paternal leave and father-infant bonding at 14 months postpartum, potentially mediated by weekly hours spent on childcare. To the best of our knowledge, such a relation had not been researched before. When not considering any confounders, longer duration of paternal leave had a positive effect on father-infant bonding through weekly hours spent on childcare, as hypothesized. However, this indirect path did not stay significant when considering the confounders (current status of paternal leave, part-time work during paternal leave,

TABLE 2 | Intercorrelations between study variables.

	1	2	3	4	5	6	7	8	9
1. Father-infant bonding[a]	—								
2. Duration of paternal leave[b]	−0.08	—							
3. Weekly hours spent on childcare	0.11*	0.12**	—						
4. Current status of paternal leave	0.02	0.07	0.22**	—					
5. Part-time work during paternal leave	−0.10	0.12*	0.16**	0.26**	—				
6. Duration of solo paternal leave[c]	0.03	0.27**	0.18**	0.33**	0.06	—			
7. Age	0.03	0.02	−0.17**	−0.11*	−0.09	−0.13**	—		
8. Education	−0.05	0.16**	−0.07	0.06	0.03	0.05	0.06	—	
9. Partnership satisfaction[d]	0.14**	0.08	0.05	0.08	0.01	0.04	−0.03	0.08	—

Specification of the Pearson's correlation coefficient r. Two-tailed. Outliers and extreme values excluded, n *varies between 385 and 474 due to missing data of some participants.* [a]*Postpartum Bonding Questionnaire (PBQ); reversed items so that higher scores indicate a higher level of father-infant bonding.* [b]*Sum of all paternal leave periods in months until T3.* [c]*Sum of all paternal leave periods in months that the father took on his own, i.e., not parallel to maternal leave until T3.* [d]*Short version of the Partnership Questionnaire ("Kurzform des Partnerschaftsfragebogens", PFB-K).*
*p < 0.05. **p < 0.01.

TABLE 3 | Model coefficients for the simple mediation analysis of the association between duration of paternal leave and father-infant bonding through weekly hours spent on childcare without confounders.

		Consequent						
		***M* (Weekly hours spent on) childcare)**				***Y* (Father-infant bonding[b])**		
Antecedent		**Coeff.**	***SE***	***p***		**Coeff.**	***SE***	***p***
X (Duration of paternal leave[a])	*a*	**0.996**	0.369	0.007	*c'*	−0.448	0.233	0.055
M (Weekly hours spent on childcare)		—	—	—	*b*	**0.074**	0.029	0.010
Constant	i_M	24.917	0.870	< 0.001	i_Y	111.605	0.909	< 0.001
		$R^2 = 0.015$				$R^2 = 0.020$		
		$F_{(1, 511)} = 7.289, p = 0.007$				$F_{(2, 510)} = 4.696, p = 0.009$		

Simple mediation analysis using ordinary least square regression. Heteroscedasticity consistent standard errors (HC3) employed. N = *513. Outliers and extreme values excluded.* X, *predictor variable;* M, *mediator variable;* Y, *outcome variable;* a, *effect of* X *on* M*;* b, *effect of* M *on* Y*;* c', *direct effect of* X *on* Y, *estimates the difference between* X *and* Y *holding* M *constant; Coeff., unstandardized path coefficients. Significant associations (*p < *0.05) are in boldface.*
[a]*Sum of all paternal leave periods in months until T3.* [b]*Postpartum Bonding Questionnaire (PBQ); reversed items so that higher scores indicate a higher level of father-infant bonding.*

duration of solo paternal leave, age, education, and partnership satisfaction). Moreover, on the direct path, longer duration of paternal leave now had a negative effect on father-infant bonding. Of the confounders, partnership satisfaction had a positive effect on father-infant bonding.

Factors increasing the number of weekly hours spent on childcare, the mediator, were longer duration of paternal leave, currently being on paternal leave, younger age, and lower educational level. There were no associations between weekly hours spent on childcare and part-time work during paternal leave as well as partnership satisfaction.

Predictors of Father-Infant Bonding

In this study, we could only find unstable indications that longer periods of paternal leave and more hours spent with the child may strengthen father-infant bonding, suggesting that time might not be its most important facilitator. The underlying mechanisms might be more complex than hypothesized. In female populations, factors which have been repeatedly found to promote mother-infant bonding are factors in close proximity to the birth event, such as a positive birth experience and physical contact in the immediate postpartum period (for overview, see Kinsey and Hupcey, 2013). Those factors might lay an important foundation for father-infant bonding as well and do not take place during paternal leave. Moreover, experiences during paternal leave might not only be positive. Spending a prolonged duration of time with a newborn infant entails challenges and can be demanding, potentially explaining the negative direct effect of paternal leave on father-infant bonding in the adjusted mediation.

Partnership satisfaction was positively related to father-infant bonding, which is in line with previous research (Condon et al., 2013; de Cock et al., 2016; Kerstis et al., 2016; Wynter et al., 2016; Nishigori et al., 2020). Condon et al. (2013) have discussed that this association may be explained by an underlying capacity to form a strong bond or attachment with other human beings.

TABLE 4 | Model coefficients for the simple mediation analysis of the association between duration of paternal leave and father-infant bonding through weekly hours spent on childcare including six confounders.

		Consequent						
		M (Weekly hours spent on) childcare)				*Y* (Father-infant bonding[b])		
Antecedent		**Coeff.**	***SE***	***p***		**Coeff.**	***SE***	***p***
X (Duration of paternal leave[a])	*a*	**1.258**	0.550	0.022	*c'*	**−0.700**	0.353	0.048
M (Weekly hours spent on childcare)		—	—	—	*b*	0.059	0.035	0.090
C_1 (Current status of paternal leave)	f_1	**5.306**	1.731	0.002	g_1	0.176	0.934	0.851
C_2 (Part-time work during paternal leave)	f_2	2.470	1.680	0.141	g_2	−1.822	1.151	0.115
C_3 (Duration of solo paternal leave[b])	f_3	1.380	0.792	0.083	g_3	0.379	0.428	0.377
C_4 (Age)	f_4	**−0.338**	0.132	0.012	g_4	0.122	0.082	0.137
C_5 (Education)	f_5	**−2.717**	1.157	0.019	g_5	−0.666	0.708	0.347
C_6 (Partnership satisfaction[c])	f_6	−0.096	0.148	0.518	g_6	**0.208**	0.087	0.018
Constant	i_M	37.077	5.356	< 0.001	i_Y	105.218	3.154	< 0.001
		$R^2 = 0.132$				$R^2 = 0.053$		
		$F_{(7, 373)} = 6.158, p < 0.001$				$F_{(8, 372)} = 2.073, p = 0.038$		

Simple mediation analysis using ordinary least square regression. Heteroscedasticity consistent standard errors (HC3) employed. N = *381. Outliers and extreme values excluded.* X*, predictor variable;* M*, mediator variable;* Y*, outcome variable;* C_{1-6}*, confounders;* a*, effect of* X *on* M*;* b*, effect of* M *on* Y*;* c'*, direct effect of* X *on* Y*, estimates the difference between* X *and* Y *holding* M *constant;* f_{1-6}*, effects of* C_{1-6} *on* M*;* g_{1-6}*, effects of* C_{1-6} *on* Y*; Coeff., unstandardized path coefficients. Significant associations (*p < *0.05) are in boldface.*
[a]Sum of all paternal leave periods in months until T3. [b]Sum of all paternal leave periods in months that the father took on his own, i.e., not parallel to maternal leave, until T3. [c]Short version of the Partnership Questionnaire ("Kurzform des Partnerschaftsfragebogens", PFB-K). [d]Postpartum Bonding Questionnaire (PBQ); reversed items so that higher scores indicate a higher level of father-infant bonding.

Partnership satisfaction as well as father-infant bonding might represent fathers' attachment behavior or learned attachment schemata. Previous research supports this idea. Multiple studies on father-infant bonding found bonding levels to be stable across different measurement points (Condon et al., 2013; Parfitt et al., 2014; Hall et al., 2015; de Cock et al., 2016). Moreover, fathers who reported to had experienced more care by their own parents—which might facilitate an underlying capacity to form strong bonds (Bretherton, 1987)—showed higher levels of father-infant bonding (Hall et al., 2015).

In view of the above, fathers who do not have the opportunity to take long periods of paternal leave due to employer or financial restrictions still are able to bond with their infant, which is positive. It can reduce pressure for parents to know that pausing work for long periods is not the most important precondition to form a parent-infant bond. Nevertheless, results should not be interpreted in a way that father involvement does not matter for children's development. Father involvement has previously been measured with quantitative (e.g., time, as done in this study) and qualitative (e.g., sensitivity, warmth) measures. Multiple studies have shown positive outcomes of both types of father involvement on child development (for review, see Behson et al., 2018). Only some examples include less externalizing and internalizing problems (Zhang et al., 2019), more prosocial behavior (Flouri, 2008), and increased executive functioning (Meuwissen and Carlson, 2015) of children. While bonding may not be among those, we emphasize that this does not mean that paternal leave is not to be promoted and facilitated.

Predictors of Weekly Hours Spent on Childcare at 14 Months Postpartum

Some interesting relations were found between the predictors and the mediator, weekly hours spent on childcare. Concerning the specifications of paternal leave, longer periods of paternal leave were found to increase weekly hours spent on childcare at 14 months postpartum. This was expected and in line with previous research (Tanaka and Waldfogel, 2007; Romero-Balsas, 2015; Pragg and Knoester, 2017). Fathers currently being on paternal leave (vs. at work) was the strongest predictor of weekly hours spent on childcare. This indicates that fathers spend the work-free time, which they gain during paternal leave, with their children. If fathers worked part-time during paternal leave, this did not influence their weekly hours spent on childcare at 14 months postpartum. Working part-time during paternal leave might therefore not represent a lesser interest to spend time with the child, but could potentially be a financial necessity for some fathers. Once these fathers complete their paternal leave, they seem to spend just as much of their work-free time with their children as fathers, who had the opportunity to take paternal leave without working part-time. Surprisingly, duration of solo paternal leave did not have a significant impact on weekly hours spent on childcare, which is in line with one prior study examining solo paternal leave (Bünning, 2015). We expected fathers practicing solo paternal leave to be particularly motivated concerning childcare and therefore spend more hours on childcare at 14 months postpartum. However, only a very low percentage of fathers

take solo paternal leave, therefore findings should be considered as preliminary.

Older fathers spent less weekly hours on childcare activities such as feeding, putting to bed, dressing, organizing chaperones, playing, or talking at 14 months postpartum. This might reflect the social development that younger German men think fathers should be more involved in childcare (Wippermann, 2017).

Fathers with a higher educational level spent less time on childcare activities at 14 months postpartum. This is in line with a finding by Romero-Balsas (2015), discussing that more educated fathers might have greater work-related responsibilities or reducing work would have greater opportunity costs for them. Contrasting this, Hobler and Pfahl (2015) found that more educated fathers reduce their working hours after the completion of their paternal leave. They argue that more educated fathers can chose their work hours more flexibly. Study results for the influence of education on the duration of paternal leave also vary (Sundström and Duvander, 2002; Lappegard, 2008; Geisler and Kreyenfeld, 2011). In sum, knowledge about the influence of education on father involvement is still limited and non-conclusive. Our results point toward the idea that more educated fathers may have greater work-related responsibilities, such as the expectation to work overtime or business travel, making it more difficult for them to spend time with their child.

Partnership satisfaction did not have a significant influence on weekly hours spent on childcare, which might indicate that fathers do not let their relationship quality influence their motivation to spend time with their child. However, this finding contradicts previous findings (McClain and Brown, 2017; Petts and Knoester, 2019) and the relation might be underestimated in the present study due to systematic dropout of fathers less satisfied.

Strengths

While research has focused on factors associated with mother-infant bonding (Kinsey and Hupcey, 2013), there are only few studies on father-infant bonding. Our study therefore contributes to a research area that has scarcely been explored and extends the limited existing literature with new information on father-infant bonding and its associated factors. Considering today's fathers wish to be more involved in childcare (Wippermann, 2017; Juncke et al., 2018) and many OECD countries trying to facilitate this (Castro-García and Pazos-Moran, 2016; Gauthier and Bartova, 2018), research addressing fathers' involvement in childcare is highly relevant. As our data were derived from a large population-based cohort study (DREAM; Kress et al., 2019), we were able to include a number of possibly relevant factors. The study combined many specifications of paternal leave (e.g., part-time work during paternal leave or duration of solo paternal leave) as well as fathers' and family aspects (e.g., education or partnership satisfaction).

Limitations

Some limitations in our analyses need to be addressed. For the present investigation, duration of paternal leave, weekly hours spent on childcare, and father-infant bonding were all measured at the same time (T3). However, duration of paternal leave is a relatively objective information and it can be assumed that paternal leave preceded father-infant bonding, due to the retrospective nature of the question. Concerning time spent on childcare and father-infant bonding however, it can only be spoken of association and not of causation. To be able to meet the assumptions of the linear model, outliers and extreme values were excluded. This led to the final sample of $n = 637$ being smaller in the main analyses and n varying significantly between the different analyses. Fathers in our sample took, on average, 2 months of paternal leave, i.e., most fathers took only the two non-transferable partner months. This is in accordance with the general German population (Samtleben et al., 2019). On the one hand, the present findings are therefore generalizable to the German population. On the other hand, the present results cannot infer conclusions regarding populations where more fathers take much longer periods of paternal leave. As for generalizability concerning other study variables, the participants of the present study were predominantly well-educated fathers, which is typical for epidemiological studies (O'Neil, 1979; Søgaard et al., 2004). Additionally, dropout analyses revealed that completers had a higher university degree and partnership satisfaction than non-completers. Considering that education as well as partnership satisfaction were two predictors in the analyses, it is important to be careful generalizing the study's findings to the German population. At the same time, it is important to bear in mind that selection bias does not necessarily influence the results when associations between variables are investigated (Nilsen et al., 2009).

Future Research Implications

To further elucidate our and previous findings, future research on predictors of father-infant bonding should focus on (a) factors in close proximity to the birth event, such as birth experience and physical contact to the newborn, (b) potentially demanding factors during paternal leave, and (c) father's underlying capacity to bond, for example by considering his own childhood history or his partnership quality. Future research on factors such as mentioned under (a) would benefit from including qualitative measures, for example qualitative assessments of early face-to-face father-infant interactions. As duration of paternal leave and weekly hours spent on childcare predicted father-infant bonding in the unadjusted mediation analysis, research should include these variables as confounders, whenever possible. Moreover, the negative association between duration of paternal leave and father-infant bonding needs to be explored further. In addition, it would be interesting to repeat a similar study in a specific population of fathers with longer durations of paternal leave and solo paternal leave.

Concerning factors predicting weekly hours spent on childcare, there are some uncertainties regarding duration of solo paternal leave, education, and partnership satisfaction. Solo paternal leave of fathers has barely been explored even though its impact should be understood in societies where more and more fathers are actively involved in childcare. Concerning educational level, there are two plausible ideas: Either more educated fathers are hindered to be involved in childcare, due to greater job-related responsibilities (Romero-Balsas, 2015), or more educated fathers have better options to be involved in childcare due to more flexible jobs (Hobler and Pfahl, 2015) and better financial

situations. Those ideas should be explored to gain a better understanding of what might help different types of fathers to be more involved in childcare. Moreover, it would be interesting to analyze the impact of education and partnership in a more heterogeneous sample.

Future Practical Implications

As there was no stable association between duration of paternal leave and father-infant bonding, we cannot conclude that longer periods of paternal leave will strengthen father-infant bonding. Expecting parents could be informed that pausing work for long periods might not be the most important precondition to form a parent-infant bond. This could reduce pressure for parents, who either do not have the opportunity or do not want to take long periods of parental leave. However, we strongly emphasize that paternal involvement is important for many other child outcomes (see section Predictors of Father-Infant Bonding and Behson et al., 2018) and therefore should be promoted and facilitated as currently done by some OECD countries (Castro-García and Pazos-Moran, 2016; Gauthier and Bartova, 2018; Samtleben et al., 2019; Statistisches Bundesamt [Desatis], 2020).

CONCLUSION

Since father-infant bonding is crucial for child development (Condon, 1993; Condon and Corkindale, 1998), it is essential to examine and strengthen it. We were especially interested in time as a potential facilitator, as new generations of fathers are spending more time with their children (Wippermann, 2017; Juncke et al., 2018) and OECD countries are facilitating this by passing paternal leave reforms (Castro-García and Pazos-Moran, 2016; Gauthier and Bartova, 2018). The present study drew data of a large population-based cohort study (DREAM; Kress et al., 2019) to examine the association between duration of paternal leave and father-infant bonding at 14 months postpartum, potentially mediated by weekly hours spent on childcare.

Duration of paternal leave positively predicted father-infant bonding through weekly hours spent on childcare. However, this indirect path did not stay significant when considering the confounders (current status of paternal leave, part-time work during paternal leave, duration of solo paternal leave, age, education, and partnership satisfaction). Moreover, in the adjusted model and on the direct path, paternal leave negatively predicted father-infant bonding. These unstable results indicate that the underlying mechanisms might be more complex than hypothesized. Other factors might be more relevant in strengthening father-infant bonding, one of these being partnership satisfaction, which was a significant predictor for father-infant bonding in the present study.

Weekly hours spent on childcare, the mediator, was positively predicted by longer durations of paternal leave and currently being on paternal leave. Age and educational level negatively predicted weekly hours spent on childcare, i.e., younger fathers and fathers with a lower educational level spent more time with their child.

Results suggest that fathers, who do not have the opportunity to take long periods of paternal leave, are still able to form strong bonds with their infants. At the same time, results should not be interpreted in a way that father involvement (e.g., paternal leave/hours spent) does not matter for children's development. Multiple studies have shown other positive outcomes of father involvement, e.g., less externalizing and internalizing problems (Zhang et al., 2019) or more prosocial behavior (Flouri, 2008) of children. The present study's result that longer durations of paternal leave can lead to more father involvement supports the idea that facilitating father involvement can be achieved by paternal leave incentives such as non-transferable father months.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of legal and ethical constraints. Public sharing of participant data was not included in the informed consent of the study. Requests to access the datasets should be directed to Susan Garthus-Niegel, susan.garthus-niegel@uniklinikum-dresden.de.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (No: EK 278062015). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AZ and SG-N conceived the research question. AZ designed and prepared the statistical analyses. RS performed the statistical analyses and drafted the initial manuscript. MK and VK supported the conduction of the study, especially through data collection, and prepared the data for statistical analyses. JM supported the conduction of the study. SG-N acquired the funding, was responsible for conception and design of the basic DREAM study with its sub-studies as well as the coordination and supervision of the data collection and the ongoing cohort study. All authors contributed with the interpretation of the data, contributed to the manuscript revision, read, and approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

FUNDING

The DREAM study was funded by the German Research Foundation (Deutsche Forschungsgemeinschaft; DFG; grant numbers GA 2287/4-1 and GA 2287/4-2).

ACKNOWLEDGMENTS

We want to thank all (expectant) fathers for supporting our project. Furthermore, we want to thank all cooperating clinics and midwives for providing access to potential participants as well as all colleagues and (doctoral) students performing the recruitment.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 15 July 2021
doi: 10.3389/fpsyg.2021.668284

Examining the Effectiveness of the Fathers and Babies Intervention: A Pilot Study

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OPEN ACCESS

Edited by:
Jeannette Milgrom, Parent Infant Research Institute, Austin Health, Australia

Reviewed by:
Loredana Lucarelli, University of Cagliari, Italy
Marco Carotenuto, University of Campania Luigi Vanvitelli, Italy
Freya Thiel, Medical School Hamburg, Germany

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *15 February 2021*
Accepted: *21 June 2021*
Published: *15 July 2021*

Citation:
Tandon SD, Hamil J, Gier EE and Garfield CF (2021) Examining the Effectiveness of the Fathers and Babies Intervention: A Pilot Study. Front. Psychol. 12:668284. doi: 10.3389/fpsyg.2021.668284

There is increasing recognition of the importance of addressing the mental health of fathers, including during the perinatal period. Fathers exhibiting mental health concerns during the perinatal period are at heightened risk for future negative mental health outcomes and are less likely to engage in nurturing relationships with their children, leading to a sequalae of negative child outcomes during infancy and into adolescence. Although interventions have been developed for perinatal fathers, they typically do not focus directly on addressing paternal mental health. To fill this gap, we developed the Fathers and Babies intervention to be delivered to perinatal fathers whose partners (mothers) were enrolled in home visiting programs. A pre-post longitudinal study was conducted in which 30 father-mother dyads were recruited from home visiting programs. Fathers received the 12-session Fathers and Babies intervention while the mother concurrently received the Mothers and Babies intervention delivered to her by a home visitor. Baseline, 3- and 6-month self-report surveys were conducted with both fathers and mothers. Fathers and mothers had statistically significant decreases in perceived stress between baseline and both follow-up time points, with moderate effect sizes generated for both sexes. No statistically significant differences were found for depressive symptoms, anxiety symptoms, or perceived partner support, although we found small effects for reductions in depressive symptoms among fathers, as well as increases in the percentage of fathers and mothers who reported high levels of emotional and instrumental support post-intervention. While preliminary, these findings suggest the potential for Fathers and Babies to positively impact the mental health of fathers in the perinatal period, and also signal the viability of home visiting as a setting for delivering this intervention. Future research should employ a comparison group to generate stronger evidence of intervention effectiveness and include measurement of dyadic relationships and paternal parenting practices.

Keywords: intervention, home visiting, cognitive-behavioral therapy, paternal depression, maternal depression, behavioral technology

INTRODUCTION

Gradually over the past few decades, attention is being paid to paternal mental health and its impact on fathers and their children. Prevalence rates estimate that 5–13% of fathers will experience depression during their partner's pregnancy and the first year postpartum (Paulson and Bazemore, 2010; Cameron et al., 2016; Pace et al., 2016), with a recent meta-analysis indicating that prior mental illness and paternal unemployment were the strongest predictors of paternal depression, with financial instability, limited social support, and low level of paternal education also associated (Ansari et al., 2021). Two meta-analyses have also highlighted positive, moderate correlations between paternal depression and maternal depression (Paulson and Bazemore, 2010; Thiel et al., 2020). The transition into fatherhood itself has been associated with an increase in depressive symptoms of as much as 68% in the first 5 years after the birth of the child (Garfield et al., 2014). A systematic review of paternal anxiety during the perinatal period found that between 2 and 18% of fathers experience anxiety during their partner's pregnancy or in the first year postpartum (Leach et al., 2016), with a separate meta-analysis noting maternal depression, marital distress, and parental stress as having the strongest associations with paternal anxiety (Chhabra et al., 2020).

Paternal depression and anxiety have both been associated with decreases in positive father-child interactions and attachment (Wilson and Durbin, 2010; Davis et al., 2011; Vreeswijk et al., 2014; Nath et al., 2015). Poor paternal mental health has also been associated with delayed neuromuscular maturation at 6 months and increased negative interactions (corporal punishment) during infancy (Davis et al., 2011; Sethna et al., 2017). Beyond infancy, evidence of paternal depression in early fatherhood is a predictor of emotional and behavioral issues when the child is 4–5 years of age (Fletcher et al., 2011) and poor child language development (Paulson et al., 2009). Residing with fathers who exhibit depressive symptoms has also been associated with increased rates of emotional and behavioral problems among school-aged children and adolescents (Weitzman et al., 2011; Reeb et al., 2015). Paternal mood symptoms and disorders themselves are independently associated with child emotional and behavioral problems after adjustment for maternal psychological distress, predicting child emotional symptoms (Flouri et al., 2019), psychiatric disorders (Ramchandani et al., 2008), adolescent depressive symptoms (Lewis et al., 2017) and a range of problem behaviors, including conduct disorder and hyperactivity (Ramchandani et al., 2008; Flouri et al., 2019). Maternal depression, however, is an important mediator of the relationship between paternal depression and child behavior (Gutierrez-Galve et al., 2015), and children with two depressed parents are at particularly high long-term risk for mood disorders (Havinga et al., 2017).

Unfortunately, there has been limited attention placed on developing interventions specifically focused on addressing paternal mental health in the perinatal period. A systematic review conducted by Lee et al. (2018) found 19 interventions for fathers—delivered in the United States—during the perinatal period that had been tested using experimental or quasi-experimental designs. These interventions focused on general childbirth education and infant care, co-parenting skills, or case management with only four examining mental health outcomes (Diemer, 1997; Feinberg and Kan, 2008; Field et al., 2008; Salman-Engin et al., 2017). Of the four interventions that assessed paternal mental health, improvements in mental health were found only by Field et al. (2008) who generated reductions in paternal depressive symptoms via an intervention that taught fathers how to provide massages for their partner aimed at reducing pain and improving dyadic relationship quality.

Home visiting (HV) is a service delivery strategy that connects expectant parents and parents with young children with a designated supportive individual who may be a professional (e.g., nurse, social worker) or paraprofessional. There are 21 evidence-based HV models that have demonstrated positive impact on one or more maternal and child health outcomes using rigorous research designs (Office of Planning, Research and Evaluation, 2020). These HV models are voluntary and provide services in the family's home, with models typically focusing on discussion of infant and young child development, linkages to prenatal and pediatric care, preparation for childbirth, and referrals to external providers to address physical or psychosocial risks.

While HV programs typically focus on the mother as client, recent years have seen considerable emphasis placed on including and engaging fathers in HV services. Fathers have reported that they view HV programs as trusted sources of information and value the services and information provided by HV (Child and Family Research Partnership, 2013). Evidence-based HV models vary in their approaches to engaging fathers through their service delivery, with most models focusing their efforts on promoting responsible fatherhood (Sandstrom et al., 2015). Fathers who are engaged in HV services alongside their partner have shown increased knowledge of child development, more responsive parenting practices, and greater connection with education, employment, and other community resources (Sandstrom et al., 2015). However, we are unaware of previous attempts to focus directly on addressing the mental health needs of fathers who engage in HV services alongside their partners.

This study's overall aim was to develop and pilot test an intervention for fathers whose partners were enrolled in HV with the goals to improve paternal mental health and to help fathers support the mental health of their partner. FAB was designed to be delivered concurrently with the Mothers and Babies (MB) intervention—an evidence-based intervention based on principles of cognitive-behavioral therapy and attachment theory that has been found to be efficacious in preventing the onset of postpartum depression and reducing depressive symptoms via multiple randomized controlled trials (Muñoz et al., 2007; Le et al., 2011; Tandon et al., 2014, 2018; McFarlane et al., 2017), including several conducted in the context of HV (Tandon et al., 2014, 2018; McFarlane et al., 2017). A major goal of cognitive-behavioral approaches to is the development of skills for managing negative emotions and mood, which are often deficient in both mothers and fathers exhibiting depressive symptoms and underlie a parent's ability to engage in well-regulated and responsive parenting practices that promote

parent-child interaction and children's self-regulation. Thus, the cognitive-behavioral approaches found in maternal-focused interventions like MB were posited to have similar value in reducing mental health adversity among fathers. Additional details on MB can be found in Le et al. (2015), and a more detailed description of the partnership between our research team and HV stakeholders to develop FAB can be found in Hamil et al. (under review). This manuscript reports on the paternal and maternal mental health outcomes associated with our pilot testing of FAB among a diverse group of father/mother dyads enrolled in HV.

MATERIALS AND METHODS

Study Design and Participants

We used a single group longitudinal pre-post design to evaluate study outcomes. Nine HV programs served as project partners and referral sites. These HV programs had been previously trained on MB and had prior experience delivering MB to perinatal women. HV programs participated in a training webinar with study investigators to review FAB implementation, study design and participant recruitment. We received 37 father-mother dyad referrals, of whom 30 (81%) were enrolled.

Participants were initially screened for eligibility criteria by their HV programs. Eligibility requirements included English speaking dyads (mothers and fathers); women (mothers) ≥18 years old enrolled in HV programs who were pregnant or had a child ≤12 months old, and men (fathers) ≥18 years. The dyad (mother and father) both had to agree to participate in the study to be eligible. Non-biological fathers or biological non-resident fathers were eligible given the diverse relationship and co-habitation statuses of families receiving HV services.

Baseline demographic data for pilot participants (30 fathers and 30 mothers) are located in **Table 1**. Mean age for fathers was 27.7 years, while mothers' mean age was 26.5 years. Both fathers and mothers were nearly equally distributed across race/ethnicity (Black, Hispanic, White). Slightly less than half of the dyads were married or engaged. Eighty percent of dyads enrolled in the study after their child had been born and the mean age of these postnatal enrollees' children at time of enrollment was 3 months. Nearly all participants had obtained a high school degree or higher and all fathers were employed, at least part-time at baseline.

TABLE 1 | FAB pilot participants: baseline demographic characteristics.

Characteristics	Fathers (*n* = 30)	Mothers (*n* = 30)
Age (Mean, SD)	27.7 (6.0)	26.5 (5.5)
Race (N,%)		
Black/African American	11 (37)	10 (33)
Hispanic/Latino	9 (30)	9 (30)
White/Caucasian	8 (27)	8 (27)
Other	2 (7)	3 (10)
Week' Gestation (Mean, SD) among prenatal enrollees (*n* = 6)		30 (4.7)
Age in month of child (Mean, SD) among postnatal mothers (*n* = 24)		3 (2.7)
Employment status (N,%)		
Not currently working	0 (0)	18 (60)
Working part-time	5 (17)	7 (23)
Working full-time	25 (83)	5 (17)
Educational attainment (N,%)		
<High school degree	3 (10)	3 (10)
High school degree/GED	12 (40)	6 (20)
Some college or beyond	15 (50)	21 (70)
Relationship Status (N,%)		
Married	8 (27)	
Engaged	5 (17)	
Single	10 (33)	
Living with partner, not married/engaged	7 (23)	

Fathers and Babies Intervention

The FAB intervention is described in additional detail in Hamil et al. (under review). It was designed to be delivered to partners of women who concurrently received the 12-session version of the MB postpartum depression preventive intervention from their HV program. **Figure 1** depicts how FAB and MB are delivered. The initial FAB session was delivered in person or by phone by the home visitor working with the mother, and lasted 30 min on average. Subsequent sessions were delivered, in-person, via text message with embedded links to online content, or a mix of both in-person and text messages, depending on the preference and availability of the father. For fathers who received FAB in person, FAB content was delivered by the home visitor concurrent with delivery of MB to the mother using the FAB facilitator guide and FAB participant workbook. All fathers received the FAB workbook regardless of how they received the intervention to encourage them to use their workbooks to promote skill practice and to engage in conversations with their partner. The FAB facilitator guide provides instruction for delivering each of the 12 intervention sessions. Each session is broken into topics, with a script provided for each topic's didactic content and interactive activities, as well a summary of key points that should be covered. The FAB workbook consists of a series of worksheets that corresponds with the FAB facilitator guide—for example, Worksheet 1.1 aligns with the first topic of the first intervention session. Worksheets are designed to be visually appealing and interactive in nature, with each worksheet allowing fathers to engage in intervention content being delivered. The last topic of each session asks fathers to engage in a "personal project" that promotes the practice of one or more skills that were discussed in the session.

When a father did not receive his FAB session in person, the FAB session was "triggered" when the home visitor delivered a MB session to the mother. Specifically, after the mother received her MB session, the home visitor documented MB session completion in our HealthySMS platform (Aguilera et al., 2017)[1]—a web-based platform designed to send health-related text messages. Home visitor documentation of a completed MB session set in place the deployment of a series of text messages to the father. Fathers received three to six text

[1]www.healthysms.org

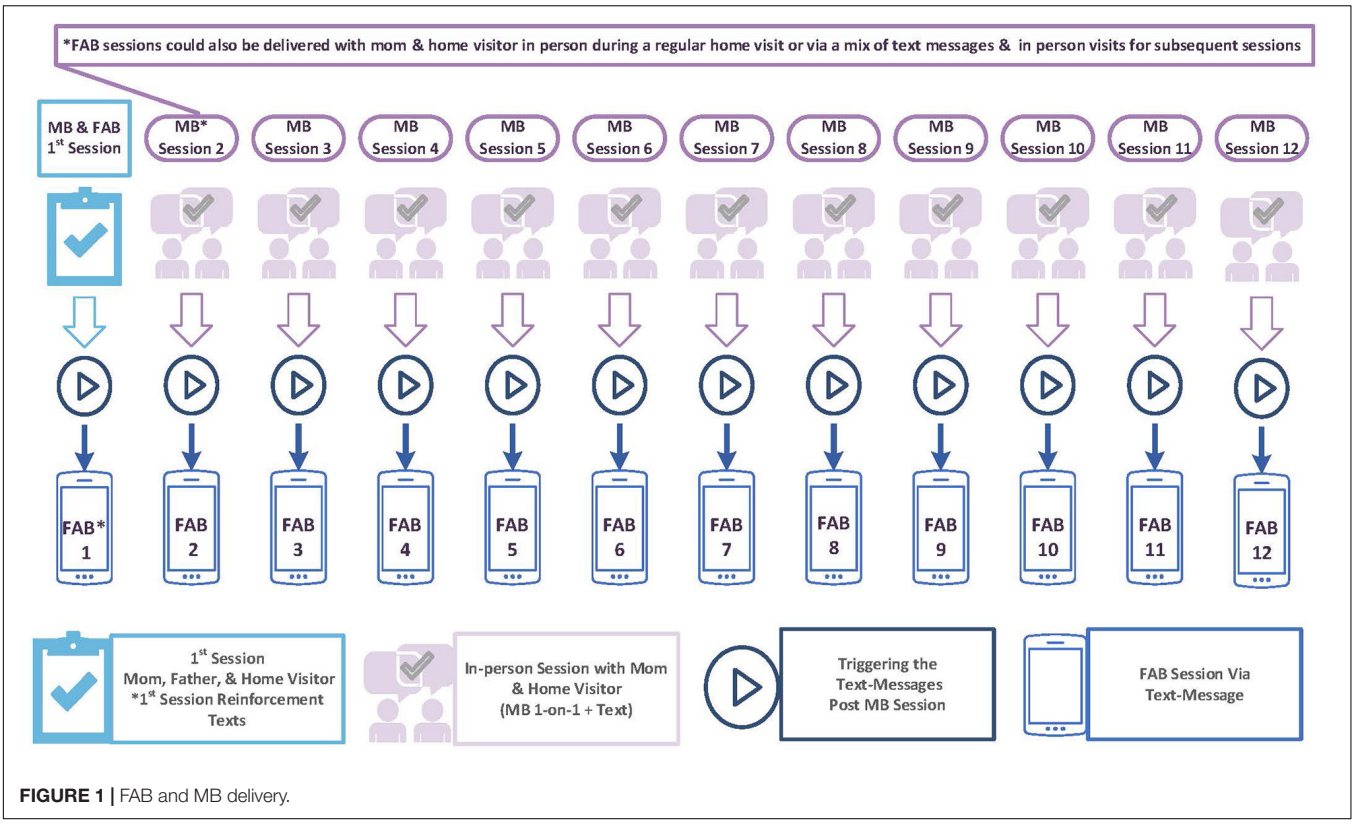

FIGURE 1 | FAB and MB delivery.

TABLE 2 | Example of the FAB text messages.

Skill reinforcement	Personal project reminder	Self-monitoring
Session 1: We can do activities, change our thoughts, and seek support to help us manage our stress. FAB will help you manage stress and help you support your partner. ***LINK: Worksheet 1.1***	Session 3: Pleasant activities can be low cost, brief, and part of our daily routines. You can do Pleasant Activities by yourself, with your partner, and with your baby. Link: https://www.first5california.com/en-us/videos/keeping-kids-physically-active-can-be-simple-and-fun/	Session 6: Have you noticed any harmful thoughts you have? Reply Y/N [Also tell us if you used one of the talking back strategies to reduce it.

messages per FAB session over the course of 7 days. The initial text messages had embedded links to external worksheets, videos, and other content that delivered the core FAB content. Subsequent text messages focused on reinforcing skill practice, reminding fathers to conduct personal projects assigned in the curriculum, and promoting self-monitoring of one's mood. An example of a text message in each of these three areas is provided in **Table 2**. Fathers did not receive more than one text message per 24-h period and messages were automated to be sent at different times during the day between 8 a.m. and 10 p.m. The three to six text messages delivered the same amount of session material (i.e., content in the text message itself and content found when clicking the embedded links) over the 7 days as one in person session (30 min). Mothers also received three supplemental text messages between each session to reinforce skill practice and remind them about their personal projects.

FAB is a 12-session intervention with content that mirrors the cognitive-behavioral therapy and attachment content found in MB. There is an introductory module followed by three cognitive-behavioral therapy modules: (1) pleasant activities, (2) thoughts, and (3) contact with others. **Table 3** briefly describes core content found in each FAB module. It also illustrates the core content found in each of the corresponding MB modules. The goal of concurrent delivery of FAB and MB was to have both the father and mother receive similar CBT-related content that will provide each of them with skills to improve their own mood and help them support their partner's use of cognitive-behavioral and attachment skills to also improve their partner's mood. For example, the third FAB session focused on encouraging fathers to identify pleasant activities to help alleviate their own stress that can be easily integrated into their daily lives and routines. This FAB session also encouraged fathers to support their partners' efforts to engage in pleasant activities as a way of attempting to improve mom's mental health as well. The FAB facilitator guide explicitly points out places where conversations are encouraged with one's partner around the CBT and attachment content being delivered.

TABLE 3 | Overview of Mothers and Babies (MB) and Fathers and Babies (FAB) content, by intervention module.

Intervention module	Sessions	MB content	FAB content
Introduction	1–2	Relationship between stress and mood	How stress affects father-baby interactions and the relationship with your partner
		How stress affects mother-baby interactions	Purpose and overview of FAB
		Purpose and overview of MB	Relationship between stress and mood
		Importance of noticing one's mood and its triggers	Importance of noticing one's mood and its triggers
		Introduction to Quick Mood Scale	Introduction to Quick Mood Scale
Pleasant Activities	3–5	Relationship between pleasant activities and mood	Relationship between pleasant activities and mood
		Brainstorm pleasant activities to do alone, with adults, and with children	Brainstorm pleasant activities to do alone, w/adults, and w/children
		Pleasant activities with child can promote maternal-child bonding	Pleasant activities with child can promote paternal-child bonding
		Identify pleasant activities for mother-child bonding across baby's first year	Identify pleasant activities for father-child bonding across baby's first year
		Overcome obstacles to mothers doing pleasant activities	Overcoming obstacles to fathers doing pleasant activities
			Strategies to support mother's engagement in pleasant activities
Thoughts	6-8	Relationship between thoughts and mood	Relationship between thoughts and mood
		Helpful and unhelpful thoughts about being a mother	Helpful and unhelpful thoughts about being a father
		Ways unhelpful thoughts inhibit maternal responsiveness	Ways unhelpful thoughts inhibit paternal responsiveness
		Ways to change unhelpful thought patterns	Ways to change unhelpful thought patterns
		Goals for my future	Goals for my future and ways to support my partners' goals
		Goals for my baby's future, including understanding importance of maternal-child bonding	Goals for my baby's future, including understanding importance of paternal-child bonding
Contact with others	9–12	Relationship between mood and contact with others	Relationship between mood and contact with others
		Identify supportive people in one's life and the ways they provide support to me and my child	Identify supportive people for me, my child, and my partner
		Communication styles to help get needs met	Communication styles to help get needs met
		Role changes and how they can increase need for social support	Role changes in becoming a father
		Role changes impact on relationship with other children	Role changes and how they increase need for social support in both mothers and fathers
			Role changes impact on relationship with other children

Data Collection

The Northwestern University Institutional Review Board approved all study procedures. Fathers and mothers completed three self-report assessments—at baseline, 3-month follow-up, and 6-month follow-up. Survey links were sent via Research Electronic Data Capture (REDCap) (Harris et al., 2009) or administered via telephone by a member of the research team for participants who did not choose to complete their survey online. Participants provided informed consent via REDCap or via telephone prior to starting their baseline assessment. Compensation was $20 for completing the baseline and 3-month follow-up survey and $35 for completing the 6-month follow-up survey. All participants also received a stipend of $5 dollars per month while receiving the intervention to help offset text messaging costs. Dosage data was obtained from HealthySMS. Home visitors used HealthySMS to document completion of a MB intervention session, which also deployed FAB content to the father via text message if the father was not present for an in-person intervention session. A session was considered complete for both MB and FAB when the home visitor documented MB session completion in HealthySMS.

Among the 30 fathers who enrolled in the study, 80% (24/30) and 57% (17/30) completed 3- and 6-month follow-up assessments, respectively. For mothers enrolled in the study, 90% (27/30) and 77% (23/30) completed 3- and 6-month follow-up assessments, respectively.

Instruments

Beck Depression Inventory-II (BDI-II) (Beck et al., 1988)

The BDI-II was used to assess severity of depressive symptoms consistent with DSM-IV symptom criteria. The BDI-II is a 21-item survey that asks respondents to indicate on a 4-point scale ranging from 0 to 3 the extent to which they endorse different symptoms of depression over the past 2 weeks with higher scores indicating greater depression severity.

Generalized Anxiety Disorder 7-Item Scale (GAD-7) (Spitzer et al., 2006)

The GAD-7 is a 7-item survey that asks respondents to indicate on a 4-point scale the extent to which they endorse different

symptoms of anxiety over the past 2 weeks with higher scores indicating greater anxiety symptoms.

Perceived Stress Scale 10-Item Scale (PSS-10) (Cohen and Williamson, 1988)

The PSS-10 is a 10-item survey that asks respondents to indicate on a 5-point scale the extent to which they appraised certain situations as stressful over the past month, with higher scores indicating greater perceived stress.

Social Support Effectiveness Questionnaire (SSE-Q) (Rini et al., 2011)

The SSE-Q is a 25-item survey that asks respondents to indicate the extent to which their partners provided different types of support in the past 3 months. The SSE-Q consists of subscales on task support, informational support, emotional support, and negative effects of support. For this study, we calculated a total social support score that summed these four subscales (range 0–80).

NIH Toolbox Instrumental Support and Emotional Support Survey (Cyranowski et al., 2013)

Each survey consists of 8 questions and asks respondents to indicate on a 5-point scale the extent to which they have received different types of instrumental and emotional support in the last month. Higher scores indicate greater support.

Analysis

Descriptive data (mean, standard deviation, range) were generated for all demographic variables and study outcomes. To assess paternal and maternal outcomes on the BDI-II, GAD-7, PSS-10, and SSE-Q, we conducted a series of paired t-tests with Bonferroni correction for multiple comparisons. *T*-tests compared baseline scores on each outcome to 3-month follow-up scores, with separate *t*-tests conducted to examine changes between baseline and 6-month follow-up. We used a Cohen's *d* statistic (Cohen, 1988) to indicate effect sizes for our BDI-II, GAD-7, and PSS-10 outcomes. We calculated the percentage of mothers and fathers who reported scores above the cutoff for elevated depressive symptoms (BDI-II $>$ 13) who moved below the cutoff at the 3- and 6-month follow-up time points. Similar analyses were conducted examining the percentage of mothers and fathers reporting scores above the cutoff for moderate severity of anxiety symptoms (GAD-7 $>$ 10) who moved below the cutoff at each follow-up assessment. For the Instrumental and Emotional Support scales, we calculated the percentage of respondents at each time point who scored one standard deviation or more above the normed mean score of 50 which is suggestive of high levels of support (Cyranowski et al., 2013).

RESULTS

FAB Dosage

Fathers participating in the FAB intervention received an average of 7.7 sessions (4.5SD), with a range of sessions from 1 to 12. The mode number of sessions received was 12, with 14 of the 30 (47%) of participants receiving the full FAB intervention. Dosage was identical for mothers receiving MB, as receipt of a MB session was the trigger for a father to have received his FAB intervention content (**Figure 1**).

Paternal Mental Health Outcomes

Fathers on average entered the study with baseline scores of 6.5 on the BDI-II and 4.1 on the GAD-7, which fall into the mild symptom range for each assessment. Perceived stress at baseline was 14.9, which is suggestive of moderate stress levels. We found symptom declines for each outcome between baseline and 3-month follow-up with small, additional, symptom decline occurring between the 3- and 6-month follow-ups. Statistically significant improvements in perceived stress were found when comparing baseline to 3-month follow-up and 6-month follow-up means; observed *d* scores were 0.48 and 0.66, respectively, at each follow-up timepoint, indicative of moderate effect sizes. No statistically significant differences were found when comparing baseline and follow-up anxiety or depressive symptom scores, although *d* scores indicate small effect sizes when examining the magnitude of change in depressive symptoms. Among the five fathers who entered the study with elevated depressive symptoms, only two remained in the elevated range at both the 3- and 6-month follow-ups. Only one father entered the study with moderate anxiety symptoms, with this father dropping below the cutoff for moderate symptoms at the 3-month follow-up but returning to the moderate range at the 6-month time point. Paternal mental health outcomes are summarized in **Table 4**.

Maternal Mental Health Outcomes

Mothers on average entered the study with higher baseline scores on the BDI-II (9.7) and the GAD-7 (6.8), although these scores still fall into the mild symptom range. Perceived stress at baseline was 20.4, which also falls into the moderate stress range. Similar to fathers, statistically significant reductions in perceived stress were found when comparing baseline to 3- and 6-month follow-ups, with observed *d* scores (0.57, 0.47) indicating moderate effect sizes. No statistically significant differences were found when comparing baseline and follow-up depressive symptom or anxiety symptom scores, although a small effect (d = 0.21) was found in examining the magnitude of change in depressive symptoms between baseline and 3-month follow-up. There were seven mothers who entered the study with elevated depressive symptoms, with five of these mothers remaining in the elevated range at both the 3- and 6-month follow-ups. Four mothers entered the study with moderate anxiety symptoms, with two of these mothers remaining in this range at both follow-up time points. Maternal mental health outcomes are summarized in **Table 4**.

Social Support Outcomes

Fathers reported greater perceived support from their partner than mothers at baseline on the SSE-Q, although fathers' perceptions of partner support decreased slightly over time. Mothers reported increased levels of perceived support from their partners at both follow-up assessments compared to baseline, although these improvements were not statistically significant.

TABLE 4 | Paternal and maternal outcomes from FAB pilot study.

	Fathers[a]					Mothers[b]				
	Baseline	3-Month		6-Month		Baseline	3-Month		6-Month	
	Mean (SD)	Mean (SD)	*d*	Mean (SD)	*d*	Mean (SD)	Mean (SD)	*d*	Mean (SD)	*d*
Depressive symptoms	6.5 (6.6)	4.5 (4.6)	0.35	3.6 (5.1)	0.24	9.7 (8.1)	8.4 (9.5)	0.21	8.3 (8.4)	−0.02
Anxiety symptoms	4.1 (4.5)	3.2 (3.4)	0.20	2.8 (3.2)	0.13	6.8 (5.5)	6.2 (5.1)	0.11	6.3 (4.8)	−0.08
Perceived stress	14.9 (7.6)	12.6 (7.1)[c]	0.48	10.9 (9.1)[c]	0.66	20.4 (9.1)	16.9 (7.4)[c]	0.57	16.8 (6.8)[c]	0.47
Social support effectiveness	60.9 (14.3)	57.8 (12.6)		59.3 (13.7)		48.9 (11.6)	51.4 (14.5)		52.2 (12.2)	
High emotional support[d]	30%	24%		50%		22%	32%		22%	
High instrumental support[d]	27%	28%		38%		13%	29%		41%	

[a] *Sample size at baseline (n = 30), 3-month follow-up (n = 24), 6-month follow-up (n = 17).*
[b] *Sample size at baseline (n = 30), 3-month follow-up (n = 27), 6-month follow-up (n = 23).*
[c] $p < 0.05$.
[d] *Percentage of respondents one standard deviation or more above normed mean.*

Results from the NIH Toolbox Instrumental Support survey found increases in both the percentage of fathers and mothers who exhibited high levels of instrumental support, as defined by scores = one standard deviation above the normed mean. We found that 27% of fathers exhibiting high instrumental support at baseline compared to 38% at 6-month follow-up while 13% of mothers exhibited high instrumental support at baseline compared to 41% at 6-month follow-up. A similar pattern was found among fathers when examining emotional support, with the percentage of fathers exhibiting high emotional support increasing from 30 to 50% between baseline and 6-month follow-up. Paternal and maternal social support outcomes are summarized in **Table 4**.

DISCUSSION

This study developed and pilot tested FAB among a diverse group of fathers whose partners were enrolled in HV programs and concurrently received the evidence-based MB intervention. Results on the pilot study's acceptability and feasibility are presented in Hamil et al. (under review), with this manuscript describing paternal and maternal mental health outcomes associated with the FAB pilot study. Consistent with previous research, we found that mothers exhibited greater anxiety and depressive symptomatology than fathers (Wee et al., 2011; Darwin et al., 2021). We found statistically significant decreases in perceived stress among both fathers and mothers with corresponding moderate effect sizes. We also found small effect sizes associated with the magnitude of depressive symptom reduction among fathers. Results related to social support were mixed. Our measure of perceived partner support did not elicit any changes over time; however, broader assessment of social support found increases among both males and females who reported high levels of emotional and instrumental support post-intervention.

Fathers experience unique stressors during the perinatal period. From pregnancy, through the child's birth and into infancy, fathers have been noted to experience stress related to negative feelings about pregnancy, changes in roles and responsibilities, and feeling incompetent in childcare (Philpott et al., 2019). Stress during this time period can in turn contribute to adverse mental health outcomes for fathers themselves and for their children. As such, our findings that FAB was able to significantly reduce paternal stress is notable. A systematic review conducted by Philpott et al. (2019) found that among 11 studies that reported on the impact of stress on fathers in the perinatal period, eight studies reported an association between higher stress levels and paternal mental health concerns including depression and anxiety (Johnson and Baker, 2004; Gao et al., 2009; Mao et al., 2011; Kamalifard et al., 2014; Wee et al., 2015). Paternal stress during the perinatal period has also been associated with behavioral concerns among fathers' offspring during infancy and into early childhood (Choi et al., 2018; Lee et al., 2018). A recent meta-analysis found that perceived stress was among the strongest predicators of paternal postpartum depression (Ansari et al., 2021), suggesting that efforts to reduce perceived stress among fathers in the prenatal and early postpartum period may prevent the onset of postpartum depression and reduce depressive symptoms among fathers in the postpartum period. This is consistent with findings from our FAB pilot which found declines in paternal perceived stress and paternal depressive symptoms at both follow-up time points.

We found little change in perceptions of partner support, although there was some evidence suggesting that both fathers and mothers perceived higher levels of emotional and instrumental support post-intervention. Although discussion of social support permeates the entire FAB and MB curricula, most discussions occur during the last three intervention sessions. It is possible that more intentional focus on social support may need to be incorporated into earlier intervention content, along with additional and more prescriptive language for fathers on how to provide different types of support to their partner. Fathers and mothers receiving FAB and MB, respectively, may also have needed more time to practice using the social support skills taught in the intervention and that improved perceptions of partner support may have been exhibited if data collection had extended beyond 6 months. Our dosage data also indicated that

while nearly half of the dyads received the entire FAB and MB interventions, the mean number of sessions on average was less than 8, which roughly translates to receipt of two-thirds of the intervention. Thus, several dyads in our sample did not receive the social support content found in FAB/MB since that content was found in the final module that began with session 9.

HV programs are an ideal setting for interventions aimed at improving paternal and maternal health and well-being. HV services delivered in a family's home can serve large numbers of families, including the ones most in need of mental health services and those who are challenging to reach. Father engagement has been a high priority for HV programs in recent years, with a growing set of promising practices emerging (Sandstrom et al., 2015). Many of these practices have been incorporated into FAB, including father-centric engagement strategies, tailored content specific to fathers' needs and experiences, and flexible delivery via text messages with embedded links to intervention content.

FAB is also likely to be of interest to HV programs who are seeking approaches to address maternal depression among their clients. It is estimated that nearly half of HV clients experience major depression or elevated depressive symptoms (Ammerman et al., 2010; Michalopoulos et al., 2015). MB has been increasingly sought out by HV programs for this reason, given its strong evidence base in preventing onset of major depression and reducing depressive symptoms among HV clients (United States Preventive Services Task Force et al., 2019). In light of this evidence base, MB has been designated by the Health Resources and Services Administration's MIECHV HV initiative as an "approved" referral for HV clients who are experiencing depressive symptoms or major depression. As HV programs have been trained on MB in recent years, many have inquired about the availability of services and supports for fathers, which was a catalyst for our developing FAB. Findings presented in this manuscript about FAB's impact on paternal and maternal mental health, juxtaposed with strong acceptability and feasibility data (Hamil et al., under review), suggest that FAB will be viewed as a potentially impactful tool for engaging fathers in HV services and improving their mental health. Fathers' participation in HV services have been shown to promote mothers' HV program engagement (Eckenrode et al., 2000; Korfmacher et al., 2008), which may also incentivize HV programs' adoption of FAB. There may also be benefits for the mental health of mothers enrolled in HV if their partner receives FAB. Paternal depression has been consistently associated with elevated maternal depression (Paulson and Bazemore, 2010; Thiel et al., 2020), and persistence of maternal postpartum depression has been shown to be directly influenced by the presence of depression in their partners (Vismara et al., 2016). Thus, implementation of FAB in conjunction with MB may allow HV programs to more effectively address maternal depression than through their usual services, or their usual services enhanced only with mental health interventions that are maternal-focused.

Study Strengths and Limitations

This study is among the first to examine paternal mental health outcomes associated with receipt of an intervention for fathers in the perinatal period. Moreover, FAB is the first intervention to our knowledge that explicitly focuses on paternal mental health that has been implemented in the United States (Lee et al., 2018), although researchers in Australia (Mihelic et al., 2018) and Pakistan (Husain et al., 2021) have also developed mental health interventions for perinatal fathers. We recruited a sample of racially and ethnically diverse fathers, including non-biological partners or biological non-resident fathers, given the growing number of households with contemporary family structures like these (Child Trends, 2018). Fathers from diverse racial and ethnic backgrounds also exhibit higher rates of unemployment than their white counterparts (Bureau of Labor Statistics, 2020). Given that paternal unemployment has been shown to be the strongest predicator of paternal depression (Ansari et al., 2021), our inclusion of racially and ethnically diverse fathers in our pilot suggests that we are focusing on fathers at heightened risk for poor mental health outcomes. This study is also strengthened by integrating FAB into an existing service—HV—that is trusted by fathers (Sandstrom et al., 2015) and has great potential for scaling given the presence of HV across the United States.

There are important limitations to consider in interpreting our study findings. Our pilot did not include a comparison group, so it is possible that the improvements in mental health outcomes were associated with forces external to FAB. This is perhaps more likely for mothers who were simultaneously receiving HV services since these services may have helped to offset stressors via provision of different types of instrumental (e.g., diapers) and informational (e.g., knowledge of child development) support. We were only able to collect pre-birth depressive symptoms from 25% of enrolled fathers since the other 75% of fathers enrolled postnatally. Attrition among fathers at our follow-up time points was higher than among mothers, thereby limiting generalizability of our findings. This could attributed to the fact the mothers had pre-existing relationships with their HV program and, therefore, may have had a stronger relationship with them than the fathers by virtue of being the primary HV client. Given the limitations of our sample size, we did not conduct analyses examining potential dosage effects of FAB. It is possible that fathers who received more FAB content exhibited improved outcomes. Modest impact on paternal or maternal social support alluded to a possible dosage effect, as individuals who did not receive the full intervention would not have benefited from the social support module which is delivered at the end of the FAB intervention. It is also important to point out that in calculating dosage, fathers who had the series of FAB text messages for a session deployed to them were deemed to have received that session although there may have been variability in the amount of time spent by fathers reviewing intervention content. Finally, fathers entered the study with relatively mild depressive symptoms. While some maternal and paternal depressive symptoms are common in the perinatal period, fathers are more likely to present with irritability symptoms as well as alcohol and substance use (Walsh et al., 2020). Future research examining FAB intervention effects should consider using an assessment tool specifically designed to capture paternal depression symptoms that includes somatization and externalizing items that are likely to be more commonly endorsed among men (Psouni et al., 2017).

Future Directions

Future testing of FAB's impact on paternal and maternal mental health outcomes is needed using experimental designs to provide stronger evidence of the intervention's effectiveness. This future research should continue to examine mental health and father engagement outcomes, but also expand its focus to examine other outcomes related to dyadic relationships. Longitudinal follow-up beyond 6 months could also help illuminate whether effects on paternal and mental health seen in this pilot are sustained over time and whether other outcomes such as social support may exhibit improvements after intervention recipients are able to practice core cognitive-behavioral therapy skills related to expanding and more effectively activating one's support network. Given the strong interest among HV programs in father engagement, future research should also examine whether participating in an intervention like FAB is associated with fathers' engagement in other types of HV services. Data could also be collected from HV programs' management information systems to ascertain potential impact of FAB on mothers' program retention.

Subsequent trials should also consider selection criteria for FAB participants. For our pilot, we did not exclude dyads except if they had a child > 12 month old or did not feel comfortable receiving the intervention in English. Meta-analyses have identified risk factors most strongly associated with paternal (Ansari et al., 2021) and maternal (Guintivano et al., 2018) depression. For example, history of previous depression and relationship discord are two of the strongest predictors of both paternal and maternal depression. Although delivering of FAB and MB universally may be desirable to HV programs since it de-stigmatizes intervention participation, we may find greater evidence of intervention effectiveness if additional inclusion and exclusion criteria were added that would identify individuals at greatest risk for poor mental health outcomes in the perinatal period.

Results from this study also suggest that there may need to be revisions made to FAB content, and the manner in which the intervention is delivered, to heighten its impact. In light of our pilot findings and data related to the intervention's feasibility and acceptability (Hamil et al., under review), we are refining intervention content in several ways, such as the inclusion of additional skills-based activities to improve perceptions of social support and tailoring content that model FAB skills across child development phases. We are also creating a welcome packet for fathers and adding more father-centric graphic design elements into the FAB curriculum as strategies for promoting greater engagement with intervention content.

HV programs are not the only setting where perinatal women present for services. Accordingly, as FAB is further refined and tested it is important to think about other settings in which the intervention could be implemented that could reach fathers such as primary care clinics and community health centers. There may also be settings where fathers are more easily reached such as employment or "re-entry" programs. While FAB is currently developed to be delivered concurrently with MB, it may be useful to also think of FAB as a free-standing intervention to reach a larger number of perinatal fathers who could from its content uncoupled from MB implementation.

CONCLUSION

With the gradual increase in research to understand the contributions fathers make to families, national and international professional societies have called for greater focus on fathers and their mental health. Among these is the most recent American Academy of Pediatrics clinical report on fathers and pediatrics which highlights advances in understanding the role fathers play and the impact paternal depression may have on the family (Yogman et al., 2016). Similarly, HV programs are calling for improved services, along with evaluations of these services, as one way to support fathers and the needs of the entire family ecosystem. As more research becomes available on the association of paternal mental health and downstream child outcomes, programs such as FAB will be critical as they meet a growing need and can be disseminated at scale to serve a diverse population of men during the transition to fatherhood. At the heart of this work is the notion that the health and human services sector needs to be transformed to provide additional supports—especially as relates to fatherhood wellbeing and mental health. Doing so ensures that fathers are supported to the benefit of themselves, their partners and their children.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Northwestern University School of Medicine Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

ST, JH, and CG were responsible for the design of the work. JH oversaw data collection. ST, JH, and EG were involved in data analysis. All authors were involved in interpretation of findings, drafting the article, critically reviewing the article, and have approved of the version that has been submitted.

FUNDING

This project was supported via funding from the National Institutes of Health/National Institute on Minority Health and Health Disparities (R21 MD011320-01 to DT) and the Illinois Children's Healthcare Foundation (DT).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 06 August 2021
doi: 10.3389/fpsyg.2021.667577

The Impact of Parental Relationship Satisfaction on Infant Development: Results From the Population-Based Cohort Study DREAM

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OPEN ACCESS

Edited by:
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Reviewed by:
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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *13 February 2021*
Accepted: *05 July 2021*
Published: *06 August 2021*

Citation:
Nicolaus C, Kress V, Kopp M and Garthus-Niegel S (2021) The Impact of Parental Relationship Satisfaction on Infant Development: Results From the Population-Based Cohort Study DREAM. Front. Psychol. 12:667577. doi: 10.3389/fpsyg.2021.667577

Extensive literature has shown that interparental conflicts and violence have detrimental effects on children's adjustment in childhood and adolescence. It is not equally well-understood how parental relationship satisfaction impacts infant communicational and personal-social development during the first year of life. This longitudinal study examines (a) the impact of maternal and paternal relationship satisfaction on infant development, (b) whether this prospective association is mediated by parent-infant relationship, and (c) a potential moderating effect of infant gender. Data were derived from the population-based cohort study "Dresden Study on Parenting, Work, and Mental Health" (DREAM) including 1,012 mothers and 676 fathers. Relationship satisfaction and parent-infant relationship were assessed eight weeks postpartum, infant communicational and personal-social development were measured 14 months postpartum. Multiple linear regression, mediation, and moderation analyses were conducted for mothers and fathers separately. It was shown that paternal relationship satisfaction is a significant predictor of infant personal-social development. This prospective association was partially mediated by father-infant relationship. When postnatal depression was included in the analysis, however, father-infant relationship was not a significant mediator. The association in fathers is neither reduced nor increased as a function of infant gender. No similar effects were found in the mothers' sample. Parental relationship satisfaction did not significantly predict infant communicational development in either mothers or fathers. The study findings highlight the importance of paternal relationship satisfaction, father-infant relationship, and postnatal depression for infant personal-social development.

Keywords: relationship satisfaction, couples, parent-infant relationship, infant development, longitudinal research, DREAM study

INTRODUCTION

The family context forms the central living environment for young children and is often seen as the most proximal system by which children are socialized (Bush and Peterson, 2013). Hence, besides other social, environmental, and biological factors, the family system is an essential influential factor for child development (e.g., Bronfenbrenner, 1979; Feldkötter et al., 2019). On the one hand, it offers a fundamental resource pool, on the other hand, it represents a potential origin of risk factors for child development (O'Brien, 2005; Garthus-Niegel et al., 2017; Junge et al., 2017; Polte et al., 2019; Thiel et al., 2020). The first years of life are a particularly formative time during which certain experiences can have a maximally positive or negative impact on further life (Montada, 2008). Therefore, the experiences children have in their early years are of enormous importance for further development and long-term mental health (Harold et al., 2016). The strength and adaptive functioning of the inter-parental relationship can have particularly profound implications for child well-being and development (Grych and Fincham, 2001; Goldberg and Carlson, 2014). It is widely acknowledged that this relationship represents a key element in determining the quality of family life (Erel and Burman, 1995; Goldberg and Carlson, 2014; Feldkötter et al., 2019).

Emerging research indeed demonstrates an association between parental relationship and child development. Available evidence on negative features of the parental relationship, such as conflicts and violence, indicates that higher levels of unresolved conflict and discord are associated with various child emotional and behavioral problems, insecure attachment to parents, social difficulties, less academic and educational attainment, and worse relationship stability in later life (Fishman and Meyers, 2000; Harold et al., 2016). In contrast, the literature concerning positive aspects of parental relationship, such as intimacy or constructive communication, is sparse (Dominick, 2018). Studies suggest that parents' supportiveness of one another, positive affect, and the ability to resolve conflict and communicate effectively are positively linked to better child behavioral outcomes (e.g., Goldberg and Carlson, 2014; Feldkötter et al., 2019). Furthermore, Cowan and Cowan (2005) showed that strengthening the partner relationship positively impacts both child adjustment and parent-child relationship.

In this context, mechanisms of action, explaining how and why relationship quality is related to child outcomes, have yet to be identified. Family system theory emphasizes that individuals cannot be understood in isolation from one another, but rather as a part of their family. Thus, families are conceptualized as a dynamic and integrated whole, in which individual family members are influenced by one another (Minuchin, 1988; O'Brien, 2005). Changes in the relationship between certain family members are believed to affect the development and growth of other individuals within the family. Hence, the manner in which parents communicate and relate to each other is important for their children's development, because it affects children both directly and indirectly (Goldberg and Carlson, 2014). In terms of direct effects, social learning theory proposes that children imitate the behavior and interactions of significant others, especially their parents (Bandura, 1978). Therefore, loving and constructive interaction between parents may produce similar behavioral styles in children. In addition, spillover theory can provide an additional explanation for the link between parental relationship quality and child outcomes. It postulates that emotions or behaviors generated in one family subsystem are transferred to another within the family system (Harold et al., 2016; Dominick, 2018). Therefore, parental relationship also affects children's development indirectly through its influence on parenting behaviors. Accordingly, parental relationship quality may be directly related to specific parenting behaviors, because difficulties, stress, or anger produced in the dyadic couple relationship may carry over into the parent-child relationship, which in turn may impact child development. Spillover theory has received strong empirical support (e.g., Krishnakumar and Buehler, 2000; Bradford and Barber, 2005; Harold et al., 2016). Feldkötter et al. (2019) found that the negative association between relationship satisfaction and child problem behavior was mediated by negative parental behavior and parental stress. Similarly, Cox et al. (1989) showed that mothers who experienced their partnership as close and open-minded also expressed more warmth and sensitivity toward their infant during playing interactions. Howard and Brooks-Gunn (2009) noted that a supportive relationship between parents is associated with positive parenting behaviors. In turn, positive and empathetic interactions between the reference person and the child are an essential prerequisite for adequate communicative and personal-social development (Papoušek, 2006; Mensah and Kuranchie, 2013).

The association between parental relationship quality and child development may vary depending on child gender. Although both girls and boys are affected by parental relationship quality, they may respond differently (Grych et al., 2003). Previous research suggests that boys are more likely to perceive conflicts between their parents as a threat to themselves, whereas girls are more likely to interpret them as a threat to family harmony (Grych et al., 2003; Harold et al., 2016). In addition, compared to boys, girls may hold themselves more accountable for interparental conflicts (Buchanan et al., 1991; El-Sheikh and Reiter, 1996). However, past research yielded ambiguous results. For example, Davies and Lindsay (2001) showed that parental conflict (i.e., avoidance-surrender and verbal aggression) had a greater impact on externalizing problems in boys and internalizing problems in girls. In contrast, other studies found no significant differences regarding the association between parental relationship and well-being of female versus male children (Fishman and Meyers, 2000; Goldberg and Carlson, 2014). And still other studies found that interparental disagreements had a greater impact on boys (Emery and O'Leary, 1982; Reid and Crisafulli, 1990). Resulting from these discrepant findings, the effect of child gender on the prospective association between parental relationship quality and developmental outcomes requires explication.

Preceding research provides theoretical and empirical support for the notion that parental relationship quality plays an important role in child development. Nevertheless, previous research on the consequences and correlates of parental

relationship satisfaction was primarily focused on late childhood and adolescence, including children aged 10 years and older. Research pertaining to early childhood, including infants and toddlers, is sparse (Dominick, 2018). Because the first years of life have a considerable impact on further development (Bedi and Goddard, 2007), studies focusing on the effects of parental relationship satisfaction on their children's first year are needed. This study extends existing literature by taking into account this prospective association during infancy. Additionally, the present study addresses the relationship of *positive* interparental interactions, which has received relatively little prior empirical attention. Whereas a large number of studies primarily examined marital conflict behavior and consequences of separation (Dominick, 2018; Feldkötter et al., 2019), the present study broadens the view and considers not only dispute behavior, but also positive features of the couple relationship, such as endearment and community/communication. Both parents are considered in this investigation to create a more comprehensive picture of the prospective associations between parental relationship satisfaction, parent-infant relationship, infant gender, and infant development.

In light of the empirical and theoretical considerations stated above, the aim of this longitudinal study is to examine the prospective association between maternal and paternal relationship satisfaction at eight weeks postpartum and infant development at 14 months postpartum, controlling for a set of potential confounders. It is hypothesized that higher levels of maternal and paternal relationship satisfaction are prospectively and directly associated with better infant communicational and personal-social development. In addition, the study aims to investigate whether infant gender moderates the direct association between parental relationship satisfaction and infant communicational and personal-social development. Due to prior mixed findings in this area, no specific hypothesis is postulated. Further, it is assumed that for mothers and fathers, parent-infant relationship mediates the positive association between parental relationship satisfaction and infant communicational and personal-social development, i.e., higher levels of parental relationship satisfaction are related to better parent-infant relationship, which in turn is linked to positive infant developmental outcomes.

MATERIALS AND METHODS

Design

Data were derived from the Dresden Study on Parenting, Work, and Mental Health ("**DR**esdner **S**tudie zu **E**lternschaft, **A**rbeit und **M**entaler Gesundheit," **DREAM**). This prospective multi-method cohort study examines "the relationship between parental work participation, role distribution, stress factors, and their effects on perinatal outcomes and long-term family mental and somatic health […]" (Kress et al., 2019, p. 1). Expectant mothers and their partners were recruited during pregnancy, mostly at obstetrical clinics' information events and birth preparation courses in and around Dresden, Germany. DREAM is a longitudinal study consisting of six measurement points spanning over the course of pregnancy to 4.5 years postpartum. Various questionnaires are completed by (expectant) mothers and their partners at each time point.

The current investigation included data of the first three measurement points: T1: during pregnancy, T2: eight weeks after the anticipated birth date, and T3: 14 months postpartum. Further details regarding DREAM study design and measures can be found in the study protocol (Kress et al., 2019) and **Supplementary Figure 1**.

Participants

The present study included data from women and men who were expecting one child, completed T1–T3, and indicated being in a relationship with the other biological parent. The retention process is presented in **Supplementary Figure 2**. Mothers and fathers could take part in the study alone or with their partner. At the time of data extraction (3rd of December 2020), $n = 1{,}065$ women and $n = 695$ men completed T3 in time. Because of the aforementioned inclusion criteria, $n = 24$ (2.3%) mothers and $n = 12$ (1.7%) fathers with twins or multiples were excluded, as well as $n = 28$ (2.7%) mothers and $n = 6$ (0.9%) fathers who were not in a relationship with the other biological parent. Likewise, $n = 1$ (0.0%) mother and $n = 1$ (0.1%) father were excluded because their infant was living separated from them. The final sample included $n = 1{,}688$ parents, consisting of $n = 1{,}012$ mothers and $n = 676$ fathers.

Measures

Parental relationship satisfaction was measured via the validated German short version of the relationship questionnaire ("Kurzform des Partnerschaftsfragebogens," PFB-K; Kliem et al., 2012) at T2, i.e., eight weeks after the anticipated birth date. The questionnaire consists of three subscales (endearment, dispute behavior, and community/communication) with three items, respectively. Each item was rated on a scale from 0 (*never/very rare)* to 3 *(very often)*, and the total score for the whole scale was obtained by summation of all items ranging from 0–27. Higher scores reflect higher levels of parental relationship satisfaction. In the current sample, internal consistency was high for both mothers ($\alpha = 0.80$) and fathers ($\alpha = 0.78$).

Parent-infant relationship was measured with the German version of the Postpartum Bonding Questionnaire (PBQ; Reck et al., 2006) at T2. The PBQ was designed to provide an early indication of disorders within parent-infant relationships (Brockington et al., 2001), comprising 25 items on four dimensions, namely *general factor*, *rejection and anger*, *anxiety about care*, and *risk of abuse*. Parents are asked to think of the most difficult time with their infant and to rate how frequently they experience each situation. Items are scored from 1 (*always*) to 6 (*never*), with the total score ranging from 0–125. In the current study, items were recoded so that higher values represent better parent-infant relationship. Internal consistency in the current sample was high for mothers ($\alpha = 0.89$) and fathers ($\alpha = 0.85$).

Infant development was assessed at T3 using the *communication* and *personal-social* subscales of the 14 months version of the Ages and Stages Questionnaire-3 (ASQ-3; Squires and Bricker, 2009), a brief parent rated questionnaire. Each

domain contains six questions about age-specific developmental key-milestones (communication covers babbling, vocalizing, listening, and understanding; social-personal measures adaptive and social behaviors). Responses to each item is indicated as *yes* (0), *sometimes* (5), or *not yet* (10), depending on whether or not the infant is able to perform a certain task. For each scale, items are summed, resulting in total scale scores ranging from 0–60. In accordance with the questionnaire manual (Squires and Bricker, 2009), items were recoded so that higher scores represent better development. Internal consistency for the two ASQ-3 dimensions were somewhat low for mothers (communication $\alpha = 0.50$, personal-social development $\alpha = 0.55$) and fathers (communication $\alpha = 0.55$; personal-social development $\alpha = 0.55$).

Confounders pertaining to maternal, paternal, and infant characteristics assumed to be associated with the predictor and outcome were incorporated in the analyses. These included parental age and education [1 = *no school certificate*, 2 = *lower secondary education*, 3 = *secondary school certificate*, 4 = *advanced technical college entrance qualification*, 5 = *subject-related or higher education entrance qualification (A-level)*], both measured at T1. Moreover, infant characteristics such as infant gender (1 = *boys* and 2 = *girls*), prematurity, i.e., born before completion of gestational week 37 (0 = *not premature* and 1 = *premature*), and infant health (1 = *not healthy*, 2 = *healthy*) were assessed at T2. Further, parental postnatal depression was measured with the Edinburgh Postnatal Depression Scale (EPDS; Bergant et al., 1998) at T2. The scale ranges from 0–30. Higher scores indicate stronger symptoms of postnatal depression.

Statistical Analyses

Descriptive data analyses and bivariate correlational analyses were conducted to acquire information on the present sample and about the relationships between the assessed variables. Dropout analyses were performed to examine potential differences regarding sociodemographic characteristics, predictors, and confounders between participants who did not complete T3 and those who did. Before running regression analyses, the main assumptions of the linear model were tested. Missing items on a psychometric scale were substituted with the person's mean score if <20% of the scale items were missing. Subsequently, multiple linear regression analyses were carried out to explore the prospective impact of maternal and paternal relationship satisfaction on infant developmental outcomes over time. To analyse mediating pathways through parent-infant relationship, the SPSS modeling tool PROCESS v3.5 macro by Hayes (2018) was used. Bootstrapping with 5,000 samples was applied to compute confidence intervals and inferential statistics. Effects are deemed as significant if the confidence interval does not include zero. If the effect of the predictor on the outcome is not statistically significant when entering the mediator to the model, a full mediation effect is assumed. If the effect remains significant but decreases in size, the mediator partially mediates the effect (Urban and Mayerl, 2018). Further, multiple regression analyses were used to compute standardized regression coefficients (β). To examine the possible moderating effects of infant gender, multiple regression analyses were conducted with mean centered predictors for a better interpretation of regression coefficients (Hayes, 2018). Potential confounders, i.e., parental age, education, depression, infant gender, infant health, and premature birth, were considered in the analyses. Forced entry was utilized, as recommended by Morgan and Winship (2014). To consider the possibility of differing maternal and paternal perspectives, analyses and accordingly all scale scores were calculated separately for mothers and fathers. Because of missing data and exclusion of extreme values, n varied between the different analyses. The analyses were conducted with statistical significance at $p < 0.05$ and performed using IBM SPSS Statistics 27.

Ethical Statement

The DREAM study received ethical approval from the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (No: EK 278062015). During recruitment, participants received written information about study aims and procedures. They were informed about pseudonymization and confidentiality as well as the possibility to withdraw from the study at any time. All participants gave written informed consent.

RESULTS

Descriptive Statistics

The final sample consisted of $n = 1{,}012$ mothers and $n = 676$ fathers. Their characteristics are displayed in **Table 1**. Mean age of expectant mothers and fathers at T1 was 30.1 years ($SD = 3.8$) and 32.3 years ($SD = 4.9$), respectively. In the sample, 44.3% of expectant mothers and 47.7% of expectant fathers were married and 59.3% of expectant mothers and 58.3% of expectant fathers held a university degree. This indicates a rather high educational level of study participants compared to the overall German population (Statistisches Bundesamt, 2020). The majority of participants were expecting their first child (expectant mothers: 79.4%; expectant fathers: 78.9%). In both, the mothers' and fathers' subsamples, around half the infants were female (51.6% and 51.7%, respectively). Parents did not differ significantly in their assessments of parent-infant relationship and infant development ($p > 0.05$). Mothers were significantly more satisfied with their partnership, $t_{(1,617)} = 3.30$, $p < 0.01$ (mothers: $M = 20.4$, $SD = 4.3$; fathers: $M = 19.7$, $SD = 4.0$).

Dropout Analyses

Dropout analyses were conducted for all sociodemographic characteristics, predictors, and confounders of completers (T3 was completed) vs. non-completers (T3 was not completed), separately for mothers and fathers. In both subsamples, more completers than non-completers had a higher school-leaving qualification, mothers: $U = 63{,}544.000$, $Z = -3.00$, $p < 0.01$; fathers: $U = 32{,}074.500$, $Z = -4.46$, $p < 0.01$ and more completers held a university degree, mothers: $U = 61{,}833.000$, $Z = -3.00$ $p < 0.01$; fathers: $U = 32{,}276.000$, $Z = -4.19$, $p < 0.01$. In addition, female completers were less likely to have a premature birth than female non-completers (0.04% versus 0.09%), $\chi^2(1) = 5.44$, $p = 0.02$, and reported significantly lower levels of depression, $t_{(1,119)} = 2.90$, $p < 0.01$. In terms of

TABLE 1 | Sample description.

Sample characteristics	Total (n^a = 1,688)			
	n (%[b])		*M* ± *SD* (Range)	
	Mothers (*n* = 1,012)	**Fathers (*n* = 676)**	**Mothers (*n* = 1,012)**	**Fathers (*n* = 676)**
Age in years[c]			30.1 ± 3.8 (19–43)	32.3 ± 4.9 (20–56)
Country of birth				
Germany	983 (97.1)	669 (99.0)		
Other	29 (2.9)	7 (1.0)		
Partnership status				
Married	447 (44.3)	322 (47.7)		
Unmarried	535 (53.0)	323 (47.9)		
Divorced	25 (2.5)	28 (4.2)		
Widowed	1 (0.1)	1 (0.1)		
Unknown	1 (0.1)	1 (0.1)		
Duration of the partnership in years			7.7 ± 4.0 (0–23)	7.8 ± 4.0 (0–20)
Parents living together				
Living permanently together	962 (96.2)	644 (96.6)		
Living together, but not permanently	35 (3.5)	20 (3.0)		
Living separated	3 (0.3)	3 (0.4)		
Parents living together (T3)[d]				
Permanently living together	988 (98.4)	662 (99.0)		
Not permanently living together	15 (1.5)	7 (1.0)		
Living separated	1 (0.1)	0 (0.0)		
Education				
No school certificate	1 (0.1)	0 (0.0)		
Lower secondary education	6 (0.6)	23 (3.4)		
Secondary school certificate	192 (19.0)	146 (21.8)		
Advanced technical college entrance qualification	85 (8.4)	53 (7.9)		
Subject-related or higher education entrance qualification (A-level)	728 (71.9)	449 (66.9)		
Professional education				
No university degree	411 (40.7)	278 (41.7)		
University degree	599 (59.3)	388 (58.3)		
Employment status[e]				
Full-time employed	461 (45.6)	557 (83.1)		
Part-time employed	171 (16.9)	56 (8.4)		
Others[f]	378 (37.4)	57 (8.5)		
Parity				
Nulliparous	796 (79.4)	519 (78.9)		
Primiparous	179 (17.8)	107 (16.3)		
Multiparous	28 (2.8)	32 (4.8)		
Relationship satisfaction (T2[g]; 0–27)[h]			20.4 ± 4.3 (4–27)	19.7 ± 4.0 (4–27)
Endearment			6.2 ± 2.1 (0–9)	5.8 ± 2.0 (0–9)
Community/communication			6.8 ± 1.7 (1–9)	6.9 ± 1.6 (2–9)
Disput behavior			7.4 ± 1.7 (0–9)	7.0 ± 1.7 (0–9)
Communicational development (T3; 0–60)[i]			45.3 ± 9.9 (20–60)	44.5 ± 10.6 (15–60)
Personal-social development (T3; 0–60)[i]			46.7 ± 10.7 (20–60)	46.0 ± 10.9 (20–60)

(Continued)

TABLE 1 | Continued

Sample characteristics	Total (n^a = 1,688)			
	n (%[b])		*M* ± *SD* (Range)	
	Mothers (*n* = 1,012)	Fathers (*n* = 676)	Mothers (*n* = 1,012)	Fathers (*n* = 676)
Parent-infant relationship (T2)[j]				
General factor (0–125)			112.2 ± 9.8 (32–125)	112.3 ± 8.4 (71–125)
Impaired bonding (0–60)			52.8 ± 5.7 (7–60)	53.1 ± 5.0 (27–60)
Rejection and anger (0–35)			32.3 ± 3.1 (9–35)	32.2 ± 2.7 (20–35)
Anxiety about care (0–20)			17.1 ± 2.0 (6–20)	16.9 ± 1.8 (8–20)
Risk of abuse (0–10)			10.0 ± 0.3 (5–10)	10.0 ± 0.1 (8–10)
Postnatal depression (T2; 0–25)[k]			5.6 ± 3.8 (0–25)	3.5 ± 3.2 (0–20)
Infant gender (T2)				
Female	516 (51.6)	341 (51.7)		
Male	484 (48.4)	318 (48.3)		
Infant age in weeks (T2)			8.5 ± 2.2 (3–23)	9.0 ± 2.2 (4–21)
Infant age in months (T3)			13.7 ± 0.5 (13–14)	13.8 ± 0.4 (13–14)
Infant health (T2)				
Healthy	979 (98.0)	650 (97.9)		
Ill	20 (2.0)	14 (2.1)		
Infant premature birth				
Premature birth	45 (4.5)	24 (3.6)		
No premature birth	966 (95.5)	652 (96.4)		

[a]n slightly varies due to missing data of some participants; [b]Valid percent; [c]Unless stated otherwise, the data source is T1 = measurement point during pregnancy; [d]T3 = 14 months after the actual birth date; [e]Multiple answers possible; [f]Including marginal employment, retraining, federal armed forces, apprenticeship, student, maternity leave, currently not working, and other; [g]T2 = 8 weeks after the anticipated birth date; [h]Short version of the Partnership Questionnaire ("Kurzform des Partnerschaftsfragebogens," PFB-K); [i]Subscale of Ages and Stages Questionnaire-3 (ASQ-3); [j]Postpartum Bonding Questionnaire (PBQ) and it's subscales; reversed items so that higher scores indicate a higher level of parent-infant relationship [k]Edinburgh Postnatal Depression Scale (EPDS).

parental relationship satisfaction, male completers were found to be significantly more satisfied than male non-completers, $t_{(766)} = -2.27$, $p = 0.03$. No further significant differences between completers and non-completers were observed.

Direct Effect of Parental Relationship Satisfaction on Infant Development

Pearson correlations among all predictors, potential confounders, and outcomes were computed to explore their associations (mothers: see **Table 2**; fathers: see **Table 3**). In the maternal sample, there was no association between relationship satisfaction and the infant's personal-social ($r = 0.05$, $p = 0.15$) or communicational development ($r = 0.02$, $p = 0.57$). In the paternal sample, a positive correlation between relationship satisfaction and personal-social development ($r = 0.11$, $p < 0.01$) was revealed. Maternal ($r = 0.11$, $p < 0.01$) and paternal relationship satisfaction ($r = 0.14$, $p < 0.01$) were both significantly positively associated with parent-infant relationship. Parent-infant relationship showed a stronger association with infant development in fathers (communication: mothers: $r = 0.08$; $p = 0.01$, fathers: $r = 0.12$, $p < 0.01$; personal-social development: mothers: $r = 0.08$, $p = 0.02$; fathers: $r = 0.13$, $p < 0.01$).

In order to examine the prospective impact of maternal and paternal relationship satisfaction on infant communicational and personal-social development over time, linear regression analyses were conducted. Parental age, education, depression, infant gender, infant health, and premature birth were included as confounders in all regression analyses. Paternal relationship satisfaction and infant personal-social development were positively associated ($\beta = 0.08$, $p = 0.04$; see **Table 4**), with $f^2 = 0.09$ indicating a small and medium effect (Cohen, 1988). No prospective association was found for mothers, nor was it found for either mothers or fathers with respect to communication development (see **Supplementary Tables 1–3**).

For exploration, the significant association between paternal relationship satisfaction and infant personal-social development was investigated in more detail. To this end, it was examined whether the three subscales of the PFB-K (endearment, dispute behavior, and community/communication) are differently related to infant personal-social development. Endearment ($\beta = 0.09$; $p = 0.03$) and community/communication ($\beta = 0.09$; $p = 0.02$) were significantly associated with infant personal-social development. Dispute behavior ($\beta = 0.05$; $p = 0.23$) did not significantly relate to infant personal-social development (tables on request).

Moderation Effect by Infant Gender

Moderation analysis was used to determine whether infant gender moderates the prospective association between paternal

TABLE 2 | Pearson correlation coefficients (*r*) of predictors, control variables, and outcomes for mothers.

Variable	1	2	3	4	5	6	7	8	9	10
1. Communicational development	—									
2. Personal-social development	−0.47**	—								
3. Relationship satisfaction	−0.02	−0.05	—							
4. Mother-infant relationship	0.08*	0.08*	0.11**	—						
5. Parental age	−0.07*	−0.07	−0.07*	0.00	—					
6. Education	−0.03	−0.04	−0.01	−0.16	−0.06	—				
7. Depression	0.02	−0.02	−0.14**	−0.41**	−0.03	−0.03	—			
8. Infant gender	0.16**	0.18**	−0.04	0.00	−0.05	−0.03	0.02	—		
9. Infant health	0.03	0.01	0.06	−0.01	0.07*	0.04	0.05	0.01	—	
10. Premature birth	−0.09**	−0.14**	−0.03	0.03	−0.00	−0.04	−0.03	0.00	−0.07*	—

*Two-tailed-testing. *p < 0.05. **p < 0.01. N = 953.*

TABLE 3 | Pearson correlation coefficients (*r*) of predictors, control variables, and outcomes for fathers.

Variable	1	2	3	4	5	6	7	8	9	10
1. Communicational development	—									
2. Personal-social development	0.47**	—								
3. Relationship satisfaction	0.01	−0.11*	—							
4. Father-infant relationship	0.12**	0.13**	0.14**	—						
5. Parental age	−0.02	−0.01	−0.02	0.05	—					
6. Education	−0.01	−0.03	−0.06	−0.07	−0.08	—				
7. Depression	−0.02	−0.08*	−0.23**	−0.39**	−0.07	−0.05	—			
8. Infant gender	0.15**	0.23**	−0.03	−0.00	−0.04	0.01	−0.03	—		
9. Infant health	0.01	0.03	0.01	0.00	0.04	0.06	0.06	0.04	—	
10. Premature birth	−0.06	−0.00	−0.05	0.01	−0.01	−0.02	−0.01	0.03	0.03	—

*Two-tailed-testing. *p < 0.05. **p < 0.01. N = 605.*

TABLE 4 | Predictive value of paternal relationship satisfaction on infant personal-social development, controlled for parental age, education, depression, infant gender, infant health, and premature birth[a].

Modell		*B*	*SE B*	β	95% CI	*p*
1	Paternal relationship satisfaction	−0.29	0.11	−0.11	[0.07; 0.52]	0.01
2	Paternal relationship satisfaction	−0.28	0.11	−0.10	[0.07; 0.50]	0.01
	Age	−0.00	0.10	−0.00	[−0.19; 0.18]	0.99
	Education	−0.69	0.46	−0.06	[−1.55; 0.25]	0.14
	Depression	−0.20	0.16	−0.05	[−0.52; 0.12]	0.23
	Infant gender	−5.19	0.87	−0.24	[3.51; 6.85]	0.00
	Infant health	−2.59	2.90	−0.04	[−8.45; 2.94]	0.35
	Premature birth	−0.95	1.45	−0.02	[−3.74; 1.92]	0.50

Two-tailed-testing. B = unstandardized regression coefficient; SE B = standard error for unstandardized regression coefficient; β = standardized regression coefficient; CI = confidence interval; p = probability value. N = 585.

[a] *Multiple linear regression, carried out by forced entry.*

relationship satisfaction and infant personal-social development, when controlling for parental age, education, depression, infant gender, infant health, and premature birth. The analysis yielded a non-significant interaction term between paternal relationship satisfaction and infant gender ($\beta = 0.01$, $p = 0.84$), even when the individual subscales of the PFB-K were considered (endearment: $\beta = 0.02$, $p = 0.70$; dispute behavior: $\beta = 0.00$, $p = 0.93$; and community/communication: $\beta = 0.00$, $p = 0.99$). Thus, the prospective association between paternal relationship satisfaction and infant development was neither reduced nor increased as a function of infant gender.

Mediation Effect by Father-Infant Relationship

To analyse whether the significant direct path between paternal relationship satisfaction and infant personal-social development could be explained by the father-infant relationship, mediation analysis was performed. As shown in **Figure 1**, higher values of paternal relationship satisfaction predicted a better father-infant relationship ($\beta = 0.15$, $p < 0.01$), which in turn predicted better personal-social development ($\beta = 0.12$, $p < 0.01$). The direct association between relationship satisfaction and personal-social development ($\beta = 0.12$, $p < 0.01$) was reduced when including father-infant relationship as a mediator ($\beta = 0.10$, $p = 0.01$). Thus, father-infant relationship partially mediated the relationship between paternal relationship satisfaction and infant personal-social development, when controlling for parental age, education, infant gender, infant health, and premature birth, indirect effect $ab = 0.02$, 95% CI [0.01; 0.09].

When depression was included as another control variable, the mediation effect was no longer significant, indirect effect $ab = 0.05$, 95% CI [−0.00; 0.05]. As presented in **Figure 2**, the association between paternal relationship satisfaction and father-infant relationship, was no longer significant ($\beta = 0.06$, $p = 0.10$) when considering depression. Moreover, the association between father-infant relationship and personal-social development became slightly smaller ($\beta = 11$, $p = 0.01$). The direct associations between father-infant relationship and personal-social development ($\beta = 11$, $p = 0.01$) as well as between relationship satisfaction and personal-social development ($\beta = 0.10$, $p = 0.01$) remained stable when considering father-infant relationship ($\beta = 0.10$; $p = 0.02$).

An additional exploratory investigation was carried out to determine whether the mediation effect of the father-infant relationship differed for the various subscales of the PFB-K. The direct association between paternal relationship satisfaction and infant personal-social development was mediated by the father-infant relationship for all subscales when controlling for parental age, education, infant gender, infant health, and premature birth. When adding depression as a control variable the mediation effects were no longer significant (tables on request).

DISCUSSION

The present study sought out to explore the role of parental relationship satisfaction, a key aspect of family functioning (Garthus-Niegel et al., 2018), in infant development. Specifically, the aim was to investigate the prospective impact of maternal and paternal relationship satisfaction eight weeks postpartum on infant personal-social and communicational development one year later, controlling for parental age, education, depression, infant gender, infant health, and premature birth. Higher levels of maternal and paternal relationship satisfaction were hypothesized to be significant predictors of infant communicational and personal-social development. This prospective association was confirmed in the paternal sample with respect to infant personal-social development, whereas no such association was observed for mothers. Further, parental relationship satisfaction did not appear to be a significant predictor of infant communicational development. The strength of the prospective association between paternal relationship satisfaction and infant personal-social development did not vary as a function of infant gender. Findings further revealed that the father-infant relationship partly mediated the association between paternal relationship satisfaction and infant development. When controlling for paternal postnatal depression however, the mediation effect did not remain significant.

Parental Relationship Satisfaction and Infant Development

Infant personal-social development was only significantly related to *paternal* relationship satisfaction. Accordingly, fathers who were more satisfied in their partnership reported better personal-social development of their infant when controlling for all potential confounders, and when the father-infant relationship was included. Detailed analyses of paternal relationship satisfaction revealed that infant personal-social development was mainly predicted by paternal perception of interparental endearment and affectionate community/communication. In contrast, fathers' assessment of arguing behavior yielded no prospective association with infant personal-social development. Although carried out in an exploratory manner, this finding suggests a great relevance of positive features of the couple relationship for optimal development in infancy. Similarly, Goldberg and Carlson (2014) showed that high interparental support is associated with less behavioral problems in children aged 3 to 9 years. Although, both mothers and fathers were included in their study, no distinction was made between them in the calculations. Therefore, no conclusions could be drawn about potential differences between mothers and fathers. In addition, Fishman and Meyers (2000) found that both maternal and paternal marital satisfaction were significantly associated with behavioral and emotional problems in children aged 5 to 9 years. Thus, in contrast to the results of the present study, an association between marital satisfaction and child outcomes was also found in the maternal sample. These differing results may be explained by the facts that children of different ages were included in the respective studies. Indeed, the prospective impact of parental relationship satisfaction on child outcomes may differ between developmental stages. To the best of our knowledge, no prior study included both parents when investigating how

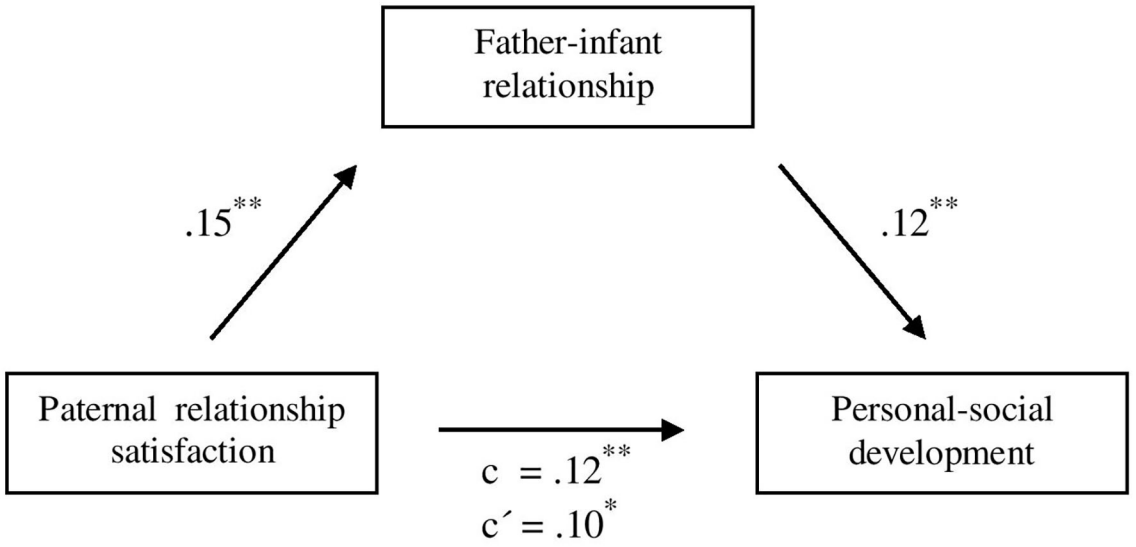

FIGURE 1 | Mediation analysis for the prospective association of paternal relationship satisfaction on infant personal-social development, mediated by father-infant relationship, controlled for parental age, education, infant gender, infant health, and premature birth. Specification of the standardized regression coefficients (β); c = total effect; c' = direct effect. $^{*}p < 0.05$. $^{**}p < 0.01$. $N = 583–585$.

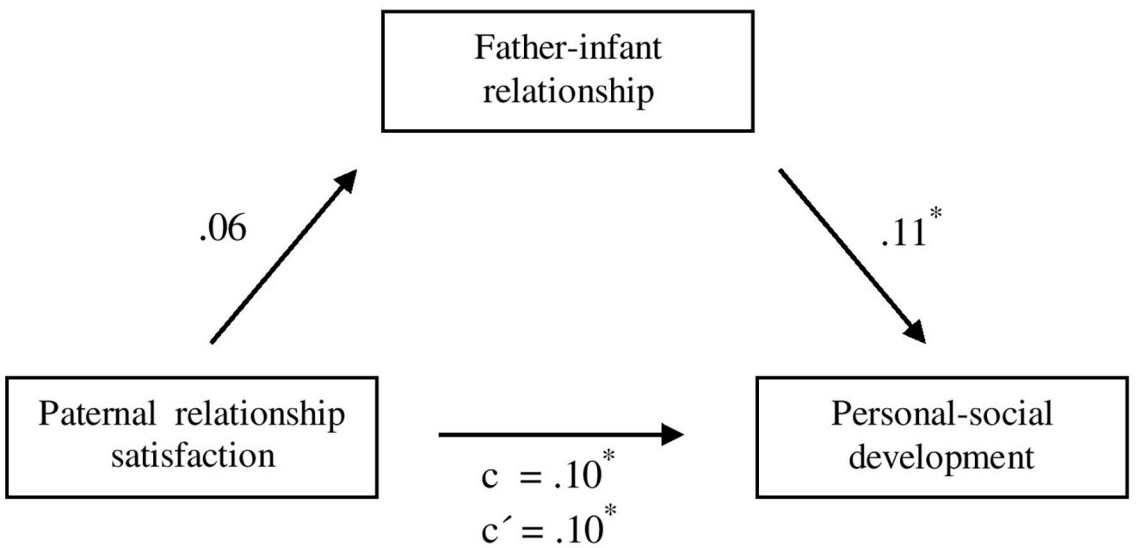

FIGURE 2 | Mediation analysis for the prospective association of paternal relationship satisfaction on infant personal-social development, mediated by father-infant relationship, controlling for parental age, education, infant gender, infant health, premature birth and depression. Specification of the standardized regression coefficients (β); c = total effect; c' = direct effect. $^{*}p < 0.05$. $^{**}p < 0.01$. $N = 583–585$.

relationship satisfaction may predict development in infancy. Therefore, the current finding of a positive predictive association only in the paternal but not in the maternal sample highlights the need for inclusion of both, mothers and fathers in future research. However, it must be noted that the partner is of great importance for the level of paternal relationship satisfaction—as measured with the PFB-K. For instance, in the paternal PFB-K, the man is asked how often the woman hugs him or tells him that she loves him. Hence, the extent to which it is the mother's loving, affectionate behavior in the partnership that has a predictive impact on the infant's development warrants further research. The direct association between paternal relationship satisfaction and father-infant relationship could be explained by processes of social learning, in which the infant observes and imitates the parents' prosocial, affectionate interactions. For example, the infant may have learned to hug their dolls or soft toys (Item

of the ASQ-3; Personal-social development) by watching their parents hug each other (Item of the PFB-K; Endearment).

Contrary to these findings, further analyses showed that in neither the mothers' nor the fathers' sample, infant communicational development was predicted by parental relationship satisfaction. This could be due to the fact that parental relationship satisfaction experienced in infancy may only have an effect on child communicational abilities in later life. Children's exposure to inter-parental interaction does often occur in coexistence with various other risk or protective factors (Dominick, 2018). The presence of multiple stressors or resources throughout childhood can confer decreased or increased risk and therefore explain the link between earlier experiences of parental relationship satisfaction and long-term effects on child communicational development. Thus, parental relationship satisfaction could have a delayed effect on child communicational development. Because research on maternal and paternal relationship satisfaction as a predictor of infant communicational development is rare, clarification of this long-term relation should be the subject of further investigations.

Infant Gender

Furthermore, moderation analysis revealed no difference in how paternal relationship satisfaction was associated with boys' vs. girls' personal-social development. This absence of moderation by infant gender is consistent with previous research. For instance, Zhou et al. (2017) reported no child gender differences regarding the association between interparental conflict and behavior problems in two-year-old children. In addition, Goldberg and Carlson (2014) found that the association between interparental supportiveness and child internalizing as well as externalizing behavior problems in 3 to 9-year-old children was not moderated by child gender. Studies that report a difference between boys and girls mostly relate to older children. For them, cognitive factors such as different appraisals and self-accusations may be of explanatory importance, which, however, seem more relevant in children aged ∼10 years and older (Dominick, 2018). In the first year of life, it appears that all infants, regardless of gender, benefit from parents' tenderness, support, and constructive communication with each other. Because of the previous ambiguous results and lack of prior investigations focussing on infancy, this research question was investigated in an exploratory way and therefore the results need to be confirmed in further analyses.

Parent-Infant Relationship

The prospective association between paternal relationship satisfaction and infant personal-social development was partly explained by the father-infant relationship. In agreement with spillover theory, our results support the notion that feelings or behaviors generated in the interparental relationship may be transferred to the father-infant relationship. Accordingly, fathers who were more satisfied with their current partnership also had a better relationship with their infant, which in turn was associated with better infant personal-social development. The finding that paternal relationship satisfaction predicted father-infant relationship is in line with previous studies demonstrating that emotions, affect, and mood produced in the partnership carry over into parenting behaviors. Indeed, withdrawal from the family and hostility toward the infant were found to be common reactions to interparental disagreements especially among men (Harold et al., 2016; Zhou et al., 2017; Dominick, 2018). Moreover, a better father-infant relationship, in turn, significantly predicted increased infant personal-social development. Similarly, previous studies have shown that parent-child involvement significantly predicts children's emotional well-being (Fishman and Meyers, 2000) and that parenting behavior predicts child behavior (Feldkötter et al., 2019). However, when paternal postnatal depression was included as a control variable, the mediation effect disappeared. Fathers reporting higher levels of depression indicated lower relationship satisfaction, a poorer father-infant relationship, and poorer personal-social development of the infant. Hence, not surprisingly, the postnatal period represents a time of adjustment for fathers, including redefining the relationship and role distributions with their partner and learning to respond adaptively to their infant (Tsivos et al., 2015; Garthus-Niegel et al., 2020). Paternal relationship satisfaction did not explain the father-infant relationship beyond the contribution of depression, highlighting the importance of postnatal depression for the entire family. Previous studies have shown that partner support is essential for mental health, especially among fathers. In this regard, Garthus-Niegel et al. (2020) showed that perceived social support and relationship satisfaction serve as protective factors against paternal depression symptoms. Similarly, Røsand et al. (2012) reported that relationship satisfaction strongly buffers the effects of emotional distress in both men and women. Depressive symptoms in fathers at two months following birth in turn were found to predict a higher risk of behavioral problems in 3.5-year-old children (Ramchandani et al., 2005). According to these results, paternal depression may act as a mediator between paternal relationship satisfaction and infant personal-social development. This, as well as the role of the father-infant relationship, should be subject of further research. The major impact of depression is supported in numerous other studies indicating that parental depression has profound and widespread effects on interparental conflicts, parenting skills, parent-child relationship, and child development (e.g., Tsivos et al., 2015; Zhou et al., 2017; Dominick, 2018; Garthus-Niegel et al., 2018).

Although less strong than among fathers, positive associations were found between maternal relationship satisfaction and mother-infant relationship as well as between mother-infant relationship and infant development. Taken together, it seems that a higher level of parental relationship satisfaction is linked with a better parent-infant relationship, which in the case of fathers, is associated with personal-social infant development.

Strengths and Limitations

Noteworthy strengths of this study are the longitudinal approach and the large sample size, comprising more than 1,600 parents. This study also includes both maternal and paternal perspectives, as well as the extended view of relationship quality, not focused on interparental conflicts and violence, but taking into account positive partnership features such as

endearment and community/communication. Whereas most prior studies examined child development during late childhood and adolescence, this study focused on infancy, because these early months are a particularly formative time with an enormous impact on the infant's future life (Montada, 2008; Harold et al., 2016; Feldkötter et al., 2019).

Even though the study results extend the existing literature by providing important findings, they should be interpreted in light of several limitations. First, infant development was assessed through the parents' reports and therefore could be biased by parental perceptions. Although these reports provide an important perspective, it would be of interest to supplement this approach by means of independent observers and via standardized observational procedures in the future (e.g., using the Bayley Scales of Infant and Toddler Development; Bayley, 2006). Second, dyadic effects between partners were not taken into account. For this purpose, the Actor-Partner Interdependence Model (APIM; Kenny, 1996; Kashy and Kenny, 1999) offers a suitable framework because it maintains each individuals' unit measures but treats them as nested within the dyad. However, in the present study it was decided against a dyadic model in order to include those participants whose partner did not participate in the study and thus obtain a larger sample size. Third, even though the ASQ-3 is one of few recommended universal screening tools qualified to investigate children's development in infancy (Garthus-Niegel et al., 2017), internal consistency measured by Cronbach's α was rather low when assessing communicational and personal-social development. Low internal consistency tends to indicate low measurement accuracy and thus may lead to unreliable results. However, broad constructs such as the two developmental domains investigated in the current study are naturally expected to have lower item correlations than item collections reflecting a narrow, more tightly defined construct. Accordingly, lower reliability estimates can be expected for broad constructs (Garthus-Niegel et al., 2017). Fourth, it should be noted that parental relationship satisfaction and parent-infant relationship were assessed at the same time (T2). Due to this lack of temporal sequence between predictor and mediator, the mediation effect should not be interpreted in a causal sense. Lastly, participants were predominantly well-educated, first-time parents. Systematic dropout occurred in the maternal sample among mothers with a preterm birth and higher level of depression, whereas in the paternal sample, dropout occurred among fathers who were dissatisfied with their interparental relationship. Therefore, caution is warranted when generalizing the study findings to other populations. Nonetheless, selection bias may not necessarily influence the results when associations between variables are investigated (Nilsen et al., 2009).

Implications

Future research should investigate whether current findings on the prospective association of relationship satisfaction and infant development can be replicated in other populations, e.g., populations with lower educational levels or more parents already having children. Additionally, it would be instructive to consider additional variables that may contribute to a more comprehensive understanding of this association. For example, the frequency of contact of the infant with others from whom it can learn and imitate communicative and personal-social behavior could be taken into account. Because the current analyses demonstrate the important role of paternal depression, future research should examine the extent to which the prospective association between paternal relationship satisfaction and infant personal-social development is mediated by paternal depression. Moreover, it would be of interest to further investigate the non-significant results regarding the three subscales of PFB-K (endearment, dispute behavior, and community/communication), in addition to the overall score.

In light of the study findings, it seems reasonable that (preventive) interventions for infant personal-social development should not only focus on the infant, but also comprehensively incorporate the couple relationship, the parent-infant relationship, and parental depression (Zemp and Bodenmann, 2015). Paternal relationship satisfaction could, for example, be strengthened by enhancing couples' interpersonal skills in the areas of open and benevolent communication and emotional empathy. Parent-infant relationships could for instance be strengthened through supporting paternal sensitivity and responsiveness to the infant's signals, as well as through parenting skills and strategies. As indicated by Tsivos et al. (2015), parent-infant therapy and a coaching intervention to promote parental responsiveness have the greatest efficacy for reducing symptoms of postnatal depression. Because the mother is of great importance for the father's relationship satisfaction and because the results suggest that both mother- and father-infant relationship are significantly related to infant development, both parents should be involved in these prevention or intervention approaches. Nevertheless, the findings of this study, namely the different impact of mothers and fathers on infant communicational and personal-social development, should be investigated further in order to develop more targeted measures for mothers and fathers.

CONCLUSION

Taken together, the study findings emphasize the interconnectedness of family relations and individual development. The results indicate a direct prospective association between the father's relationship satisfaction and infant personal-social development. In addition, part of the association appears to be mediated by father-infant relationship. However, this mediation effect does not hold when postnatal depression is taken into account. Both girls and boys benefit from high parental relationship satisfaction. Future research should focus on this finding with consideration of additional factors that might mediate or moderate this prospective association. Hence, the current findings underscore the great relevance of paternal relationship satisfaction, father-infant relationship, and postnatal depression for infant personal-social development. Resulting from these findings and because the first years of life form the foundation for further development and long-term mental health (Harold et al., 2016; Feldkötter et al., 2019),

prevention and intervention programmes that strengthen parental relationship satisfaction, parent-infant relationship, and postnatal depression are needed.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of legal and ethical constraints. Public sharing of participant data was not included in the informed consent of the study. Requests to access the datasets should be directed to Susan Garthus-Niegel, susan.garthus-niegel@uniklinikum-dresden.de.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (EK 278062015). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CN performed the statistical analyses, drafted the initial manuscript, and reviewed and revised the manuscript. VK and MK supported the conduction of the study, especially through data collection, contributed with the interpretation of the data, and prepared the data for statistical analyses. SG-N acquired the funding, was responsible for conception and design of the basic DREAM study with its sub-studies as well as the coordination and supervision of the data collection and the ongoing cohort study, and contributed with the interpretation of the data. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

The DREAM study received funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation; GA 2287/4-1 and GA 2287/4-2). Also, SG-N is a management committee member of COST action CA18211: DEVoTION: Perinatal Mental Health and Birth-Related Trauma: Maximizing best practice and optimal outcomes.

ACKNOWLEDGMENTS

We want to thank all (expectant) mothers and fathers for supporting our project. Furthermore, we want to thank all cooperating clinics and midwives for providing access to potential participants as well as all colleagues and (doctoral) students performing the recruitment. We would like to acknowledge that study data were collected and managed using Research Electronic Data Capture (REDCap; Harris et al., 2009, 2019). REDCap is a secure, web-based application for capturing data within research studies and is hosted at the Koordinierungszentrum für Klinische Studien at the Faculty of Medicine of the Technische Universität Dresden.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.667577/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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BRIEF RESEARCH REPORT
published: 29 September 2021
doi: 10.3389/fpsyg.2021.705655

Father's Perspectives on Family Relationships and Mental Health Treatment Participation in the Context of Maternal Postpartum Depression

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Objective: To understand the perspectives of fathers whose partners experienced postpartum depression, particularly (1) views on how fathers and family relationships were impacted by maternal PPD, and (2) attitudes regarding inclusion of fathers within the treatment process.

Methods: We conducted qualitative interviews with 8 postpartum couples using a semi-structured protocol, and administered questionnaires assessing demographics, depression, and family functioning. We abstracted data from hospital records regarding the mother's depressive episode. We summarized quantitative data using descriptive statistics, and analyzed interview transcripts using qualitative analysis techniques, focusing specifically on fathers' input on postpartum relationships and treatment involvement.

Results: Over one-third of fathers had elevated symptoms of depression, and family functioning scores suggested that most couples were experiencing dysfunction in their relationships. Qualitative analysis identified three major categories of themes, and subthemes in each category. Major themes included: (1) fathers' experiences during the postpartum period, including not understanding postpartum mental health conditions and desiring more information, experiencing a range of emotions, and difficulty of balancing work with family; (2) fathers' views on postpartum relationships, such as communication problems, empathy for partner, and relationship issues with other family members; (3) fathers' attitudes toward postpartum treatment, including openness to be involved, perceived benefits, and barriers and facilitators to the inclusion of partners in treatment.

Conclusion: Though barriers exist, many fathers are motivated to be included in the treatment process. In addition to supporting maternal wellbeing, fathers view treatment as a means to improve issues in the couple or family system, such as communication difficulties.

Keywords: fathers, partners, postpartum depression, perinatal mental health, family treatment

OPEN ACCESS

Edited by:
Barbara Figueiredo, University of Minho, Portugal

Reviewed by:
Rosanne Jocson, Ateneo de Manila University, Philippines
Joseph Michael Trombello, University of Texas Southwestern Medical Center, United States

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *05 May 2021*
Accepted: *27 August 2021*
Published: *29 September 2021*

Citation:
Battle CL, Londono Tobon A, Howard M and Miller IW (2021) Father's Perspectives on Family Relationships and Mental Health Treatment Participation in the Context of Maternal Postpartum Depression. Front. Psychol. 12:705655. doi: 10.3389/fpsyg.2021.705655

INTRODUCTION

The past decade has seen a steady increase in studies focused on postpartum fathers and partners (Darwin et al., 2021). Although most clinical, policy, and research attention remains focused on maternal mental health, there is growing recognition that many fathers and other non-birthing parents and partners face significant challenges during the perinatal period, with up to 10% suffering clinical symptoms of depression or anxiety in the months after a new baby is born (Paulson and Bazemore, 2010; Cameron et al., 2016; Leach et al., 2016). This work has helped to propel new public health and advocacy initiatives targeting the wellbeing of fathers and partners, across a range of national and international advocacy and healthcare organizations. However, much remains to be understood about fathers' and partners' experiences and interests in engaging in treatment.

In cases where the mother is experiencing major depression or other significant distress during pregnancy or after birth of the baby, the partner's role becomes even more central. Partners may be the first to notice changes in a mother's functioning or mood, and can play a critical role in accessing appropriate care. In addition, stress in the couple's relationship can put a mother at risk for greater symptoms or a prolonged course of depression. Indeed, there are well-documented associations between relationship factors (partner support, family conflict, and relationship satisfaction) with onset and course of maternal depression during the perinatal period (Dennis and Ross, 2006; Figueiredo et al., 2018); Interconnections have been shown to exist between maternal and paternal symptomatology (Cameron et al., 2016; Figueiredo et al., 2018) such that if one parent has elevated symptoms, the other parent is more likely to have symptoms themselves. The unique vulnerabilities of each parent, including their clinical history and their individual capacity to adapt to stressful circumstances, are likely to play an important role in predicting the long-term stability of the relationship. Indeed, in line with their vulnerability-stress-adaptation model (Karney and Bradbury, 1995), the transition to parenthood can be viewed as a critical period when each individual parent's vulnerabilities can have significant impacts on the family system Importantly, parental mental health issues in either the mother (Dunkel Schetter and Tanner, 2012) or father (Paulson and Bazemore, 2010) can have serious adverse effects on the child's long-term development.

Because of the salience of relationship factors in perinatal mental health, partner-inclusive treatment approaches have been proposed (Milgrom et al., 2005; Cohen and Schiller, 2017). Misri et al. (2000) conducted one of the first partner-inclusive trials for postpartum depression (PPD); however, since that time, relatively few couples or family interventions have been rigorously tested. Several investigators have tested strategies for including partners in preventative or treatment interventions for PPD, yet limitations exist to this body of work (Alves et al., 2018). Although several partner-inclusive interventions have been examined for pregnant women, primarily from a psychoeducational framework (Park et al., 2020), few trials have tested partner-or family-based interventions for PPD. Some exceptions include Brandon et al. (2012) pilot study of partner-assisted interpersonal psychotherapy, and involvement of partners in Milgrom et al. (2016) internet-based PPD intervention. Because of the strong rationale to include partners and families, and paucity of work in this area, this remains an important area for future study.

As PPD interventions are developed with partners in mind, it is critical to more fully understand their experiences. Direct input from partners of women with PPD can clarify attitudes and opinions regarding inclusion in treatment, areas of desired treatment focus, and barriers and facilitators to engagement. Studies documenting postpartum fathers' experiences have yielded important themes such as desire for education regarding perinatal mental health, feelings of helplessness, and a sense of exclusion from the treatment process. Although these studies have provided helpful information, limitations exist (Lever Taylor et al., 2018) including retrospective recall of postpartum experiences from over 10 years previously, which could be subject to recall bias, and lack of racial/ethnic diversity in the sample. Additionally, most studies only assessed the father, with little detail regarding the nature of the mother's diagnosis, symptoms, or treatment.

In light of the critical role of partners and family members, and barriers to engaging family members in postpartum mental health care, we sought to further elucidate fathers' experiences in the context of maternal PPD, with a particular focus on their perspectives regarding issues that arose within the family system. Given the profound impact that depression can have on maternal functioning during the perinatal period, it is important to understand fathers' postpartum experiences in this context – including their understanding of the mother's symptoms, how their role in the family may have changed during the episode of PPD, and their reactions to the treatment process. In addition, we sought to understand fathers' views regarding being more directly involved in PPD treatment – including potential benefits, barriers, and strategies to promote participation.

METHODS

Participants

This study included postpartum couples in which the mother experienced a major depressive episode after the baby's birth. Inclusion criteria included: (1) age 18 or older; (2) English speaking; (3) mother received treatment for depression within the first postpartum year at a local mother-baby partial hospitalization program. Exclusion criteria included acute distress at the time of interview (i.e., psychosis, substance use, thoughts of harming self or others). We note that quantitative data are included from both members of the couple to provide context; however, in light of the focus on fathers, thematic analysis of qualitative data focused specifically on father's input during the interview.

Procedures

Procedures were approved by the hospital institutional review board; all staff members were trained in the protection of human subjects and study-specific procedures.

Participants were recruited from a perinatal psychiatric partial hospitalization program (Howard et al., 2006; Battle and Howard, 2014). Once staff determined that a patient met inclusion criteria, research staff explained the study, asking screening questions, and assessing interest. If the woman and her partner were interested in participating, they attended an in-person interview. Following informed consent, they completed demographic and self-report symptom measures and took part in an audio-recorded interview. Of note, a standard component of care at the recruitment site involves staff inviting a woman's partner or other family member to take part in a family meeting during her treatment; as such, many fathers had the experience of attending a family meeting with their partner's provider at the treatment site.

Assessments

Depression Symptoms

Postpartum women completed the Edinburgh Postnatal Depression Scale; EPDS (Cox et al., 1987), a widely used, validated 10-item measure that screens for depressive symptoms during the perinatal period; scores range 0–30, with scores 13 and higher suggesting presence of depression, and scores 19 and above considered in the severe range. Partners of postpartum women completed the Beck Depression Inventory (BDI) (Beck et al., 1988), a validated 21-item measure of depressive symptoms used with clinical and non-clinical populations. BDI scores range 0–29; scores over 10 indicate presence of depression and scores 19 and higher are considered severe. Mean scores were calculated on the EPDS and BDI; higher scores indicate higher levels of depressive symptoms.

Family Functioning

Participants completed the Family Assessment Device – general functioning scale (FAD-gf)(Epstein et al., 1983), a validated 12-item measure that assesses individual's perceptions of key areas of family functioning. It has been used in perinatal samples (Blom et al., 2010; Henrichs et al., 2011). Respondents indicate the extent to which statements describe their family on a scale of 1 to 4 (e.g., "*In times of stress we turn to each other for support*"). Mean scores were computed; higher scores reflect more problems, with means over 2 suggestive of dysfunction in the family system.

Clinical Record Review

Women granted permission to obtain information regarding their treatment, including psychiatric diagnosis, clinical features during depressive episode, and intake depression severity on the EPDS (Cox et al., 1987).

Qualitative Interview

Each couple took part in a joint, 60-min audio-recorded interview with the first author following a semi-structured protocol that included open-ended questions and follow-up prompts. Interviews covered: (1) brief history of their relationship; (2) description of experiences in the family since the baby's birth, including when the mother was depressed; (3) discussion of issues or challenges in family relationships since the baby's birth; (4) attitudes toward mental health treatment, including the inclusion of fathers and other family members in PPD treatment.

Data Analysis

We used SPSS version 22 to analyze the quantitative data, summarizing demographics and computing ranges, means, and standard deviations of symptom measures. Interviews were audio-recorded, and verbatim transcripts generated, with all references to participant identifiers removed. Transcripts were reviewed by the transcriptionist and lead interviewer to check for errors or inconsistencies. Participant responses to the open-ended questions were analyzed using thematic analysis (Braun and Clarke, 2006). First, one author (CB) read all transcribed interviews and developed a preliminary codebook reflecting themes that arose during the interviews; themes were organized into major topic areas based upon sections of the interview. In light of the focus on father's perspectives, the codebook and thematic analysis process specifically captured themes arising from the father's input during the interviews. Once the codebook was developed, the first and second author used the codebook to independently assign themes to a subset of interviews. Through in-depth conversation regarding themes applied to this body of interviews, revisions were made to the codebook, including addition of new themes or modification of existing themes, as needed. When finalized, all transcripts were coded with the final codebook. To ensure consistent application of codes, 50% of interviews (180 pages of transcripts) were coded by more than one coder, and meetings were held to review codes applied to each passage in the transcript. Although the majority of codes matched, any discrepancies were resolved via consensus. Ultimately, after all transcripts were coded, the final list of themes, and representative quotes was developed by the first and second author, and agreed upon by consensus.

RESULTS

Participant Characteristics

Table 1 displays participant characteristics, including demographics and clinical information. All mothers met criteria for major depressive disorder with most exhibiting significant levels of symptoms: more than half expressed suicidal ideation, and one-third were hospitalized as an inpatient during their recent depressive episode. Three-quarters of women had EPDS scores above the clinical cut-off for depression at the time of their partial hospital admission, with 37.5% scoring in the severe range on the EPDS. The mothers' partial hospitalization took place between 5 and 10 months postpartum (Mean = 5.5, SD = 3.9). Interviews took place between 1 and 5 months average after that admission (Mean = 2.5, SD = 1.4). At the time of the interview, maternal depression was still elevated, but generally in the mild-moderate range and not related to time since the partial hospitalization. Paternal depression, on average, was in the minimal range at the time of the interview; however, notably, over a third (37.5%) of fathers endorsing elevated symptoms – with one depressed father (12.5%) exhibiting symptoms of severe depression. In terms of family functioning, FAD-gf scores

TABLE 1 | Participant demographic and clinical characteristics.

	Fathers		Mothers	
Variable	***n* or mean**	**% or *SD***	***n* or mean**	**% or *SD***
Age	*29.63*	*(4.43)*	*24.88*	*(5.54)*
Marital status				
Married/Cohabitating	7	87.5%	7	87.5%
Single/Not cohabitating	1	12.5%	1	12.5%
Race/Ethnicity				
White or Caucasian	2	25.0%	3	37.5%
Black or African American	4	50.0%	2	25.0%
Latino or Hispanic	2	25.0%	2	25.0%
Multiple	0	0.0%	1	12.5%
Education				
High school or Less	2	25.0%	4	50.0%
Some college	5	62.5%	4	50.0%
Completed college or graduate degree	1	12.5%	0	0.0%
Household income				
$10,000–$24,000	2	25.0%	2	25.0
$25,000–$49,999	1	12.5%	1	12.5
$50,000–74,999	5	62.5%	5	62.5
Depression severity at time of interview				
BDI (Fathers)	7.88	10.79	–	–
EPDS (Mothers)	–	–	11.75	7.06
Family functioning				
FAD-general functioning scale	2.04	0.51	2.19	0.76
Maternal clinical characteristics during episode				
Depression severity at intake (EPDS)			17.38	7.09
Primary diagnosis of MDD			8	100.0%
MDD, single episode			4	50.0%
MDD, recurrent			4	50.0%
Psychotic features this episode			2	25.0%
Anxiety features this episode			3	37.5%
Depression onset				
During pregnancy			2	25.0%
During postpartum			6	75.0%
Suicidal ideation or plan this episode			5	62.5%
Substance abuse history noted at intake			2	25.0%
Inpatient stay during this episode			3	37.5%

suggested dysfunction in the family system, with the mean scores for both partners in the clinical range.

Qualitative Themes

As shown in **Table 2**, we organized the themes into 3 broad categories, including: (1) *Fathers' experiences during*

TABLE 2 | Qualitative themes and representative quotes.

Topic area 1: Fathers' experiences during the postpartum period	
Theme	**Sample quotes**
Lack of knowledge of post-partum mental health conditions	"I wasn't thinking it was a depression at the moment, I thought that she was just having a hard time" "I am sure most guys don't know what post-partum is" "I never seen nothing like this in my life. I've never seen this. I've never even heard about it"
Empathy and desire to help partner	"Anything to help her out" "I don't, I don't like seeing her hurt like that" "I do want to provide the support that she need for her to get better"
Challenges of work-life balance	"I was working a lot so I wasn't exactly home too much" "I was like extremely exhausted between helping her get through the depression, me working sort a two jobs at once, and taking care of the baby with no sleep"
Fathers' emotional experiences and distress during the perinatal period	"I was really worried" "I was scared" "I think that mentally I wasn't ready for all these things" "I kind of felt like I was trapped in a way" "My life seemed like it was turned upside-down" "Talking about your feelings isn't something that normally think of as a me, or a "guy" thing to do" "I got to be strong for all of us"
Topic area 2: Fathers' views on postpartum relationships	
Theme	**Sample quotes**
Communication problems and tension in the couple's relationship	"The thing is that we have communication problems, we don't talk about the problems ourselves" "The main problem we have is communication, we don't communicate too well"
Role transitions during perinatal period and problem solving as a couple	"Talk about the ultimate test: having a baby" "I had to learn real quick [to do child care]" "Once the baby came along. . . we pretty much rolled uphill from there"
Feelings of love, closeness, appreciating time together	"I'd love to spend time with you like take a weekend and just go" "Bring ourselves back to the level of calmness and loving each other again" "I certainly feel like if we can get through (this) we can get through anything"
Experiencing support from and tension with family members	"If it wasn't for my mother, I think she could have gotten over the postpartum depression [sooner]" "I do really feel stuck in the middle [of mother and wife]" "Guys at work were a big help, my parents, her parents, her family"
Relationship with baby	"I want. . . to make [our relationship] work because I want to be with my kid and I want to see them grow and everything" "I focused a lot on [my baby] and making sure he was taken care of" "I don't want our kids subjected to that kind of stuff [tension with family"

(Continued)

TABLE 2 | (Continued)

Topic area 3: Fathers' attitudes toward mental health treatment	
Theme	**Sample quotes**
Openness and benefits to being involved in treatment	"It was really great that [clinician] did actually call me if she hadn't called me. I wouldn't have known [what their partner was struggling with]" "It's like I understand where she's coming from, and it's like I'm trying just To help her get through it" "The lady there just telling me about everything that, like telling about how she's feeling that's when I really understood and like it motivated me to help her"
Barriers, challenges and strategies for involving family members in treatment	"It's hard to go up there and talk to somebody" "I think the flexibility [in scheduling treatment] would be more of an issue" "[If the therapist] came to the home? That would be awesome" "Well, if she needs you there for your support, just be there, cause you want her to do the same for you" "If you really care about the kid, you will be there [in treatment]"

the postpartum period – including thoughts and feelings as individuals, fathers, and partners in the context of maternal PPD; (2) *Fathers' views on postpartum relationships* – including relationship with his partner, others family members and the new baby; and (3) *Fathers' attitudes toward mental health treatment* – including perspectives regarding inclusion of family members in the treatment. Below we describe major areas and sub-themes that emerged within each category.

Thematic Category 1: Fathers' Experiences During the Postpartum Period

Lack of knowledge of postpartum mental health conditions

Most fathers (6/8) reported lack of knowledge of maternal postpartum mental health conditions. They reported either not knowing their partner was having difficulties or believing their partners were having typical issues that were expected of perinatal period *("wasn't thinking it was depression at the moment, I thought that she was just having a hard time").* As summarized by one father, *"I am sure most guys don't know what postpartum is."* Many fathers endorsed a wish to know how to recognize mental health conditions earlier, and more knowledge about strategies to support their partner.

Empathy for partner

Fathers reported feeling worried, scared, frustrated, overwhelmed, or helpless by their partners' emotional difficulties ("*I was really worried*" "*I was scared*"). Most fathers (6/8) voiced empathy for their partners, and a desire to help them get through this difficult time ("*I do want to provide the support that she needs for her to get better;" "I don't want to see her like this;" "Anything to help her out"*). They also provided emotional and practical support for their partners including taking their partners to treatment appointments, supporting partners' self-care including engaging in healthy nutrition and sleep. Some reported having to do most of the childcare while their partners were depressed.

Challenges of work-life balance

One of the difficulties many fathers (5/8) described was balancing work and family life during the perinatal period, a challenge that was exacerbated during the period of time when mothers were depressed. Some expressed difficulty attending as many of their partners' prenatal or postnatal appointments as they had wished. Some noted that their need to maintain employment made it hard to notice that their partners were struggling emotionally. Many fathers discussed a desire to take time off of work during the period when their partners were depressed, yet for some it was not possible. Fathers who maintained regular working hours when their partner was depressed reported feelings of exhaustion from the joint responsibility of going to work full time, and also caring for their baby and partner.

Fathers' emotional experiences and distress during the perinatal period

All fathers (8/8) brought up the range of emotions, and often the distress, that they experienced during the postpartum period. Many fathers expressed the feeling that they were not prepared for the perinatal period ("*I think that mentally I wasn't ready*" "*The first week home for me [with the baby] – 'Oh my God'*"). In addition, many noted challenges were compounded and intensified by their partner having a mental health condition. They describe this period as "*surreal*" and "*my life felt like it was turned upside down*." They reported feeling sleep deprived, run-down, and tired. Some expressed missing their pre-parenthood life when they were able to enjoy greater sleep and more time with friends.

Fathers indicated that they felt scared about their partners' health and the wellbeing of the baby. They were concerned about when or if their partners were going to get better, and whether they would be able to manage caring for both the baby and their partners. A few fathers expressed anger, feeling their experience was unfair, missing out on the postpartum experience they hoped for ("*Everybody knew I was angry it's unfair – she's missing out on him, and I am missing out of both of them. We couldn't be a family*"). Other fathers expressed regret and guilt that they did not seek help earlier for their partners, or did not recognize symptoms sooner ("*I should have taken her to the doctor then*," "*I really didn't know. I know she was having a hard time with the baby but never thought she was having those kinds of thoughts*").

Although fathers described a wide range of emotions that they experienced during the postpartum period, many reported a sense that it was not acceptable to have these feelings, or that they were unsure how to express them. (*My mood didn't matter what I felt was not a concern," "I couldn't get depressed, that wasn't, that couldn't not an option*"). Some made a connection between limited expression of emotion and their gender ("*Talking about your feelings isn't something that normally think of as a me, or a guy thing to do*").

Thematic Category 2: Fathers' Views on Postpartum Relationships

A number of themes emerged regarding postpartum relationships, including the couple's relationship, relationship with the new baby and with other family members such as in-laws and siblings.

Communication problems and tension in the couple's relationship

All fathers (8/8) reported either some form of communication problems, or an increase in tension during the perinatal period, often relating to managing care for the baby and adjusting to parenthood. Tension sometimes stemmed from differing communication styles and problems *("The thing is that we have communication problems. We don't talk about the problems"*). Fathers often believed that tension and communication problems were compounded by their partners' depressive symptoms- in particular, increases in partners' irritability. In some cases, fathers reported that they did not want to hurt partners' feelings by sharing concerns. Therefore, many fathers reported that during arguments they tried to stay calm and not argue back, which in turn decreased communication. Some mentioned their partner did not communicate feelings directly, making it difficult to understand her level of distress. A few believed that if they had better communication, this may have prevented a progression of their partner's depression.

Role transitions during the perinatal period and problem solving as a couple

All fathers (8/8) described role transitions the couple underwent during the perinatal period including establishing co-parenting routines and finding new ways of relating to each other. Some found adjusting to co-parenting routines easy, while others did not. Many felt that the communication as a couple changed during this period, and for those with prior conflict, disagreements intensified with the demands of the postpartum period. Some fathers felt that their partners changed and were not the same person they were prior to pregnancy. To cope, some couples developed new ways of problem solving and communicating. For example, one couple developed a strategy of going out to eat in a public space, to be "forced" to calmly talk about issues ("*we have to be civil when we are out in public*").

Feelings of love, closeness, and appreciating time together

Many couples (6/8) reported not having sufficient time or opportunity to be together as a couple ("*I'd love to spend time with you – like, take a weekend and just go*"). Some fathers noted that postpartum experiences had made them feel closer and stronger as a couple, while others reported the opposite.

Experiencing support from and tension with family members

Many fathers (6/8) reported receiving practical and emotional support during the postpartum period from their in-laws, parents, siblings, extended family, and friends. Most support was related to childcare, but some fathers reported receiving emotional support. Conversely, many fathers (6/8) described varying degrees of tension with family members, especially the couple's parents (grandparents of the baby). Many fathers described differences in opinion related to childcare; some reported that grandparents could be critical of their partner. This led many fathers to feel "*in the middle.*" Some reported that the tension with their family worsened the distress of the couple and of their partner ("*[tension with the mother-in-law] made the depression worse*").

Relationship with baby

Fathers reported the birth of the baby as both a source of stress, and a motivation for change and growth. Many fathers (4/8) reported infant difficulties with sleeping, feeding, and crying as sources of stress. However, they also reported that their babies were a motivation for learning how to be a father, improving their relationship with their partner, and supporting their partner through their depression ("*we can't be like this it's not healthy for the two children*" *"I had to be there for the baby").*

Thematic Category 3: Fathers' Attitudes Toward Mental Health Treatment

Openness and benefits to being involved in treatment

As noted earlier, most fathers participated in a family meeting during their partner's treatment. Fathers universally reported this as helpful in promoting understanding of PPD, and how to support her ("*The lady there just telling me about everything that, like, telling her about how she feels that's when I really understood it motivated me to help her*"). Some felt that the family meeting was helpful in improving the couple's communication, including having someone mediate the conversation when there was tension. When asked about important areas of focus for postpartum family or couples treatment, many endorsed communication, problem solving strategies, and promoting increased time together as important goals. They also emphasized the importance of PPD education, "warning signs" and strategies to address PPD with their partner. In all, the vast majority of fathers interviewed (7/8) remarked that they were open to engaging in family treatment during the postpartum period and viewed it to be potentially helpful.

Barriers, challenges, and strategies for involving family members in treatment

Many fathers (6/8) identified barriers or challenges with becoming involved in their partner's PPD treatment. Specifically, some fathers expressed finding the family meeting helpful and desired more, while others found it time-consuming and disruptive to work. There was a reported preference for evening or weekend appointments and childcare assistance for older children. Some preferred to have sessions at locations that were familiar, including the obstetrical hospital where they received prenatal and postnatal care are even in their homes. Some fathers suggested a "fathers' only" peer treatment group could be beneficial; however, other fathers reported feeling uncomfortable sharing information in groups, and preferred privacy, e.g., participating in online forums to access resources on postpartum mental health conditions.

DISCUSSION

Fathers and partners are largely left out of perinatal research and clinical care, in spite of their impact on the wellbeing of mothers and infants during the postpartum period. The current findings shed light on the experiences of fathers who have a partner struggling with significant symptoms of depression, representing families who are more at risk for adverse outcomes and

arguably in most need of services. Not surprisingly, in addition to the high levels of depression among the mothers, many fathers exhibited depression symptoms themselves, and family functioning scores in the clinical range. Our analyses found that fathers reported multiple challenges when their partner was experiencing depression symptoms, including feeling exhausted, unprepared, uninformed regarding maternal postpartum illness, and experiencing difficulty balancing work and family needs. Second, fathers were universally open to engaging in various forms of psychosocial and mental health treatments, although many described logistic and personal barriers. Overall, these results add to the growing evidence of the importance of including fathers and partners in perinatal research and clinical care in the context of maternal PPD.

Consistent with prior studies regarding concordance of parental depression, many partners of mothers with PPD reported elevated depression; however, regardless of depression status, all fathers endorsed strong emotional experiences during the postpartum period. Fathers expressed a wide range of emotions –fear, guilt, anger, worry, and exhaustion, echoing other research with postpartum fathers (O'Brien et al., 2019). In spite of fathers voicing an array of strong emotions during the research interview, many also noted that they had trouble expressing their feelings, or felt they needed to prioritize their partners' needs. Prior research has similarly found that postpartum fathers may question the legitimacy of their feelings and needs, particularly when they have a depressed partner (Darwin et al., 2021). Our sample was diverse in terms of race and ethnicity and socio-economic background; though not directly examined in the current study, it is possible that cultural norms and beliefs could impact father's views regarding expression of emotions.

Fathers voiced feelings of empathy and a desire to help with partners, but also acknowledged problems in the relationship, such as communication issues, impaired problem-solving, and difficulty managing parenting tasks. This distress was also reflected in the self-report family functioning scores which on average reached clinical levels. Thus – couples were struggling with serious issues, some apparently long-standing, and other issues were exacerbated with the transition to parenthood and onset of maternal depression. The fact that all mothers and many fathers in the sample struggled with symptoms of depression may have shaped their assessment of their relationship, potentially leading to a more negative appraisal in some cases.

Although relationship challenges were universal in our sample, similar to other samples of postpartum men (Marrs et al., 2014), we also found that fathers endorsed openness to being involved in mental health treatment. They noted that treatment could help improve problems in the relationship and help them communicate and find ways of spending more time together. Additionally, consistent with prior research (Letourneau et al., 2011; Mayers et al., 2020) fathers were eager for information regarding PPD and wanted to learn about specific ways they could provide support for their depressed partner. However, many wished they had received information sooner, to help identify problems, potentially preventing progression of the mother's illness and the impact on the family system. There was a generally positive acceptance of mental health treatment, but fathers noted that personal and logistic barriers impeded attendance. To fathers, the new baby and other children represented strong motivators for engaging in treatment as did supporting their partner's recovery. Fathers also voiced interest in flexible scheduling, location, and onsite childcare, as well as interest in various modalities (couples/family treatment, peer/partner groups, and online forums). Although the motivation for treatment among postpartum couples may stem from the need to address PPD or other maternal symptoms or functioning issues, treatment approaches that provide support specifically for fathers and partners to manage their own distress – and to discuss their vantage point regarding role changes and challenges – are critically important, including sensitivity to differing levels of comfort that partners may have with emotional expression. For many families, engaging in professional mental health treatment may be new; efforts to make the treatment experience accessible, pleasant, and directly useful for fathers and partners will likely help promote greater engagement.

Building on these findings, future maternal mental health interventions should consider expanded strategies to include partners in the treatment process. It will be important for services to be designed in such a way that family involvement is feasible, with a flexible format, scheduling, welcoming the presence of the baby, and potentially offering home-based services. Additionally, building on existing internet-based interventions for perinatal women (O'Mahen et al., 2014; Milgrom et al., 2016), it will be important to develop or expand digital health interventions that more centrally involve partners and other family members.

Strengths of the present study include assessment of both paternal and maternal depression and including data from the clinical record regarding the mother's depressive episode to contextualize the couples' postpartum experiences. In addition, our sample, though small, had diverse representation across a range of racial and ethnic groups and socioeconomic backgrounds, consistent with the population in our geographic region in the northeastern United States. In terms of limitations, our sample size is small and in these analyses we specifically focused on the paternal experience. Given that some participants were remarking upon a more recent postpartum experience and treatment episode (e.g., past 3 months), and others were remarking on an experience that was earlier (e.g., 6–9 months ago), there may be variability with regard to how clearly events are recalled. Although the sample is diverse in terms of racial and ethnic background, it may not reflect the views of all postpartum fathers. We did not have any same-sex couples or gender diverse individuals. Understanding the experiences and treatment needs and preferences of diverse families and families with non-traditional structures will be important in future research. In addition, other family structures should be considered in developing new treatment approaches that explicitly include other support persons particularly for single parents who may not live with a partner or co-parent (Alves et al., 2018). Accurate screening and identification of mental health concerns in *both* parents and effective treatments that promote active involvement of key family members and support persons, will allow for more effective reduction of stress during the perinatal period, and ultimately help prevent long term adverse outcomes for children and families.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Butler Hospital Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CB conceptualized the study, conducted quantitative and qualitative data analyses, and prepared the manuscript. ALT contributed to the qualitative data analysis and prepared portions of the manuscript. MH and IM helped in the initial planning stage of the study and provided editorial suggestions for the final manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

The findings reported in this publication were supported by NIH grants K23MH066402 and T32MH019927.

ACKNOWLEDGMENTS

We are grateful to the fathers and mothers who participated in this research, without, whom this report would not be possible.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

ORIGINAL RESEARCH
published: 17 January 2022
doi: 10.3389/fpsyg.2021.751330

The Baby Care Scale: A Psychometric Study With Fathers During Pregnancy and the Postpartum Period

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The Baby Care Scale (BCS) was designed to assess the involvement of father in infant care during pregnancy and the postpartum period. This study aimed to examine the psychometric characteristics of the BCS – antenatal (BCS-AN) and BCS – postnatal (BCS-PN) versions. A sample of 100 primiparous fathers completed the BCS-AN and/or the BCS-PN and self-reported the measures of anxiety and depressive symptoms and of father–infant emotional involvement during pregnancy and the postpartum period, respectively. Good internal consistency was found for both the BCS-AN and the BCS-PN. A two-factor model was found for both versions of the instrument: (1) household tasks and (2) infant care tasks. The BCS-AN and BCS-PN subscales revealed good internal consistency. Higher scores on the BCS-AN predicted higher scores on the BCS-PN. Significant associations were found among the BCS (BCS-AN and BCS-PN), depressive and anxiety symptoms, and father–infant emotional involvement, revealing good criterion validity. This study suggested that both the BCS-AN and the BCS-PN are reliable multidimensional self-report measures that assess the involvement of father in infant care during pregnancy and the postpartum period.

Keywords: Baby Care Scale, psychometric characteristics, fathers, involvement in infant care, anxiety and depressive symptoms, father–infant emotional involvement

OPEN ACCESS

Edited by:
Eleonora Mascheroni, Eugenio Medea, Scientific Institute for Research, Hospitalization and Healthcare (IRCCS), Italy

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *31 July 2021*
Accepted: *15 December 2021*
Published: *17 January 2022*

Citation:
Pinto TM, Nunes-Costa R and Figueiredo B (2022) The Baby Care Scale: A Psychometric Study With Fathers During Pregnancy and the Postpartum Period. Front. Psychol. 12:751330. doi: 10.3389/fpsyg.2021.751330

INTRODUCTION

During the past several decades, major changes occurred in family structures. Thus, the role of men as fathers has changed, and an increase in their involvement in infant caregiving has been observed (e.g., Parke, 2004). Although the knowledge on father–infant relationships has increased (Lamb, 1981, 2013), validated measures to assess the involvement of father in infant care are scarce, which limits research in this field.

Literature has consistently demonstrated an association between the quality of involvement of father in infant care and infant physical and mental development (e.g., Lamb, 2010). The impact of involvement of father in infant care on infant development may occur either directly, through their behaviors, or indirectly, through its impact on the perceived support of mother and consequently on their mental health and parenting (Parke, 1979; Belsky, 1984). Indirect support can then be operationalized in the support of father to the care provided by the mother or through shared responsibilities in caring for the child and sharing domestic tasks. Moreover, the involvement of father in infant care and the household is associated with a greater subjective well-being of the

mother (e.g., Lennon et al., 1991) and a better quality of interaction with the infant (e.g., Brunelli et al., 1995; Bögels and Brechman-Toussaint, 2006).

According to the developmental perspective (Cowan, 1991), fatherhood should not be defined exclusively by the moment of birth. The care provided to the offspring begins during pregnancy and is concomitant with a wide range of developmental tasks to be performed by both the mother and the father (Figueiredo, 2013). Activities performed by the father, namely, being present in the ultrasounds or taking care of the infant arrival, are major predictors of his emotional involvement with the infant during pregnancy (e.g., Samorinha et al., 2009). Likewise, the higher levels of support received by the father, both emotional and instrumental, are associated with higher subjective well-being of the pregnant woman and the acceptance of her pregnancy (Cutrona, 1996; Kroelinger and Oths, 2000; Rini et al., 2006).

The Baby Care Scale (BCS; Figueiredo, 1997) was specifically designed to assess the involvement of father in infant care during pregnancy and the first-year postpartum. In its original version, this scale was filled in by the mother to assess different tasks of infant care (Figueiredo, 1997). The items assess the frequency of involvement of father in household and infant care tasks. Although the original version that presented good psychometric characteristics was completed by the mothers (Figueiredo, 1997), this study used a small sample and, to the best of our knowledge, the psychometric characteristics of the BCS were not yet tested in fathers. This study aimed to examine the psychometric characteristics of the BCS – antenatal (BCS-AN) and BCS – postnatal (BCS-PN) versions in fathers.

Literature highlights the impact of involvement of father in infant care during pregnancy and the postpartum period on infant development (Ramchandani et al., 2011; Gutierrez-Galve et al., 2015). Moreover, literature also provides evidence on the negative impact of adjustment problems of father to the transition to parenthood on their own parenting (Vismara et al., 2016; Rollè et al., 2017). Altogether, these studies provide evidence that perinatal screenings and interventions should target both mothers and fathers early in the perinatal period. Analyzing the psychometric characteristics of the BCS-AN and the BCS-PN in fathers could be a major contribute to the field on adjustment of father to the transition to parenthood. Both the BCS-AN and the BCS-PN could be useful tools to assess the involvement of father in infant care and identify fathers with low involvement in infant care during pregnancy and/or the postpartum period.

MATERIALS AND METHODS

Participants

The sample comprised 100 primiparous fathers who completed the BCS-AN and the BCS-PN. Participants were between the ages of 20 and 45 years (M = 31.34, SD = 4.38). Nearly all the participants were Portuguese (97.9%) and Caucasian (82.1%), employed (89.5%), married or cohabiting (91.4%), and lived only with the partner (75.8%). Of these 100 participants, 85 (85%) completed the BCS-AN. Of these 85 participants, 35.3% (n = 30) did not continue the study. Thus, 55 fathers completed both the BCS-AN and the BCS-PN. In addition, the BCS-PN was also completed by 15 new participants specifically recruited in this period (n = 70) (see **Table 1**).

Procedure

This study was approved by the Ethics Committees of all institutions involved and complied with the standards and recommendations provided by the Declaration of Helsinki. Participation was voluntary, and all participants were informed about aims and procedures of the study and signed an informed consent form. Participants were recruited in two Portuguese Health Services (one private and one public) during the first trimester of pregnancy or during the first-year postpartum. Inclusion criteria were being able to read and write European Portuguese, lived in Portugal for the past 10 years, be primiparous fathers of a single pregnancy, and have no gestational problems. Participants were randomly recruited between October 2013 and March 2015, after the first ultrasound (between 8 and 14 weeks of gestation) or in the postpartum period (between 1 and 12 months postpartum). Fathers completed the BCS-AN and/or the BCS-PN online and self-reported the measures of anxiety and depressive symptoms and of father–infant emotional involvement during pregnancy and the postpartum period, respectively.

Measures

Sociodemographic Questionnaire

A sociodemographic questionnaire (Figueiredo et al., 2009) was used to collect the sociodemographic information of father (e.g., age, ethnicity, religion, occupational status, and educational level).

Baby Care Scale – Antenatal and Baby Care Scale – Postnatal Versions

The BCS (Figueiredo, 1997) was designed to assess the involvement of father in infant care during the first-year postpartum. The scale consists of 14 items scored on a 4-point Likert-type scale (from 0 to 3) that assessed the frequency of tasks of father related to the infant care. The BCS includes items that assessed the involvement of father in household tasks (e.g., preparing meals, cleaning the kitchen, and shopping) and related to the care directly provided to the infant (e.g., feeding the infant, bathing the infant, and changing diapers when wet). The total score of BCS ranges between 0 and 42, with higher scores indicating higher involvement of father in infant care. The original version was developed by Figueiredo (1997), presenting good internal consistency (Cronbach's alpha = 0.82).

The BCS-PN was adapted to be used with fathers during pregnancy (BCS-AN), maintaining the overall structure of the BCS-PN. Although the items that assessed the involvement of father in the household tasks remained in the prenatal version, the content of the items that assessed the involvement of father in infant care tasks was modified to assess the care provided to the infant and the pregnant mother (Parke, 1979; Belsky, 1984)

TABLE 1 | Sociodemographic characteristics of participants.

		BCS-AN[1] *n* = 85 %	BCS-PN[2] *n* = 70 %	BCS-AN and PN[3] *n* = 55 %	Total *N* = 100 %
Age (years)	20–29	35.3	25.7	30.9	31.6
	30–39	62.4	70.0	65.5	65.3
	>40	2.4	4.3	3.6	3.2
Occupational status	Employed	88.2	91.4	90.9	89.5
	Unemployed	9.4	7.1	7.3	8.4
	Student	2.4	1.4	1.8	2.1
Education (in years)	<9	9.4	4.3	5.5	8.4
	9–12	55.3	54.3	63.6	50.5
	>12	35.3	58.3	30.9	41.1
Marital status	Married	64.7	67.1	65.5	63.3
	Cohabiting	27.1	25.7	25.5	28.1
	Single	8.2	7.1	9.1	26.3
Mode of conception	Spontaneous	96.5	94.3	96.4	94.7
	Medically assisted	3.5	5.7	3.6	5.3

[1]*Completed the BCS-AN.*
[2]*Completed the BCS-PN.*
[3]*Completed both the BCS-AN and the BCS-PN.*
BCS-AN, Baby Care Scale – antenatal version; BCS-PN, Baby Care Scale – postnatal version.

and involvement of father in the preparations of the infant arrival (e.g., Colman and Colman, 1994).

Baby Care Scale – Antenatal and Baby Care Scale – Postnatal Criterion Validity

Measures of anxiety and depression symptoms and of father–infant emotional involvement were used to assess criterion validity for both BCS-AN and BCS-PN. The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used to assess depressive symptoms during pregnancy and the postpartum period. The EPDS is a 10-item self-report scale scored on a 4-point Likert-type scale, designed to assess postpartum depression. This measure assesses the intensity of depressive symptoms within the previous 7 days and has been used in several studies with men during pregnancy and the postpartum period (e.g., Figueiredo and Conde, 2011; Parfitt and Ayers, 2014). The EPDS Portuguese version showed good internal consistency during pregnancy and the postpartum period (e.g., Figueiredo and Conde, 2011). In this sample, Cronbach's alpha coefficient was 0.80 during pregnancy and 0.77 during the postpartum period.

The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) is a self-report scale comprised by two subscales, namely, the state anxiety and the trait anxiety, each containing 20 items scored on a 4-point Likert-type scale. The State Anxiety Inventory (STAI-S) that measures the temporary condition of "state anxiety" (anxiety in a specific situation) was used to assess anxiety symptoms during pregnancy and the postpartum period. Several studies have used this measure with men during pregnancy and the postpartum period (e.g., Figueiredo and Conde, 2011). The STAI-S Portuguese version showed good internal consistency ($\alpha = 0.88$; Biaggio et al., 1976). In this sample, Cronbach's alpha coefficient was 0.88 during pregnancy and 0.92 during the postpartum period.

The Portuguese version of the Mother-Infant Bonding Scale (MIBS; Figueiredo, 2013) was used to assess father–infant emotional involvement. The items are organized into three subscales, with a total of 11 self-report items, rated on a 4-point Likert-type scale. The "Positive Bonding" subscale consists of three items (i.e., Affectionate, Protective, and Happy) and measures positive emotional involvement; the "Negative Bonding" subscale consists of six items (i.e., Angry, Aggressive, Sad, Resentful, Disgusted, and Disillusioned) and assesses negative emotional involvement; the subscale "Bonding not clear" consists of two items (i.e., Afraid and Neutral and No Feelings) and signals the presence of emotions not clearly related to the emotional involvement of parents with the infant. This scale has been used both during pregnancy and the postpartum period (e.g., Samorinha et al., 2009; Brandão and Figueiredo, 2012). The MIBS showed good internal consistency ($\alpha = 0.71$; Figueiredo and Costa, 2009). In this sample, Cronbach's alpha coefficient was 0.72 during pregnancy and 0.78 during the postpartum period.

Data Analysis

The analysis of the psychometric characteristics of both the BCS-AN and the BCS-PN included analysis of (1) factor structure and internal consistency and (2) criterion validity and predictive validity. The analysis of (1) factor structure and internal consistency included factor analysis in principal components, with orthogonal rotation using the varimax method, as well as a confirmatory factor analysis for each scale. To ensure that each item represented the construct underlying the factor, a minimum factor loading of 0.30 was considered. The suitability of the items to factor analysis was examined by the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's sphericity test (AIC). The internal consistency of the BCS-AN and the BCS-PN was analyzed

using Cronbach's alpha coefficient and item-total and mean-item correlations (MICs). Values of Cronbach's alpha ≥0.70, item-total correlations (ITCs) ≥0.30, and mean inter-item correlations >0.15 all indicate good level of internal consistency (Nunnally and Bernstein, 1994; Field, 2005). Pearson's correlations were also performed to analyze the intercorrelations of both scales. To analyze (2) criterion validity, Pearson's correlations were performed between the BCS-AN and the BCS-PN (total scale and subscales) and measures of anxiety (STAI-S) and depressive (EPDS) symptoms and measures of father–infant emotional involvement (MIBS). To analyze (2) the predictive validity, participants who completed both versions of the ECPB (prenatal and postnatal) were also included in a linear regression analysis to examine the predictive value of the BCS-AN scores on the BCS-PN scores.

RESULTS

Baby Care Scale – Antenatal and Baby Care Scale – Postnatal Factor Structure

Regarding the BCS-AN, the adequacy of the factor analysis to the items, by verifying the existence of significant correlations between them, was confirmed by the KMO measure (KMO = 0.73) and Bartlett's sphericity test (QQ = 434.6, df = 91, $p < 0.001$). The results obtained in the factor analysis showed as the best solution two factors that explained, in its entirety, 46.82% of the variance. The inflection point of the Cattell (1996) supported a two-factor solution. The first factor contains five items related to the involvement of father in household activities and contributes 25.1% of the total explained variance.

Table 2 shows the results of saturations by item as well as the ITCs, which ranged between 0.27 and 0.48, and the average inter-item correlation, which were 0.15 greater on each subscale. The Cronbach's alpha found was 0.81.

Regarding the BCS-PN, the KMO measure (KMO = 0.74) and Bartlett's sphericity test (QQ = 390.0, df = 78, $p < 0.001$) revealed the adequacy of factor analysis. The best solution revealed a two-factor structure that explains 45.03% of the variance. Again, the inflection point of the Cattell (1996) supports a two-factor solution. The first factor contains 8 items related to the care provided directly to the baby and contributes 21.2% of the total explained variance. The second factor contains the remaining 6 items related to the involvement of father in domestic activities and contributes 19.9% of the total explained variance.

The results of saturations by item as well as the ITCs, which varied between 0.26 and 0.62, are shown in **Table 3**. Also, as in the BCS-AN, inter-item correlation means were 0.15 higher on each of the subscales. The Cronbach's alpha for the BCS-PN was 0.82.

Pearson's correlations revealed that the BCS-AN total scale was significantly correlated with both subscales: household tasks ($r = 0.72$, $p < 0.001$) and the infant care tasks ($r = 0.89$, $p < 0.001$). Significant correlations were also found between the two BCS-AN subscales ($r = 0.32$, $p = 0.003$). Pearson's correlations also revealed that the BCS-PN total scale was significantly correlated with both subscales: household tasks ($r = 0.79$, $p < 0.001$) and the infant care tasks ($r = 0.89$, $p < 0.001$). Significant correlations were also found between the two BCS-PN subscales ($r = 0.42$, $p < 0.001$) (see **Table 4**).

Baby Care Scale – Antenatal and Baby Care Scale – Postnatal Criterion and Predictive Validity

Pearson's correlations revealed significant negative correlations between anxiety and depressive symptoms during pregnancy and the BCS-AN total scale and subscales. Likewise, significant negative correlations between anxiety and depressive symptoms during the postpartum period and the BCS-PN total scale and subscales were found (see **Table 5**).

Pearson's correlations revealed significant positive correlations between the MIBS total score during pregnancy and the BCS-AN total score ($r = 0.28$, $p = 0.010$), as well as with the infant care tasks subscale ($r = 0.36$, $p = 0.001$). The positive MIBS subscale was positively correlated with the BCS-AN total score ($r = 0.40$, $p < 0.001$) and the infant care tasks subscale ($r = 0.51$, $p < 0.001$).

Significant positive correlations were also found between the BCS-PN total score and the MIBS total score and positive subscale ($r = 0.27$, $p = 0.022$), as well as with the infant care tasks subscale ($r = 0.27$, $p = 0.023$) (see **Table 5**).

A linear regression analysis performed with participants who completed both versions of the ECPB also revealed the good predictive validity for the BCS-AN [adjusted $R^2 = 0.34$, $F(1,53) = 28.74$, $p < 0.001$]. Higher scores on the BCS-AN significantly predicted higher scores on the BCS-PN ($\beta = 0.60$, $t = 5.36$, $p < 0.001$).

DISCUSSION

This study provided evidence that the BCS has good psychometric characteristics in fathers, both in the BCS-AN and BCS-PN versions. The BCS-AN and the BCS-PN showed good internal consistency, both considering the Cronbach's alpha values ($\alpha = 0.81$ for the BCS-AN and $\alpha = 0.82$ for the BCS-PN) and the ITCs with values greater than 0.30 and mean of inter-item correlations greater than 0.15 (Field, 2005). A two-factor model was found for both the BCS-AN and the BCS-PN. The first factor included items related to the care provided by the father directly to the infant (infant care tasks), while the second factor included all the items related to the household tasks provided by the father (household tasks). All subscales of both the BCS-AN and the BCS-PN showed good internal consistency (with α ranging between 0.74 and 0.82). Moreover, a significant prediction of the BCS-AN scores was found on the BCS-PN scores. Results provided evidence that fathers who provide more care to the infant during pregnancy can be those who provide more care to the infant during the postpartum period.

Although item 14 presented a factor loading and an ITC values below the recommended (Field, 2005), it was maintained. The maintenance of this item did not interfere with the internal consistency of the scale and the number of items in the original scale (Figueiredo, 1997) was preserved. However, it is recommended that future studies should further analyze the

TABLE 2 | BCS-AN exploratory factor analysis.

Item	Factor loadings		ITC	α IID	*C*	*M*	SD
	Factor 1	Factor 2					
Household tasks subscale (α = 0.76)			MIC = 0.39				
1. Prepare meals	0.77		0.48	0.79	0.59	1.80	0.94
2. Clean the kitchen	0.67		0.36	0.80	0.45	2.26	0.90
3. Perform household tasks (e.g., vacuuming, washing)	0.80		0.46	0.79	0.64	1.69	0.90
4. Go shopping	0.69		0.48	0.79	0.49	1.74	0.71
5. Make small arrangements at home	0.55		0.27	0.81	0.31	1.48	0.77
Infant care tasks subscale (α = 0.79)			MIC = 0.33				
6. Touch your partner's belly		0.60	0.45	0.79	0.39	2.72	0.65
7. Talk to your partner's belly		0.58	0.68	0.77	0.60	1.89	0.98
8. Refers to the baby by his/her name (name you and your partner decided to give)		0.36	0.46	0.80	0.32	1.55	1.27
9. Talk about the baby		0.62	0.44	0.80	0.40	2.81	0.55
10. Participate in the purchase of essential goods for the baby (e.g., crib, clothes)		0.57	0.46	0.79	0.38	2.26	0.85
11. Imagine your baby		0.63	0.39	0.80	0.40	2.19	0.89
12. Accompany your partner to the obstetrician		0.62	0.35	0.80	0.45	2.66	0.73
13. It is present in the baby's ultrasounds		0.70	0.42	0.80	0.50	2.72	0.68
14. Think about how your baby is doing		0.79	0.41	0.80	0.64	2.66	0.63
BCS-AN total (α = 0.81)						30.44	6.23

C, communalities; ITC, item-total correlation; MIC, mean-item correlation; IID, if item deleted; M, mean; SD, standard deviation; BCS-AN, Baby Care Scale – antenatal version.

TABLE 3 | BCS-PN exploratory factor analysis.

Item	Factor loadings		ITC	α IID	*C*	*M*	SD
	Factor 1	Factor 2					
Household tasks subscale (α = 0.74)			MCI = 0.29				
1. Prepare meals		0.75	0.40	0.81	0.57	1.96	0.91
2. Clean up the kitchen		0.71	0.48	0.80	0.54	2.17	0.83
3. Perform household tasks (e.g., vacuuming, washing)		0.75	0.49	0.80	0.58	1.66	0.74
4. Go shopping		0.67	0.37	0.81	0.44	1.83	0.56
5. Make small arrangements at home		0.46	0.32	0.81	0.24	1.44	0.65
13. Take care of the house and the baby		0.43	0.46	0.80	0.32	2.37	0.75
Infant care tasks subscale (α = 0.78)			MCI = 0.32				
6. Feed the baby	0.80		0.51	0.80	0.64	2.21	0.86
7. Bathe the baby	0.31		0.26	0.82	0.13	2.27	0.82
8. Change diapers even when dirty with poop	0.62		0.56	0.80	0.48	2.54	0.85
9. Put the baby to sleep	0.90		0.63	0.80	0.81	2.54	0.77
10. Change diapers even when wet	0.90		0.62	0.80	0.80	2.54	0.77
11. Get up at night to take care of the baby	0.55		0.41	0.81	0.39	2.21	0.88
12. Take the baby for a walk	0.51		0.54	0.80	0.33	2.19	0.64
14. Play with the baby	0.15		0.13	0.82	0.04	2.79	0.59
BCS-PN total (α = 0.82)						30.39	5.83

C, communalities; ITC, item-total correlation; MIC, mean-item correlation; IID, if item deleted; BCS-PN, Baby Care Scale – postnatal version.

internal consistency of the item 14, namely, using larger samples of fathers, considering the influence of the sample size on internal consistency (Field, 2005).

Regarding the BCS-AN and BCS-PN criterion validity, significant medium-sized correlations were obtained between the BCS-AN and BCS-PN and measures of anxiety and

TABLE 4 | BCS-AN and BCS-PN intercorrelations.

	BCS-AN	Household tasks	Infant care tasks
BCS-AN	1.00		
Household tasks	0.72***	1.00	
Infant care tasks	0.89***	0.32**	1.00
	BCS-PN	**Household tasks**	**Infant care tasks**
BCS-PN	1.00		
Household tasks	0.79***	1.00	
Infant care tasks	0.89***	0.42***	1.00

*BCS-AN, Baby Care Scale – antenatal version; BCS-PN, Baby Care Scale – postnatal version. **p < 0.01 and ***p < 0.001.*

TABLE 5 | BCS-AN and BCS-PN criterion validity: correlations with anxiety and depressive symptoms, and father–infant emotional involvement during pregnancy and the postpartum period, respectively.

Pregnancy	BCS-AN	Household tasks	Infant care tasks
Anxiety symptoms STAI-S	−0.3**	−0.28*	−0.27*
Depressive symptoms EPDS	−0.48***	−0.40***	−0.46***
Total MIBS	0.28**	0.02	0.36***
Positive MIBS	0.40***	0.06	0.50***
Negative MIBS	0.08	0.07	0.07
Not clear MIBS	−0.09	−0.04	−0.09
Postpartum	**BCS-PN**	**Household tasks**	**Infant care tasks**
Anxiety symptoms STAI-S	−0.29*	−0.21*	−0.24*
Depressive symptoms EPDS	−0.41***	−0.38***	−0.44***
Total MIBS	0.098	−0.019	0.159
Positive MIBS	0.274*	0.178	0.272*
Negative MIBS	0.009	0.119	−0.076
Not clear MIBS	−0.006	0.065	−0.057

*BCS-AN, Baby Care Scale – antenatal version; BCS-PN, Baby Care Scale – postnatal version. *p < 0.05; **p < 0.01; ***p < 0.001.*

depressive symptoms and measures of father–infant emotional involvement. Specifically, significant associations were found between mental health problems of father and the frequency of care provided by the father to the infant. These results are in line with previous studies, suggesting the negative impact of mental health problems of father on their own parenting (e.g., Vismara et al., 2016; Rollè et al., 2017). Likewise, significant associations were found between the frequency of care provided by the father to the infant and the quality of the emotional involvement of father with the infant. Higher values in the MIBS total scale and in the positive subscale were associated with higher frequency of care from the father to the infant and to the partner, both during pregnancy and the postpartum period (Figueiredo and Costa, 2009). Previous studies have shown that the quality of bonding established with the infant during pregnancy is associated with the quality of care provided by the father (e.g., Wiberg et al., 1989).

A significant prediction of the BCS-AN scores was found on the BCS-PN scores. Results provided evidence that fathers who provide more care to the infant during pregnancy can be those who provide more care to the infant during the postpartum period. Fathers with low involvement in infant care can be identified early during pregnancy.

Limitations

The voluntary nature of participation in this study may work as a bias of the results found, as those who participated in this study may be those who are already more involved in providing care to the infant. A larger and a more social culturally diverse sample of fathers would have allowed to conduct more robust psychometric analyses on the BCS-AN and BCS-PN, namely, a confirmatory factor analysis.

Implications for Practice and Research

Literature provided evidence that perinatal screenings and interventions should target both mothers and father early in the perinatal period (Gutierrez-Galve et al., 2015; Vismara et al., 2016; Rollè et al., 2017). The BCS-AN and the BCS-PN may be reliable self-report measures to assess the involvement of father in infant care and may allow perinatal practitioners to screen fathers

with low involvement in infant care during pregnancy and/or the postpartum period. The use of BCS as part of routine perinatal care appointments may provide an easy and valid strategy to identify fathers with low involvement in infant care and to provide information on those who could benefit from perinatal psychological counseling.

For researchers, both versions of the BCS may be useful measures in longitudinal studies on the involvement of father in infant care during pregnancy and the postpartum period. Both versions of the BCS could also be useful tools to assess the effectiveness of new interventions aiming to promote positive parenting and/or to prevent parenting difficulties in fathers during the perinatal period. This study provided preliminary evidence on the psychometric properties of the BCS in a community sample of fathers during the transition to parenthood. Future studies might assess other psychometric properties of both versions of the BCS using larger and social culturally diverse samples of fathers during the perinatal period.

CONCLUSION

This study suggested that the BCS-AN and the BCS-PN are reliable multidimensional self-reported measures to assess the involvement of father in infant care during pregnancy and the postpartum period.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Minho. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors participated in the study design, undertook the statistical analysis, interpreted the results, and wrote the first draft of the manuscript. TP and RN-C collected the data. All authors contributed to and have approved the final manuscript.

FUNDING

This study was conducted at the Psychology Research Centre (PSI/01662), School of Psychology, University of Minho, and supported by the Foundation for Science and Technology (FCT) through the Portuguese State Budget (UIDB/PSI/01662/2020).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

MINI REVIEW
published: 20 January 2022
doi: 10.3389/fpsyg.2021.744921

Interventions for Perinatal Depression and Anxiety in Fathers: A Mini-Review

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Background and Objectives: Up to 10% of fathers experience perinatal depression, often accompanied by anxiety, with a detrimental impact on the emotional and behavioural development of infants. Yet, few evidence-based interventions specifically for paternal perinatal depression or anxiety exist, and few depressed or anxious fathers engage with support. This mini-review aims to build on the evidence base set by other recent systematic reviews by synthesising more recently available studies on interventions for paternal perinatal depression and anxiety. Secondarily, we also aimed to identify useful information on key implementation strategies, if any, that increase the engagement of men.

Methods: We drew upon three major previous systematic reviews and performed an updated search of PubMed/Medline; Psycinfo; Cochrane Database; Embase and Cinahl. The search was limited to trials, feasibility studies or pilot studies of interventions published between 2015 and 2020 that reported on fathers' perinatal mental health. We included psychological, educational, psychosocial, paternal, couple-focused, or group therapies, delivered face-to-face, via telephone and/or online that reported on either paternal depression, anxiety or both.

Results: Eleven studies satisfied search criteria (5 of which were not included in previous reviews). The majority were randomised controlled trials. Most interventions incorporated counselling, therapy or psychoeducation and took an indirect approach to perinatal mental health through antenatal or postnatal education and were couple-focused. No studies reported a presence of diagnosed depression or anxiety at baseline, although five studies reported a positive effect on sub-threshold symptoms.

Discussion: There was some evidence that these approaches may be useful in the initial engagement of fathers with perinatal supports and improve depression and anxiety scores. No studies targeted the explicit treatment of clinically depressed or anxious men, and this remains the most substantial gap in the peer-reviewed evidence base. Our results highlight the need to deliver perinatal interventions specifically designed for men and evaluate them in populations with clinical levels of depressive and anxious symptomatology.

Keywords: postnatal, depression, anxiety, mental health, digital interventions, treatment, psychological distress, father

OPEN ACCESS

Edited by:
Gian Mauro Manzoni, University of eCampus, Italy

Reviewed by:
Kenji Takehara, National Center for Child Health and Development (NCCHD), Japan
Erica Neri, University of Bologna, Italy

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *21 July 2021*
Accepted: *28 December 2021*
Published: *20 January 2022*

Citation:
Rodrigues AL, Ericksen J, Watson B, Gemmill AW and Milgrom J (2022) Interventions for Perinatal Depression and Anxiety in Fathers: A Mini-Review. Front. Psychol. 12:744921. doi: 10.3389/fpsyg.2021.744921

INTRODUCTION

The transition to fatherhood can present as a fundamental shift in a man's life. Along with the traditional challenges of learning new skills and knowledge, changes in personal identity, the couple relationship and financial commitments may lead to new fathers being overwhelmed by feelings of confusion, exhaustion, helplessness, loneliness and feeling trapped (Rowe et al., 2013). Consequently, these factors can culminate in increased vulnerability to depression and anxiety.

Approximately 10% of new fathers experience significant depression in the perinatal period with debilitating symptoms of depression commonly including lowered mood, loss of interest or enjoyment, difficulty sleeping, changes in appetite and weight, feelings of worthlessness, and thoughts of self-harm (Goodman, 2004). Depression is often accompanied by significant anxiety (Tohotoa et al., 2012).

Even more are likely to suffer from milder symptoms of depression and anxiety and also a range of negative emotions such as anger, worry, confusion, and irritability (Cameron et al., 2016). Some may resent the constant needs of a new baby and their partner's preoccupation with the baby, including breastfeeding (Earls et al., 2019; Eddy et al., 2019). Depressed fathers are more likely to engage in substance abuse and family violence than non-depressed fathers (Earls et al., 2019). There is a complex relationship between depression in couples: living with a depressed partner may also exacerbate men's mental health problems and vice versa (Goodman, 2004). Depression and anxiety not only have a serious impact on men's lives in the perinatal period, but also on the emotional and behavioural development of their infants and family's functioning (Ramchandani et al., 2008).

Whilst prevalence estimates vary widely (Tuszyńska-Bogucka and Nawra, 2014; Nath et al., 2016; Paulson et al., 2016; Carlberg et al., 2018), depending on the sample surveyed and the measurement instruments used, there is growing evidence that paternal postnatal depression presents as a significant economic burden on the Australian healthcare system (PANDA, 2012). Interventions targeting paternal perinatal depression are consequently essential not only for the well-being of new fathers and their families, but to address the wider socio-economic burden.

Typically, interventions, programs and clinical health services have targeted the amelioration of maternal perinatal mental health difficulties such as depression and anxiety (Milgrom and Gemmill, 2015). We have previously reported on the efficacy of cognitive behaviour therapy (CBT) for both antenatal (Milgrom et al., 2015a) and postnatal (Milgrom et al., 2015b) depression in women using a range of delivery modes, including digital interventions (Milgrom et al., 2016). The efficacy of prevention and treatment programs for women, delivered antenatally and postnatally, has been the subject of 3 Cochrane systematic reviews (Dennis and Hodnett, 2007; Dennis et al., 2007; Dennis and Dowswell, 2013).

Significantly less is known about the likely effectiveness of interventions or programs targeting paternal perinatal mental health difficulties. In recent years, three major systematic reviews have reviewed the evidence for perinatal interventions for fathers. Twenty-six articles in total were identified by these reviews: Rominov et al. (2016), Suto et al. (2017), and Goldstein et al. (2020). Rominov et al. aimed to include a wide range of study designs and any interventions targeting fathers' mental health in the perinatal period and thus applied the broadest inclusion criteria of these major reviews. However, Suto et al. focussed more specifically on the effects of prenatal childbirth education on paternal postnatal mental health, while Goldstein et al. limited their review to randomised controlled trials (RCTs) exclusively for paternal perinatal depression.

Rominov et al. identified 11 articles and found that psychosocial interventions and massage-technique interventions, but not couple-based interventions, showed some significant effects on depression and anxiety symptoms benefitting men. Rominov et al. concluded that there was a need for improved methodological quality in this field and that none targeted active treatment of clinical levels of psychological distress in perinatal fathers.

Suto et al. identified 11 studies addressing the impact of prenatal education on paternal postnatal mental health and the couple relationship. It was concluded that there was insufficient evidence to suggest prenatal childbirth education for partners of pregnant women protects against paternal postnatal mental health difficulties (including depression and anxiety). However, the mental health of perinatal fathers was highlighted as important to maternal and perinatal healthcare.

Goldstein et al. found that of 14 RCTs identified, only three found an effect on paternal depression scores. None of the included interventions exclusively focussed on paternal perinatal depression but targeted the couple or infant relationship, with participating fathers not required to meet criteria for depression at baseline (and fathers did not undergo a clinical interview for diagnosis). Goldstein et al. highlighted the lack of active treatments for diagnosed cases of paternal perinatal depression as a major gap in perinatal mental health service provision and the methodological heterogeneities in reviewed studies regarding depression measures and follow-up.

A further issue is that very few depressed new fathers seek help or engage with currently available treatments (Olds et al., 2007; Fletcher et al., 2015). Mental health problems in new fathers can therefore go largely unacknowledged and untreated (BeyondBlue, 2018).

The aim of this mini-review is therefore to provide an updated narrative synthesis of recent, peer reviewed articles that report on experimental or quasi-experimental studies of interventions measuring perinatal depression or anxiety in fathers, whether as an intervention target, or as a primary or secondary outcome. We aim to review articles between 2015 and 2020 and identify both those included in previous reviews and new evidence. This review will provide a 5-year update of studies in this broad area which includes those that may have been published close to or after the most broadly inclusive systematic review, by Rominov et al., but which may have fallen outside of the later, more focused searches, applied by Suto et al. and by Goldstein et al. Outside the scope of previous reviews, we also aimed to identify any useful information on key implementation

strategies, if any, employed to increase the engagement of men in such interventions.

METHODS

This mini-review was informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). While not all PRISMA items were applied, the key principles were used to provide a structure for reporting our methods and results.

Eligibility Criteria

This review was limited to peer-reviewed studies written in English, published in peer-reviewed journals. Articles published between 2015 and 2020 that report trials, feasibility studies or pilot studies of interventions that reported on fathers' depression or anxiety, from conception to 1 year postpartum, were included. Interventions or programs were defined broadly to include psychological, educational, psychosocial, or group therapies, delivered face-to-face, via telephone and/or online with men individually or the couple dyad.

Information Sources

Seven databases were searched to identify recent peer-reviewed articles reporting on interventions designed to treat or prevent perinatal depressive or anxious symptoms in fathers. Ovid MEDLINE®, OVID Embase Classic + Embase, OVID Cochrane Central Register of Controlled Trials, OVID Cochrane Database of Systematic Reviews, OVID PsycINFO, EBSCO CINAHL, and PubMed. Relevant keywords and subject headings for pregnancy, birth, infancy, fathers, male parents, as well as depression and anxiety were utilised for each database.

Search Strategies

There were two search strategies.

1. The studies identified by Rominov et al., Suto et al. and by Goldstein et al. were re-assessed for inclusion against the criteria for the current mini-review (see below), including a 5-year publication date range;
2. A new database search was run in February of 2021 including only articles published 2015–2020. We aimed to capture a comprehensive 5-year update including studies that may have been published close to or subsequent to the review published by Rominov et al., but which may have fallen outside of the inclusion criteria of Suto et al. and Goldstein et al.

Key search terms in all database searches included: (paternal* or father* or fatherhood* or paternity*), (postnatal or antenatal or perinatal), (depression or anxiety or mental health or psychological distress), (treatment* or prevention*), (programs* or intervention* or management) in titles and abstracts of peer-reviewed articles. The authors (JM, AG, JE, and AR) agreed upon final search terms.

Selection Process

After duplicate citations were removed and titles and abstracts were screened, full-text articles were reviewed for eligibility by two authors (AR and JE). Two authors (AR and JE) examined the full texts of potential articles to determine eligibility for inclusion in the systematic review. Discrepancies were resolved by consensus by all the authors.

Data Collection and Synthesis Methods

Data from the studies was manually collated into matrices in Microsoft Excel to enable a comparison of the studies aims, samples, measures of depression and anxiety, methodologies, results, and conclusions. Data extraction was completed by two reviewers (AR and JE) independently. Data from the studies were not able to be synthesised using a meta-analysis due to the heterogeneity of the methodologies adopted by the studies. Instead, a narrative synthesis was used to appraise and summarise the key findings for the included studies.

RESULTS

Study Selection

The initial search identified 41 articles. After the removal of duplicates and inclusion of relevant studies identified via reference lists, 2,725 were screened by title and abstract. Following the removal of 2,684 ineligible articles, 41 were read in full before 30 studies were removed due to being considered ineligible with reasons outlined in **Figure 1**. Eleven studies were considered to meet the inclusion criteria and formed the final sample of studies for the mini-review. See **Figure 1** for the flowchart of study selection.

Of these from the existing reviews, six were identified from the existing reviews (**Table 1**) and these plus five additional studies (**Table 2**) were located through the new literature search of electronic databases. **Tables 1**, **2** describe these 11 studies in detail.

Study Characteristics

Although this mini-review did not apply a formal framework of quality assessment, it is of note that eight out of 11 studies were Randomised-Controlled Trials (RCTs), the gold-standard in the hierarchy of evidence for the evaluation of health outcomes. Of the three remaining studies, one was a pre-post experimental study (Setodeh et al., 2017), one was a prospective study (Cano Giménez and Sánchez-Luna, 2015) and one was a pilot study (Herman, 2020). Sample sizes ranged from $n = 42$ to $n = 146$. Three studies sampled specific populations, including: one study focused on mothers and fathers with infants who were admitted to the Neonatal Intensive Care Unit (Cano Giménez and Sánchez-Luna, 2015), one study included mothers and fathers with preterm babies (Castel et al., 2016), and one study sampled fathers with newborns following caesarean section (Huang et al., 2019). Of the remaining studies, one study sampled primiparous men (Daley-McCoy et al., 2015), four studies sampled expectant couples with no limits on parity (Setodeh et al., 2017; Edward et al., 2019; Herman, 2020; Missler et al., 2020), one study sampled couples in the postpartum with no limits on parity (Shorey et al., 2017), and two studies sampled expectant couples with intervention implementation throughout pregnancy and the postpartum (with no limits on parity) (Charandabi et al., 2017;

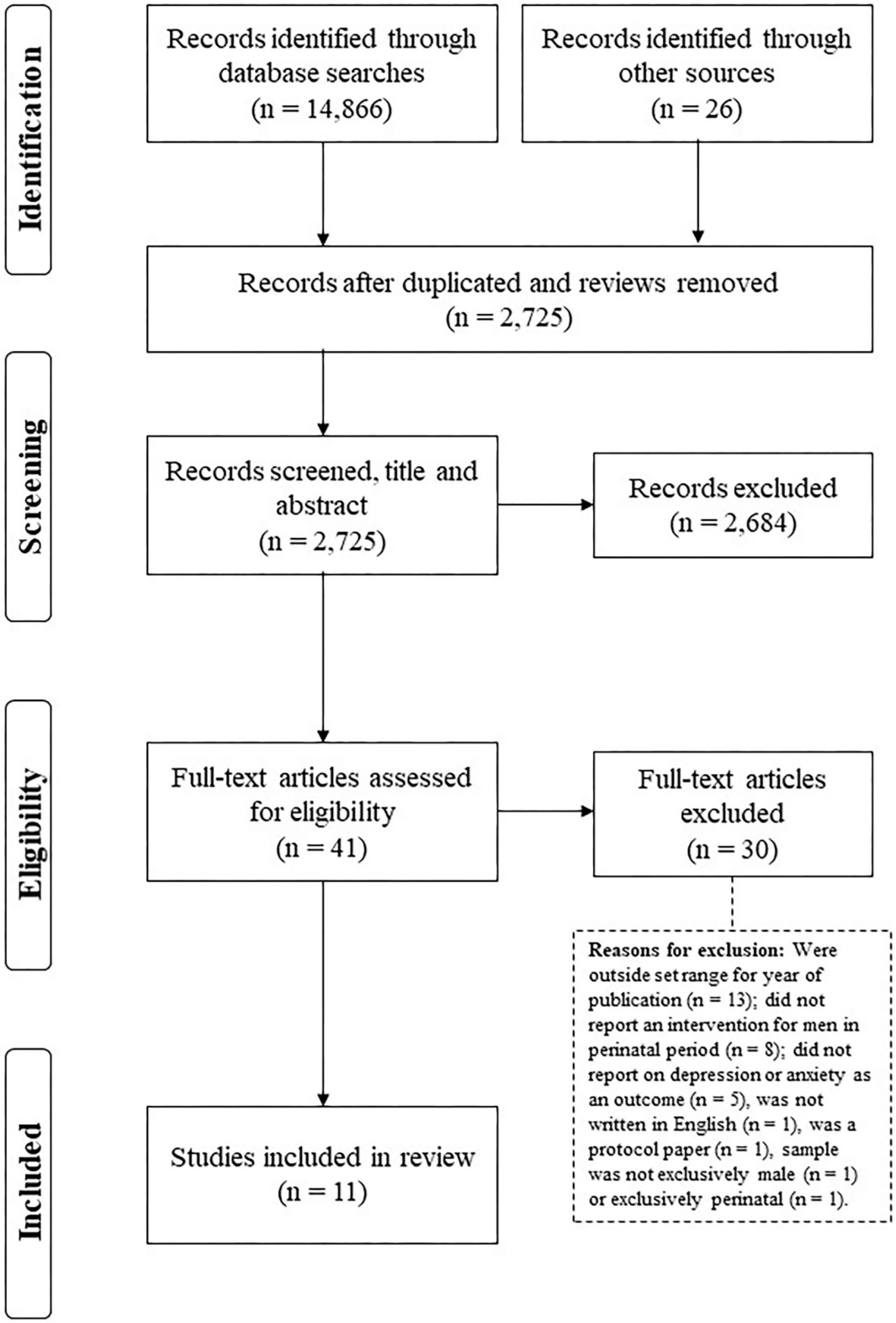

FIGURE 1 | Study selection flow diagram.

TABLE 1 | Published interventions reporting on men's perinatal depression or anxiety, 2015–2020.

		Identified in previous reviews							
References	**Study design**	**Intervention program name; main elements and targets**	**Intervention timing and length**	**Intervention delivery format**	**Sample**	**Sample recruitment, engagement and retention**	**Mental health outcome measures**	**Timing of outcome measures**	**Intervention effects**
Castel et al. (2016)	Randomised Controlled Trial	Father-infant interactions, understanding of infant development to reduce parental stress, promotion of parents-infant triadic relationship to foster infant cognitive, motor, socio-emotional and behavioural development.	**Postnatal**: 22 sessions, home visits twice per month during first 4 months, followed by monthly consultations in neonatology ward up to 18 months	Face-to-Face. Triadic parent-infant Relationship Therapy (TRT), (based on attachment theory).	65 families with pre-term babies. **Intervention *N* = 23** **Control *N* = 19**	***N* = 42 expecting fathers** included in final analysis. Recruited via partner couple. First 4 months were home-based.	Parenting Stress Index Short Form (**PSI-SF**) **EPDS** (>9 for father depression). **PTSD**. **DSM-IV** (for screening.)	**Baseline** (DSM-IV, PSI-SF, PTSD, EPDS) **3-Months** (PSI-SF, EPDS) **9-Months** (PSI-SF, EPDS) **(End-Point)** **18-Months** (PSI-SF, PTSD, EPDS)	**Depression:** Significant 2.6-point difference observed in EPDS between intervention and control group at 18 months ($p < 0.05$). Control: At baseline 14.3% of fathers scored >9 in EPDS vs. 10.5% at 18 months. Intervention: At baseline 10.0% of fathers scored >9 in EPDS vs. 0% at 18 months (differences but not significant). **PTSD:** A significant−1.1.-point difference was observed for fathers of intervention group compared to control at 18 months ($p < 0.001$)
Daley-McCoy et al. (2015)	Cluster Randomised Controlled Trial	Content involved normalising adverse changes in relationship functioning reported by many couples on becoming parents and sharing potentially useful ways of managing these.	**Antenatal:** program consisted of 5 weekly, 2-h evening sessions.	Face-to-face. Low-intensity, psycho-educational program as adjunct to existing antenatal classes led by midwife.	Expectant fathers as part of couples expecting their first child. **Intervention *N* = 39** **Control *N* = 26**	***N* = 37 expecting fathers** included in final analysis Recruited as a couple, via child services. Offered financial incentive. Extended intervention session by an additional 2-hr session to optimised attendance.	**EPDS**	**Baseline**, unknown gestation: (EPDS) **End-Point, 6-weeks Postpartum**: (EPDS)	**Depression:** Significant reduction in intervention group compared to control, ($p = 0.023$)

(Continued)

TABLE 1 | Continued

Identified in previous reviews									
References	**Study design**	**Intervention program name; main elements and targets**	**Intervention timing and length**	**Intervention delivery format**	**Sample**	**Sample recruitment, engagement and retention**	**Mental health outcome measures**	**Timing of outcome measures**	**Intervention effects**
Shorey et al. (2017)	Randomised Controlled Trial	Home-but not Alone. Psychoeducation support to parents, featuring a database on role-specific educational contents, periodic push notifications to give timely information and asynchronous communication with healthcare professionals	**Postnatal**: Early stages	Digital deliver. Psychoeducational program via mobile-health application.	125 couples recruited, including 125 fathers. **Intervention *N* = 63** **Control *N* = 62**	***N* = 125 fathers** included in final analysis. Delivered mobile phone app. Recruited via tertiary hospital, via couple. Phone app made information easy to access.	**EPDS**	**Baseline**: (EPDS) **End-Point**, 6 months postpartum: (EPDS)	**Depression**: No significant effect ($p > 0.05$).
Charandabi et al. (2017)	Single-Blind Randomised Controlled Clinical Trial	Prenatal lifestyle-based training included sleep health, nutrition, physical and sports activity, self-image and sexual problems. The training materials were presented by a male psychologist at the health centre office. 5–15 participants in each group session.	**Antenatal and Postnatal:** 24–28 weeks gestation and following 6 weeks postpartum. Weekly sessions were 60–90 min in length. Counselling calls were once/week, 10 min in duration (occurring between group sessions).	Face-to-face and Telephone. Two weekly group lifestyle-based training sessions, and telephone counselling sessions provided between sessions. All fathers of the intervention group were provided training booklet.	Spouses of pregnant women with gestational ages of 24–28 weeks. **Intervention *N* = 62** **Control *N* = 63**	***N* = 125 fathers** included in final analysis Recruited via partners. Male psychologist was used to deliver intervention. Only 2 sessions due to fathers being busy.	**EPDS** **STAI**	**Baseline:** (EPDS, STAI) **+8 Weeks:** (EPDS, STAI) **End-Point, 6 Weeks Postpartum:** (EPDS, STAI)	**Depression:** At +8 Weeks, significant difference between intervention and control in reduction ($p = 0.004$). At 6 Weeks postpartum, significant difference between intervention and control in reduction ($p = 0.001$) **Anxiety:** At +8 Weeks, significant difference between intervention and control in reduction ($p < 0.001$). At 6 Weeks postpartum, significant difference between intervention and control in reduction ($p < 0.001$)
Huang et al. (2019)	Randomised Controlled Trial	Treatment group newborns placed in prone position onto bare chest of fathers, covered with clothes/blanket. Temperature set between 24 and 26 degrees Celsius.	**Postnatal:** Involved 30 min of skin-to-skin contact with father soon after caesarean delivery. Routine care taken to crib accompanied by father for 30 min.	Skin-to-Skin Contact.	108 fathers recruited. **Intervention *N* = 54** **Control *N* = 54**	***N* = 100 fathers** included in final analysis Recruited from tertiary hospital via mothers. One session.	**SAS** (Self-Rating Anxiety Scale) **SDS** (Self-Rating Depression Scale)	**Baseline** (SAS, SDS) **End-point**, 30 min after treatment (SAS, SDS)	**Anxiety:** Lower in intervention group compared usual care ($p < 0.05$) **Depression:** Lower in intervention group compared usual care ($p < 0.05$)

(Continued)

TABLE 1 | Continued

References	Study design	Intervention program name; main elements and targets	Intervention timing and length	Intervention delivery format	Sample	Sample recruitment, engagement and retention	Mental health outcome measures	Timing of outcome measures	Intervention effects
Identified in previous reviews									
Mihelic et al. (2018)	Randomised Controlled Trial	Baby Triple P, parenting intervention. Targets the key risk factors for poor child developmental outcomes identified in early infancy (i.e., parental mental health, couple adjustment, and parenting confidence and skill.)	**Antenatal and postnatal**: parenting program. 4 × 2 h face-to-face sessions, and 4 × individual postnatal telephone consultations.	Face-to-face and telephone.	112 couples recruited, resulting in 112 fathers recruited. **Intervention *N* = 57 Control *N* = 55**	***N* = 107 fathers** included in final analysis Recruited via mother, high attrition rate. Mainly targeted mothers.	**EPDS DASS-21**	**Baseline**, pregnancy: (EPDS) **10 weeks' postpartum**: (EPDS) **End-Point**, 6 months' postpartum: (EPDS)	**Depression:** No significant effect ($P > 0.05$)

Mihelic et al., 2018). Timing of delivery varied among studies, with most occurring either exclusively during the antenatal (Daley-McCoy et al., 2015; Setodeh et al., 2017; Edward et al., 2019; Herman, 2020; Missler et al., 2020) or postnatal period (Cano Giménez and Sánchez-Luna, 2015; Castel et al., 2016; Shorey et al., 2017; Huang et al., 2019). Two interventions were delivered across both time periods (Charandabi et al., 2017; Mihelic et al., 2018).

Summary of New Individual Studies

We identified five new studies (Cano Giménez and Sánchez-Luna, 2015; Setodeh et al., 2017; Edward et al., 2019; Herman, 2020; Missler et al., 2020) in addition to those included in previous reviews. Cano and Giménez recruited fathers as part of couples with infants admitted to the neonatal intensive care unit (NICU). Parents underwent a tailored five-step intervention delivered by a psychologist. Fathers in the intervention group had significantly lower levels of anxiety and depression after 15 days, compared to the control group. Setodeh et al. investigated the effect of four 90-min fathers' attachment training sessions on anxiety and observed lower anxiety scores at follow-up.

Edward et al. delivered a self-screening tool and referral pathway pamphlet as part of an RCT. They did not observe any statistically significant differences between groups for depression at the end of the study. Herman et al. reported on a quasi-experimental study of a 6-week psycho-educational intervention aiming to reduce depression in expectant parents in early pregnancy. No significant effects were observed for depression in fathers. Missler et al.s' intervention was also delivered antenatally, during weeks 26 and 34, as part of an RCT. Their intervention consisted of a booklet, video, home visit and phone call and again, there were no interventional effects on fathers' depression at follow-up.

Types of Interventions and Focus

A large proportion of interventions incorporated counselling or therapy (Cano Giménez and Sánchez-Luna, 2015; Castel et al., 2016; Charandabi et al., 2017; Mihelic et al., 2018) or psychoeducation as part of an antenatal or postnatal education program (Cano Giménez and Sánchez-Luna, 2015; Daley-McCoy et al., 2015; Castel et al., 2016; Charandabi et al., 2017; Shorey et al., 2017; Mihelic et al., 2018; Edward et al., 2019; Herman, 2020; Missler et al., 2020), while massage was the focus of Huang and colleagues (Huang et al., 2019). Of the five studies offering therapy or counselling, the focus was varied and included parent-infant interaction/attachment (Cano Giménez and Sánchez-Luna, 2015; Castel et al., 2016; Setodeh et al., 2017), men's self care/self image (Shorey et al., 2017), and parenting (Mihelic et al., 2018).

Most of the interventions were couple-focused, with only one (Huang et al., 2019) focusing exclusively on fathers. Couple-focussed programs targeted couple- and father-baby relationships and interactions, coping strategies, physical contact (partner and/or baby), problem solving and emotion self-management. The father-focussed program provided information/education, and strategies on how to better support mothers.

TABLE 2 | Published interventions reporting on men's perinatal depression or anxiety, 2015–2020.

Identified by this Mini-Review									
References	**Study design**	**Intervention program name; main elements and targets**	**Intervention timing and length**	**Intervention delivery format**	**Sample**	**Sample recruitment, engagement and retention**	**Mental health outcome measures**	**Timing of outcome measures**	**Intervention effects**
Cano Giménez and Sánchez-Luna (2015)	Prospective Study	Parent/mother–infant interaction Parent/mother–healthcare staff interaction Coping with the new unexpected situation	**Postnatal**: 15 days	Face-to-face by Psychologist Intervention adapted by Lester et al. Interdisciplinary characteristics with participation and collaboration of all staff working in the NICU including physicians, nurses & nurse assistants.	Mothers and Fathers with new baby admitted to NICU with congenital heart defect or perinatal hypoxic-ischemic encephalopathy (at least 4-week NICU admission). **Intervention *N* = 25** **Control *N* = 29**	***N* = 54 fathers** included in final analysis. Recruited via partner, no engagement strategies.	**Parental Stressor Scale-NICU**, **ISRA** **BDI** **EPDS**	**Baseline** 3 days after NICU admission (PSS-NICU, ISRA, BDI, EPDS) **End-point**: 15 days after NICU admission (PSS-NICU, ISRA, BDI, EPDS)	**Anxiety**: 0% in intervention compared to 89.6% in control ($p = 0.001$) at end-point. **Depression** (BDI): 20% in intervention with mild depression compared to 100% in control group with mild-moderate depression ($p < 0.001$) at end-point. **Depression** (EPDS): 24% in intervention group probable depression, compared to 89.7% in control group ($p < 0.001$) at end-point. 44% of intervention group without risk of depression, 0% in control ($p < 0.001$), at end-point.
Edward et al. (2019)	Single blinded Randomised Controlled Trial	General PND information, statistics of paternal PND, the EPDS and instructions on how to complete and score it, and advice regarding referral to their General Practitioner (GP) should the participant be distressed or concerned about their EPDS score.	**Antenatal:** One-time self-screening tool for mother and father and information pamphlet.	Delivered by pamphlet Self-screening and referral pathway that was a one-page (A4 size).	70 Expectant Fathers recruited from 140 couples **Intervention *N* = 35** **Control *N* = 35**	***N* = 31** expecting fathers included in final analysis Recruited via couple. High attrition. Phone call follow-up occurred.	**EPDS** **Kessler-10 (K-10)**	**Baseline** (EPDS, K-10) **End-Point**, 12 months (EPDS, K-10)	**Depression:** No significant effects ($p < 0.05$)

(Continued)

TABLE 2 | Continued

Identified by this Mini-Review									
References	**Study design**	**Intervention program name; main elements and targets**	**Intervention timing and length**	**Intervention delivery format**	**Sample**	**Sample recruitment, engagement and retention**	**Mental health outcome measures**	**Timing of outcome measures**	**Intervention effects**
Herman (2020)	Pre-Post Quasi-Experimental Pilot Study	"PREParing for Parenthood (PREP)" antenatal class. Psychoeducational, partner inclusive focusing on depression reduction, stress management and enhancing co-parent relationship.	**Antenatal**: classes between 10 and 20 weeks gestation. Six-week intervention.	Face-to-face. Six sessions taught by paraprofessionals in a community setting (optional home visits for usual care).	46 couples recruited. **Intervention *N* = 24 Control *N* = 22**	***N* = 37** expecting fathers included in final analysis. Recruited via couple, not only male partners. Honorarium provided. Used male and female instructors.	**CES-D** (Centre for Epidemiologic Studies Depression Scale) **PSS** (Perceived Stress Scale).	**Baseline**, **beginning of 2nd trimester:** (CES-D, PSS) **End-Point, +8–10 weeks after Baseline** (CES-D, PSS)	**Stress:** Significant reduction in intervention compared to control ($p = 0.031$). **Depression:** No significant effects ($p > 0.05$).
Missler et al. (2020)	Randomised Controlled Trial	Targeting sensitive responsiveness, adapting to the parental role, attending to own needs. Crying patterns, feeding and sleeping.	**Antenatal**: Program occurred, between 36- and 34-weeks gestation.	A booklet, a video, a home visit and a telephone call.	From 138 pregnant women, 96 partners were recruited. **Intervention *N* = 31 Control *N* = 38**	***N* = 69 fathers** included in final analysis. Recruited via couple, fathers recruited incidentally.	**PSI** (Parenting Stress Index), **EPDS HADS**	**Baseline**, 26–34 weeks: (PSI, EPDS, HADS) **34–36 weeks**: (PSI, EPDS, HADS) **6 weeks** postpartum: (PSI, EPDS, HADS) **End-Point**: 10 weeks postpartum: (PSI, EPDS, HADS)	**Depression:** No significant effect ($p > 0.05$). **Anxiety:** No significant effect ($p > 0.05$).
Setodeh et al. (2017)	Pre-Post Experimental Study	Face-to-face training sessions.	Antenatal sessions between 28 and 34 weeks. 4 × 90-min sessions once a week on maternal-foetal attachment.	Fathers were trained regarding attachment skills.	150 pregnant women's spouses recruited. **Intervention *N* = 75 Control *N* = 75**	*N* = 150 expecting fathers included in final analysis. Recruited through pregnant women.	**SBS** (Spiel Berger Scale) (Anxiety).	**Baseline**, 28–34 weeks: (SBS) **End-Point**, 1 month after intervention: (SBS).	**Anxiety:** Reduced in intervention group ($p = 0.008$) compared to control.

Assessment and Outcome Measures of Men's Depression and Anxiety

No studies intentionally sought to recruit men with perinatal depression or anxiety.

Across studies, a variety of different depression and anxiety measures were reported. The Edinburgh Postnatal Depression Scale (EPDS) was the predominant psychometric outcome measure reported (Cano Giménez and Sánchez-Luna, 2015; Daley-McCoy et al., 2015; Castel et al., 2016; Charandabi et al., 2017; Shorey et al., 2017; Mihelic et al., 2018; Edward et al., 2019; Missler et al., 2020). One study reported on anxiety using the State-Trait Anxiety Inventory (STAI) (Charandabi et al., 2017) and another using the Spiel Berger Scale (SBS) (Setodeh et al., 2017) while another study reported on depression using the Centre for Epidemiological Studies Depression Scale (CES-D) (Herman, 2020). No studies reported a presence of diagnosed depression at baseline. When reported, baseline levels were well-below the threshold for probable depression. Two studies did not report on depression or anxiety at baseline (Cano Giménez and Sánchez-Luna, 2015; Shorey et al., 2017). Despite this, five studies reported a positive effect on depression (Daley-McCoy et al., 2015; Castel et al., 2016; Charandabi et al., 2017) and/or anxiety (Cano Giménez and Sánchez-Luna, 2015; Charandabi et al., 2017; Huang et al., 2019).

Engagement Strategies

Few studies evaluated the effectiveness of engagement or retention strategies.

Initial engagement of men spanned various settings, often through secondary contact via pregnant partners, ranging from prenatal programs and hospital settings (including one neonatal intensive care unit) to local advertising and health service referrals (such as general practitioner or ultrasound clinic).

Despite the range of engagement strategies used, no studies provided a concrete evaluation of their effectiveness. Whilst just over half of the studies reported no attrition at follow-up (Cano Giménez and Sánchez-Luna, 2015; Castel et al., 2016; Charandabi et al., 2017; Setodeh et al., 2017; Shorey et al., 2017; Missler et al., 2020), there were no discernible differences in design or program type between these and studies with higher attrition rates. The remaining studies had attrition rates ranging from 4 to 55%. Whilst no clear patterns across studies were observed, home-based intervention was suggested by authors as a method to improve adherence (Castel et al., 2016). Financial incentives may also play a role (Daley-McCoy et al., 2015). Incentives including free dinners, raffles for attendance, honorariums, and money for transport were reported by authors as likely to contribute to strong attendance rates (Herman, 2020).

Across the different study designs and methodologies, there were some commonalities in recruitment procedures. Recruitment of fathers indirectly through their female partners was very common. Whether this improved engagement is unclear. For example, one study (Mihelic et al., 2018) argued this method in their study may have been responsible for low father participation rate in a group triple P program and advocated for separate father sessions.

Other incentives to combat sample attrition included utilising supportive technology to circumvent potential barriers, such as telephone calls, text messaging, the internet and a mobile phone app. Male psychologists were also utilised, perhaps proving beneficial for participant retention (Seidler et al., 2018). Some studies attempted to increase retention by keeping the intervention time-commitment as low as possible. Other studies reported offering more of the popular aspects of their intervention such as psychoeducation about newborns or birth, subsequently minimising the focus on other topics, such as targeting the co-parenting relationship.

DISCUSSION

Due to the prevalence of mental health problems in expectant and new fathers, there is a need for interventions targeting mental health difficulties in fathers, primarily depressive or anxious symptoms. Yet the three most recent systematic reviews found that few such treatment studies exist.

We aimed to conduct an update of the literature and provide a narrative synthesis of peer reviewed articles published between 2015 and 2020 that report trials, feasibility studies or pilot studies of interventions that reported on fathers' perinatal depression or anxiety. A secondary purpose of the mini- review was to describe any promising evidence of key implementation, engagement and retention strategies.

Only eleven publications were found to satisfy search criteria, six of which were included in previous reviews. Rominov et al. found that psychosocial interventions and massage-technique interventions, but not couple-based interventions, showed some significant effects on depression and anxiety symptoms benefitting men. It was concluded that there was a need for improved methodological quality in this field and that none of the interventions included active treatment targeting clinical levels of psychological distress in perinatal fathers. Suto et al. concluded that there was insufficient evidence to suggest prenatal childbirth education for partners of pregnant women protects against paternal postnatal depression and anxiety. Goldstein et al. found none of the included interventions exclusively focussed on paternal perinatal depression but targeted the couple or parent-infant relationship. The lack of active treatments for diagnosed cases of paternal perinatal depression was also highlighted. Although we identified 5 new studies, our updated findings confirm a continuing lack of interventions targeting perinatal depression or anxiety in fathers, in particular when compared to the large body of literature on maternal perinatal depression and anxiety interventions. Congruent with articles identified by previous reviews, the majority of programs took a universal approach, not explicitly addressing paternal perinatal anxiety and/or depression. Compared to all of the six studies included in previous reviews, only two of the newly identified articles in this mini-review were RCTs. No studies required participants to screen positive for anxiety or depression and none of them targeted men who were depressed or anxious. Only two were able to show an improvement in depressive (Cano Giménez and Sánchez-Luna, 2015) and/or anxiety (Setodeh et al., 2017)

symptoms, compared to four of the articles included in previous reviews (Daley-McCoy et al., 2015; Castel et al., 2016; Charandabi et al., 2017; Huang et al., 2019).

The ability to draw conclusions on the effectiveness of the interventions identified is challenged due to a number of factors. First, the studies reviewed here pertained largely to universal programs assisting fathers and mothers in the transition to parenthood, with no studies designed explicitly to treat existing depressive or anxiety disorders in men. Further, no studies required participants to undertake a clinical interview for diagnosis or screen positive for anxiety or depressive symptoms on entry. In fact, in some studies, depression formed part of the exclusion criteria (Castel et al., 2016; Charandabi et al., 2017; Shorey et al., 2017). Second, paternal depression or anxiety outcomes usually formed part of secondary outcome analyses or at times were reported incidentally as a part of an intervention targeting new or expectant mothers.

The comparative lack of intervention for men compared to women in the perinatal period is reflected in national practise guidelines in Australia and the UK. While these clinical guidelines are extensive there are no recommendations for paternal mental health during the perinatal period, beyond recommendation for further research. By contrast, clinical guidelines provide recommendations for structured individual psychological therapy (e.g., CBT or IPT) for treatment of depression for women during the perinatal period (Howard et al., 2014; Austin et al., 2017).

Our results therefore provide an updated confirmation of the broad conclusions reached in the previous foundational reviews by Rominov et al. (2016), Suto et al. (2017), and Goldstein et al. (2020). Namely, that despite the increased interest and accumulating research evidence in paternal mental health in recent years, this has not translated into a substantial research literature aimed at evaluating interventions addressing paternal perinatal depression and anxiety. Specifically, there is an almost total absence of treatment programs evaluated in RCTs designed to treat fathers with a perinatal depressive or anxiety disorder.

IMPLICATIONS FOR IMPLEMENTATION

Despite the heterogeneity of study methodologies, some tentative descriptive analysis of findings that may be relevant to implementation and development of future programs is possible.

First, it is worth noting that most reviewed studies used the EPDS as a depression measure, indicating this has become a commonly used research measure of not only maternal, but also paternal, depressive symptoms.

Secondly, whilst eight out of 11 studies were randomised controlled trials (RCTs), none of the RCTs were large studies, and future replication in adequately powered trials would be needed before any definitive conclusions on efficacy could be drawn. The study populations in the studies identified by this mini-review did not, on average, have elevated levels of depressive or anxiety symptoms that would be of clinical concern. Therefore, even where statistically significant improvements in depression and anxiety scores were reported, the clinical meaningfulness of these findings and their generalisability for depressed and anxious populations of perinatal men is doubtful.

Nevertheless, it may be useful to make the following observations about studies which reported improvements in either depression scores (five studies) or anxiety scores (four studies). In terms of positive paternal mental health outcomes, the largest gains were seen in interventions which incorporated therapy/counselling components, antenatal psycho-education or baby massage. At the very least, taken together, the results of these studies suggest that symptoms of anxiety as well as depression could potentially be amenable to positive change through interventions designed for perinatal men.

The Possible Value of Indirect Methods to Engage Men

None of the reviewed studies aimed to directly identify and treat clinical levels of perinatal depression or anxiety in men. However, this might not be the only viable model for addressing paternal depression.

Using a range of more indirect approaches could, potentially, help reach a depressed/anxious population by dealing first with other salient issues of concern for new fathers. Such an approach could serve to deliver a pre-emptive or preventive support for paternal mental health. For example, involving partners in family and couple focussed programs aimed at enhancing those relationships may be a viable way to engage men initially and set a supportive context for recognising paternal mental health issues as and when they emerge. This could provide a more acceptable foundation for offering targeted treatment programs for those men who need them, should clinical levels of depression or anxiety arise.

Similarly, several interventions adopted strategies to promote fathers' attachment with their infants and support the partner relationship and these appeared to have some positive effects for fathers' wellbeing. However, as well as enhancing well-being, it may also be useful to explore whether such a focus assists in engaging men with perinatal depression or anxiety in accessing and adhering to support programs or to treatment programs.

In general, such indirect approaches based on framing content around transition to fatherhood and the new relationships between father and baby may be more acceptable to men than content that is directly and explicitly about identifying and treating mental disorders. For example, in a recent DELPHI study (Domoney et al., 2020) about developing interventions for paternal perinatal depression, the consensus was that better recruitment, retention and engagement may be attained by using a "strengths-based" approach in presenting treatment content.

Additional findings, outside of the parameters of the current mini-review, may also inform potential approaches to increasing engagement with paternal mental health supports. For example, fathers recount the benefits of programs that encourage social contact with other fathers (Herman, 2020), helping them feel less isolated and share in discussions about fatherhood (Seymour et al., 2020).

There is some evidence (Giallo et al., 2017) that facilitators to male engagement include accessibility of programs; and barriers

may include time commitments and the need to travel. Internet delivery could potentially fit with these preferences and allow men to feel empowered to drive their own treatment and recovery. Indeed, in a survey of 154 Australian fathers of young children (Parry et al., 2019), common attitudinal barriers to engaging with help-seeking included beliefs about self-reliance in managing one's own problems and suggested that men would prefer internet-based supports.

LIMITATIONS

As previously described, there was a significant level of heterogeneity across the methodologies in the studies captured by this mini-review. It is therefore difficult to proceed to a formal analysis of key parameters such as efficacy. In addition to insufficient reporting of study designs and differences in timing of program delivery, the greatest limitation to this and preceding reviews is the general absence of studies evaluating programs designed specifically to treat paternal perinatal clinical disorders (such as depression and anxiety). The available evidence allows only a speculative consideration of what might potentially be the most effective elements and ways to configure such a treatment program in the real world.

FUTURE DIRECTIONS AND CONCLUSIONS

This mini-review highlights a number of significant gaps and potentially productive avenues for future research.

Of greatest note was the absence of evidence-based psychological treatments for diagnosed depression and anxiety in men. Such programs have proven to be effective for perinatal depression in women (Dennis and Hodnett, 2007; Milgrom et al., 2011), with CBT and interpersonal therapy (IPT) extensively investigated. Given the relative absence of psychological interventions ($n = 2$) amongst the work reviewed here, further research will be needed to ascertain whether such interventions can be effective in a depressed population of perinatal men.

While reviewed studies offered some evidence that a range of universal programs have some potential to improve symptoms of anxiety and depression, whether such interventions can be effective in a real-world population of depressed and anxious perinatal men has not yet been demonstrated.

Nevertheless, such programs may provide useful indirect entry points for engaging and subsequently recognising men who may be experiencing clinical levels of depression and anxiety warranting direct treatment. Engagement strategies to engage men in seeking support for their mental health in the perinatal period therefore requires further research, including the possible benefits of online delivery. Whilst face-to-face programs offer a supportive environment, it is possible this mode of delivery adds others barriers to engagement as perinatal fathers are typically time-poor, often with increased work commitments (Bayley et al., 2009).

To ensure that appropriate interventions are developed, further research is needed to understand how men experience distress in the perinatal period, including both anxiety and depression. This should include the overlap of symptomatology and co-morbidity of depressive and anxiety disorders and further research on how their manifestations, such as anger, are associated with difficulties in the couple relationship, the co-parenting relationship, and the father-infant relationship (Macdonald et al., 2020, 2021).

AUTHOR CONTRIBUTIONS

AR, JE, AG, and JM were responsible for the design of the work and agreed upon the final search terms. AR and JE reviewed titles and abstracts for inclusion, with all authors AR, JE, BW, AG, and JM involved in screening manuscripts for eligibility, interpretation of findings, drafting the article, critically reviewing the article, and have approved of the version that has been submitted. All authors contributed to the article and approved the submitted version.

FUNDING

This review was supported and made possible by the Ian Potter Foundation, Perpetual IMPACT Philanthropy and Men of Malvern. We gratefully acknowledge their contributions.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Psychology

REVIEW
published: 03 February 2022
doi: 10.3389/fpsyg.2022.745767

Neurobiological Correlates of Fatherhood During the Postpartum Period: A Scoping Review

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OPEN ACCESS

Edited by:
Jeannette Milgrom, Parent Infant Research Institute, Austin Health, Australia

Reviewed by:
Daiki Hiraoka, University of Fukui, Japan
Randy Corpuz, University of Massachusetts Boston, United States

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Specialty section:
This article was submitted to Health Psychology, a section of the journal Frontiers in Psychology

Received: *22 July 2021*
Accepted: *05 January 2022*
Published: *03 February 2022*

Citation:
Sobral M, Pacheco F, Perry B, Antunes J, Martins S, Guiomar R, Soares I, Sampaio A, Mesquita A and Ganho-Ávila A (2022) Neurobiological Correlates of Fatherhood During the Postpartum Period: A Scoping Review. Front. Psychol. 13:745767. doi: 10.3389/fpsyg.2022.745767

During the postpartum period, the paternal brain suffers extensive and complex neurobiological alterations, through the experience of father–infant interactions. Although the impact of such experience in the mother has been increasingly studied over the past years, less is known about the neurobiological correlates of fatherhood—that is, the alterations in the brain and other physiological systems associated with the experience of fatherhood. With the present study, we aimed to perform a scoping review of the available literature on the genetic, neuroendocrine, and brain correlates of fatherhood and identify the main gaps in the current knowledge. PubMed, Scopus, and Web of Science electronic databases were searched for eligible studies on paternal neuroplasticity during the postpartum period, over the past 15 years. Reference lists of relevant key studies and reviews were also hand-searched. The research team independently screened the identified studies based on the established inclusion criteria. Extracted data were analyzed using tables and descriptive synthesis. Among the 29 studies that met our inclusion criteria, the vast majority pertained to neuroendocrine correlates of fatherhood ($n = 19$), followed by brain activity or connectivity ($n = 7$), association studies of candidate genes ($n = 2$), and brain structure correlates ($n = 1$). Collectively, studies published during the past 15 years suggest the existence of significant endocrine (testosterone, oxytocin, prolactin, and cortisol levels) and neurofunctional alterations (changed activity in several brain networks related to empathy and approach motivation, emotional processing and mentalizing, emotion regulation, dorsal attention, and default mode networks) as a result of fatherhood, as well as preliminary evidence of genetic variability accounting for individual differences during the postpartum period in fathers. No studies were so far published evaluating epigenetic mechanisms associated with the paternal brain, something that was also the focus of the current review. We highlight the need for further research that examines neuroplasticity during the experience of fatherhood and that considers both the interplay between hormones and simultaneous assessment of the different biomarkers (e.g., associations between hormones and neural activity); data collection protocols and assessment times should also be refined.

Keywords: fatherhood, neuroplasticity, neuroendocrine, molecular mechanisms, neuroimaging correlates, postpartum

INTRODUCTION

The transition to parenthood represents a transformative period, marked by diverse co-occurring biological, psychological, social, economic, and behavioral changes (e.g., decreasing levels of testosterone, increasing levels of oxytocin, changes in thoughts and behaviors oriented toward the infant; Bakermans-Kranenburg et al., 2019). These changes seem to facilitate experience-dependent acquisitions of parenting skills, aimed at caring for the infant and securing survival (Swain et al., 2014). Consequently, this period may be considered a potential "critical window" for neuroplasticity, alongside infancy and adolescence (Saxbe et al., 2018). Although a substantial amount of evidence about motherhood biomarkers has surfaced, fatherhood has been less researched by comparison. Herein, we aim to conduct a scoping review of the available literature on alterations in several neurobiological correlates underlying the experience of fatherhood.

Neuroplasticity refers to the reorganization of the brain (physiological and anatomic changes) as a result of our interactions with the environment, allowing for the adaptation to new circumstances and demands (Demarin et al., 2014). A reflection of neuroplasticity processes is the thickness or thinning of the gray matter architecture of the brain (refining, severing, or forging of neural connections; Saxbe et al., 2018). During pregnancy and the postpartum period, the parental brain suffers alterations in its structure and function. In fathers, these alterations mostly occur during the postpartum period, through the experience of father–infant interactions, and may correspond to increased neuroplasticity (e.g., Kim et al., 2014). Despite not experiencing in-person the hormonal changes of pregnancy, research has shown that fathers engage similar neural circuitry when processing infant-related stimuli compared to mothers (Swain et al., 2007). Additionally, fathers undergo significant neuroendocrine alterations during the transition to parenthood that have been found to be associated with greater involvement in caregiving (e.g., longitudinal decreases in testosterone; Gettler et al., 2011).

Furthermore, intrinsic individual genetic characteristics, such as subtle changes in the DNA sequence, called single nucleotide polymorphisms (SNPs), might contribute to differences in parental responsiveness. Indeed, studies with mothers show that variability in parenting styles can be moderated by polymorphic variations in target genes associated with affiliative and reward systems. Particularly relevant in this regard is the oxytocinergic pathway, which includes the oxytocin neuropeptide (OT) and the oxytocin receptor (OXTR). Generically, genetic variability in the OXTR gene has been associated with sociability, caregiving, and parenting (Feldman et al., 2016; Feldman, 2017), with particular evidence showing that the GG risk genotype of the rs2254298 SNP is associated with autism and depression (Lerer et al., 2008; Costa et al., 2009) and the TT risk genotype of the rs1042778 SNP correlates with lower empathy and prosocial behavior in healthy adults (Israel et al., 2009; Wu et al., 2012), while rs53576 GG genotype is associated with more sensitive parenting and the G allele of the rs1042778 SNP with positive parenting in mothers (Bakermans-Kranenburg and Van Ijzendoorn, 2008; Michalska et al., 2014). Moreover, in Riem et al. (2011) the authors showed that women carrying the presumably protector genotype (GG) were more reactive to the infants' cry (measured through heart rate response), although women with depression symptoms with the same genotype did not show this reactivity, highlighting the relevance of addressing parenthood and quality of care within a gene-by-environment framework (GxE). Yet, little is known about these genetic mechanisms concerning fathers. Furthermore, epigenetic mechanisms such as DNA methylation (DNAm) have recently entered the research field of parenting behavior. DNAm occurs at the CpG sites of the gene, where methyl residues (CH3) are added. The addition of these molecules attenuates the binding of transcription elements on the gene, which in turn contribute to the lower expression or "silencing" of the gene activity. Indeed, recent research shows that DNAm of the OT gene changes brain volume in important areas for parenting behavior in mothers (i.e., right inferior temporal gyrus; Hiraoka et al., 2021) and that DNAm profile changes during pregnancy predict postnatal variability in maternal behavior (more specifically, in intrusive behavior; Toepfer et al., 2019).

Although growing neuroimaging, molecular and hormonal-based literature has explored the neurobiological basis of parenthood, the majority of research has been conducted on human mothers during pregnancy or the postpartum period (e.g., Kim et al., 2010), and less is known about the specific correlates of the experience of fatherhood. And whereas some mechanisms appear to be shared between mothers and fathers, important differences might exist, possibly driven by biological (e.g., testosterone levels) and experience-related factors (e.g., being a primary caregiver).

Diverse reviews on fatherhood focus on different correlates and measures, such as neuroendocrine (e.g., Storey et al., 2020) and functional neuroimaging (e.g., Swain et al., 2014). Our review aims to further tap into this knowledge, providing a structured, comprehensive, and descriptive search of the literature on the neurobiological correlates of fatherhood associated with postpartum parental caregiving experiences, while extending to molecular and structural brain correlates and identifying the main gaps in the current knowledge. Thus, the following questions will be addressed:

A. What is known about the molecular mechanisms (genetic and epigenetic) related to fatherhood?
B. What is known about the neuroendocrine correlates of fatherhood?
C. What is known about the neurostructural correlates of fatherhood?
D. What is known about the neurofunctional correlates of fatherhood?

MATERIALS AND METHODS

Our review aim was too broad to be addressed by a systematic review; instead, it was thought to be better addressed by looking at the scope and nature of the research pertaining to the neurobiological correlates of fatherhood, while identifying research gaps (see guidance by Munn et al., 2018). Based on these objectives, a scoping review was considered to be the most appropriate review strategy. Scoping reviews follow the

same structured process as systematic reviews (Munn et al., 2018), however, a formal assessment of the methodological quality of the included studies is generally not performed (Colquhoun et al., 2014; Peters et al., 2020). The review process followed the Preferred Reporting Items for Systematic reviews and Meta-analyses extension for Scoping Reviews (Tricco et al., 2018) for conducting and reporting the results. The review was pre-registered in Open Science Framework.[1]

Eligibility Criteria

We included full-text primary research studies published in peer-reviewed journals within the last 15 years, given the technological progress of neuroimaging methods. Studies were eligible if they included data from human heterosexual fathers (age range 18–60) and assessed outcomes from infant birth to 1 year postpartum; assessed neuroendocrine (testosterone, oxytocin, prolactin, cortisol levels and manipulations), brain structural changes (gray matter volume and cortical thickness), brain functional changes (task-based patterns of functional activity and connectivity), and/or molecular mechanisms (genetic and epigenetic) among fathers; and were written in English language. The limited timeframe (0–12 months) was selected based on the focus of the review (neurobiological correlates of fatherhood associated with postpartum experiences).

Psychiatric or neurological disorders (in both father and infant) and premature birth were excluded, as the focus of the review was on normative correlates associated with fatherhood. Older adults were excluded as well (>60 years old), given the existing negative association between age and structural alterations in healthy aging (e.g., Salat et al., 2004). We excluded opinion pieces, editorials, conference abstracts, qualitative studies, and reviews.

Information Sources and Search Strategy

Searches were performed in PubMed, Scopus, and Web of Science electronic databases. Following the Joanna Briggs Institute methodology (Peters et al., 2020), a three-step strategy was performed. Firstly, a limited search of the PubMed database took place, with the following MeSH terms: "(Father OR fatherhood OR men) AND (Brain OR anatomical OR structural OR functional OR connectivity OR activation OR resting state OR neural OR hormonal OR neuroendocrine OR genetic OR epigenetic) AND (postpartum OR postnatal OR perinatal)." Secondly, keywords included in the title and abstract of retrieved papers and the index terms were analyzed. Afterward, a second search was performed across the included databases with the identified and relevant keywords and index terms. The searches were conducted between November and December 2020. In addition to these databases, we hand-searched reference lists of key studies included in our search and reference lists in key reviews published in the field. The full search strategies for all databases are attached as **Supplementary Material**.

[1]https://osf.io/j2x9u

Selection of Sources of Evidence

Screening was conducted in the Rayyan QCRI software (Ouzzani et al., 2016), where authors FP and MS removed the duplicates across databases. The same two reviewers independently performed the double-screening of titles and abstracts, as well as the full-text articles. A third reviewer was available to resolve inter-rater disagreements when necessary. Inter-rater agreement on study selection was calculated using Cohen's kappa coefficient (Landis and Koch, 1977). The inter-rater agreement was $k = 0.86$, indicating almost perfect agreement.

Data Charting Process and Data Items

The included reports were split across two teams of reviewers responsible for extracting data on different neurobiological correlates. FP and MS extracted structural and functional data, while JA, SM, and BP extracted data concerning neuroendocrine and genetic/epigenetic measures. The team cross-reviewed each other's extraction. After comparing each reviewer's charted data, disagreements were resolved through discussion and a third reviewer when needed as well. A data charting form was developed *a priori*, including the following information: author name, year of publication, study design, participant characteristics, methodology, and key findings. Individual data forms were constructed for the different measures available.

Synthesis of Results

In accordance with scoping review guidelines (Tricco et al., 2018; Peters et al., 2020), an assessment of the methodological quality or risk of bias of the included studies was not performed. The available data were organized in a comprehensive system of the diverse measures available. A narrative and tabular synthesis of the extracted data was performed.

RESULTS

Selection of Sources of Evidence

The selection process of sources of evidence was adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram. After the removal of duplicates, 1,492 citations were reviewed. Of these, 1,426 were excluded based on the title and abstract. Of the remaining 66 full-text articles assessed for eligibility, 37 were excluded for different reasons, detailed in the Flow Chart in **Figure 1**. Subsequently, 29 articles were included in this review.

Characteristics of Sources of Evidence and Synthesis of Results

Details of each study are provided in **Table 1**. The summary below focuses on key characteristics and findings, organized according to the parameter in question.

Endocrine and Molecular Biomarkers

In the endocrine and molecular domains, 21 articles met the inclusion criteria (*cf.* **Table 1**), of which 19 focused on endocrine

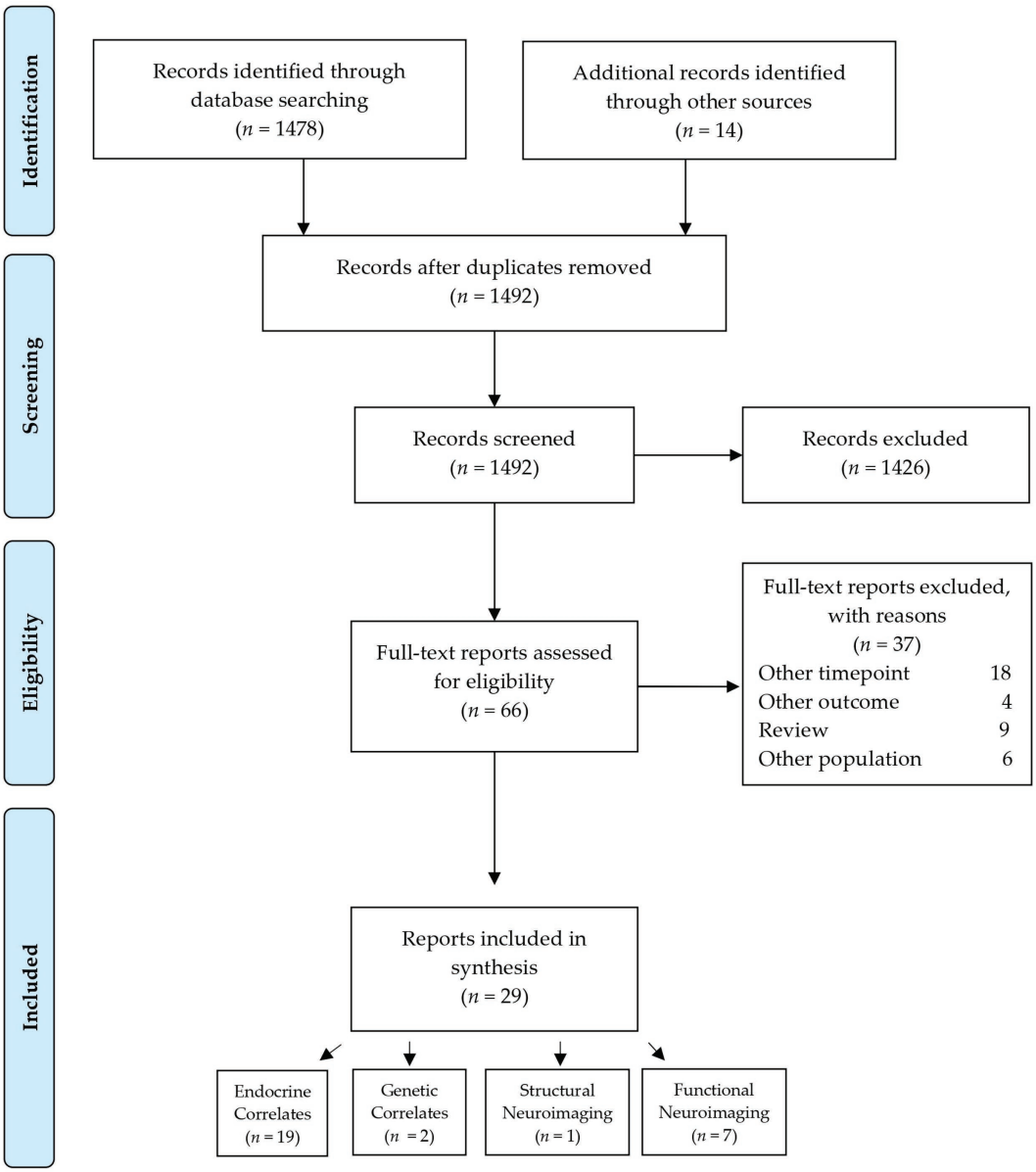

FIGURE 1 | Flow chart of the selection of sources of evidence.

changes and two combined both endocrine and SNPs analysis. Within the endocrine studies, six studies focused exclusively on Oxytocin (OT; Feldman et al., 2010a,b, 2011; Gordon et al., 2010b; Weisman et al., 2012, 2013a), five studies focused on Testosterone (T; Gettler et al., 2011; Perini et al., 2012a,b; Corpuz and Bugental, 2020; Corpuz et al., 2020), one study focused on Prolactin (PRL; Delahunty et al., 2007), two studies analyzed both OT and T (Weisman et al., 2014; Gordon et al., 2017), another two studies observed OT and Cortisol (CORT; Gordon et al., 2010a; Weisman et al., 2013b), one OT and PRL (Gordon et al., 2010c), and two T and CORT (Bos et al., 2018; Kuo et al., 2018). Regarding molecular studies, two studies analyzed both OXTR and CD38 genetic polymorphisms (Feldman et al., 2012, 2013).

The majority of studies reported longitudinal quantitative data ($n = 13$, Delahunty et al., 2007; Gordon et al., 2010a,b,c, 2017; Gettler et al., 2011; Perini et al., 2012a,b; Feldman et al., 2013; Bos et al., 2018; Kuo et al., 2018; Corpuz and Bugental, 2020; Corpuz et al., 2020). Seven of which reported data from pre-birth, but we only considered results within the 0–12 months postpartum period, meeting the criterion for inclusion. Eight studies reported on cross-sectional quantitative data (Feldman et al., 2010a,b, 2011, 2012; Weisman et al., 2012, 2013a,b, 2014). Samples ranged from 35 to 465 participants, and the father's mean age was 29.33 years. In 10 of these 21 articles, infants were the first child for the father. There was variation regarding the assessment of parenting outcomes

(subjective parental care quality and parental behaviors reported) associated with endocrinal and molecular biomarkers (*cf.* **Table 1**).

Besides controlling for the effect of time of day for hormone values, the majority of the reviewed studies included the following covariates in their models or examined potential correlations with those prior to data analysis: parent age (Feldman et al., 2010a,b, 2011, 2012, 2013; Gordon et al., 2010b,c; Perini et al., 2012a,b; Weisman et al., 2014; Bos et al., 2018; Kuo et al., 2018; Corpuz and Bugental, 2020); education (Feldman et al., 2010a, 2012, 2013; Gordon et al., 2010c; Bos et al., 2018); height (Feldman et al., 2010b, 2011, 2012, 2013; Gordon et al., 2010b,c); weight or body mass index (Feldman et al., 2010a,b, 2011, 2012, 2013; Gordon et al., 2010b,c; Perini et al., 2012a,b; Corpuz and Bugental, 2020); smoking (Feldman et al., 2010a,b, 2011, 2012, 2013; Gordon et al., 2010b,c); time of last meal (Feldman et al., 2010b, 2011, 2012, 2013; Gordon et al., 2010b,c); use of medication (Feldman et al., 2010b, 2011; Gordon et al., 2010b,c); and number of children/parity (Gettler et al., 2011; Bos et al., 2018; Kuo et al., 2018). Anecdotally, other studies observed variables related to parents such as: gender (Feldman et al., 2012), religiosity (Feldman et al., 2010a), ethnicity (Corpuz and Bugental, 2020), birth order (Feldman et al., 2010a), hours of employment (Feldman et al., 2010a), parental status (Feldman et al., 2012), parental anxiety (Gordon et al., 2010c), parenting stress (Gordon et al., 2010c; Weisman et al., 2013b), and psychosocial stress (Gettler et al., 2011), sleep quality, duration or disruption (Gettler et al., 2011; Perini

TABLE 1 | Main characteristics and findings of the studies.

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
SNPs and hormones							
Feldman et al. (2012)	*n* = 121	5.78 months (1.13)	To assess whether CD38 and OXTR risk alleles are associated with low plasma OT and less parental touch and gaze synchrony.	Cross-sectional	Coding of Parent–Infant Interaction (parent gaze, child gaze and parent touch)	- OT determination: ELISA - OXTR and CD38 SNPs determination: SNaPshot Method - OXTR rs2254298 (risk allele = G) - OXTR rs1042778 (risk allele = T) - CD38 SNP rs3796863 (risk genotype = CC)	**SNP rs379686 of the CD38 gene** C allele was associated with lower plasma OT compared with carriers of the A allele. SNP rs2254298 and rs1042778 of the OXTR gene. GG and TT, genotype were associated with lower plasma OT compared with individuals carrying the A allele and the G allele, respectively, Reduced plasma OT and both TT genotype (rs1042778) and C allele (rs379686) are related to less parental touch. The interaction of high plasma OT and A allele of the rs379686 SNP of the CD38 gene predicted longer durations of parent–infant gaze synchrony.
Feldman et al. (2013)	*n* = 160 parents (80 couples) at T1 *n* = 128 parents (62 fathers) at T2	T1: 1 month old T2: 6 months old	To understand if parents' peripheral OT levels and reciprocal parenting style would be individually stable over time and whether it correlates with more optimal allelic variations on OXTR and CD38 genes; To assess if a gene-by-environment interaction occurred, that is, if more optimal allelic variations on the parents' CD38 gene interacts with early parenting to shape children's OT response.	Prospective longitudinal	Coding of Parent–Infant Interaction (Gaze, Affect, Vocalizations, Touch)	- OT determination: ELISA - OXTR and CD38 SNPs: SNaPshot Method - OXTR rs2254298 (risk genotype = GG); rs1042778 (risk genotype = TT) - CD38 SNP rs3796863 (risk genotype = CC)	**SNP rs3796863 of the CD38 gene** Fathers carriers of CC genotype showed lower peripheral OT. High OT was associated with early parental care.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
Hormones							
Delahunty et al. (2007)	*n* = 21 couples	T1: 2–3 weeks old T2: 2 months old	To investigate sex differences in hormonal reactivity and to test whether sex-specific developmental trajectory or differences in recent/lifetime levels of exposure to infants influence these differences.	Longitudinal	Questionnaires (previous time with children; number of older and younger siblings; checklist of emotional responses to infant cries; infant contact before testing) Close contact with infant (30 min)	PRL; Plasma; AutoDELFIATM Prolactin kit	Higher increase in PRL in fathers when holding their second child (vs. first child) Fathers showed a non-significant trend toward greater percentage increases in PRL associated with above average child contact. Fathers who spent less than 3 h at home with their newborn prior to the 2–3 weeks postpartum showed significantly greater increase in PRL after holding their babies during than fathers who were home all day with their infants. At 2 months postpartum, fathers who held their babies for less than an hour in the 4 h prior testing showed higher baseline PRL concentrations than fathers who held their babies for more than an hour.
Gordon et al. (2010a)	*n* = 37	T1 = 6.97 weeks (2.35) T2 = 25.49 weeks (4.61)	To examine the relationships between triadic family interactions and maternal and parental OT and CORT.	Longitudinal	Coding of Triadic Interactions (gaze, affect, proximity position, and touch)	OT and CORT; Saliva and Plasma; ELISA	Paternal OT independently explained 22% of the variance in triadic synchrony. No relations between paternal CORT and triadic synchrony. The interaction between OT and CORT did not predict additional variance above and beyond the two hormones.
Gordon et al. (2010b)	*n* = 80 *n* = 62 at T2	T1 = 7.1 weeks (2.11) T2 = 24.8 weeks (4.38)	To understand the role of OT in the development of human parenting and its involvement in the transition to fatherhood.	Non-experimental prospective longitudinal	Coding of Parent–Infant Interaction (gaze, affect, vocalizations and touch)	OT; Plasma; ELISA	Paternal OT levels were associated with paternal stimulatory parenting behavior, but not with paternal affectionate parenting behavior.
Gordon et al. (2010c)	*n* = 43	T1: 2 months postpartum T2: 6 months postpartum	Examine the associations between PRL, OT, and paternal behaviors.	Longitudinal	Social Play-Coding of Parent–Infant Interaction (gaze, affect, vocalizations and touch) Toy Exploration—Coding of Parent–Infant Interaction (Parent gaze, Parent affect, Parent facilitation of infant toy exploration, Infant Toy Exploration, Paternal Coordinated Exploratory Play)	PRL determination: Chemiluminescent Microparticle Immunoassay (CMIA) technology; OT determination: ELISA	Averaged OT uniquely predicted Father–infant Affect Synchrony, while Averaged PRL was unrelated to Affect Synchrony. Averaged PRL uniquely predicted Coordinated Exploratory Play, but Averaged OT was unrelated to Coordinated Exploratory Play. In combination, PRL and OT explained 38 and 26% of the variance in Affect Synchrony and Coordinated Exploratory Play, respectively.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
Feldman et al. (2010a)	*n* = 41	166.3 days (12.6)	To assess the involvement of the oxytocinergic system in human fathering and its consistency with parenting in other mammals; more specifically, to examine if fathers with high levels of stimulatory contact would show an increase in OT following a father–infant interaction.	Cross-sectional	Rating of father involvement on house-care and childcare responsibilities Coding of Parent–Infant Interaction (parental touch patterns and parent's active engagement in exploratory)	OT; Saliva and Plasma; ELISA	Paternal stimulatory touch but not affectionate contact was related to plasma and salivary OT. OT increases in high stimulatory contact fathers but not in low stimulatory contact fathers, following parent–infant contact OT increased from the pre- to post-contact assessment among high stimulatory contact fathers.
Feldman et al. (2010b)	*n* = 19	157.1 days (11.9)	To examine: whether parental and infant OT, at both the baseline and post-interaction assessments, would be significantly correlated and if more sensitive parenting behavior would be associated with higher parental and infant OT.	Cross-sectional	Coding of Parent–Infant Interaction (parent/infant gaze, affect, vocalizations, touch)	OT; Saliva and Plasma; ELISA	OT increased in both parent and child following the contact interaction. Higher OT levels in parent and child were related to greater affect synchrony. Under conditions of high affect synchrony, infants with parents showing high OT had significantly higher OT than infants with parents with low OT.
Gettler et al. (2011)	*n* = 624 fathers and non-fathers	0–12 months	Clarify the role of T in human male reproductive strategy.	Observational longitudinal	Questionnaire (daily time spent providing physical care to children)	T; Saliva; EIA	Largest declines at waking (AM) and before bed (PM) T in new fathers. Fathers with newborns differed significantly for AM T compared with fathers with older infants. Fathers reporting higher involvement in childcare showed significantly lower values of AM and PM T compared with fathers reporting no care.
Feldman et al. (2011)	*n* = 41	166.3 days (12.6)	To assess the relation between OT and synchronous parent–infant interactions and to test the relation between OT and parent's attachment relationships to infant.	Cross-sectional	Coding of Parent–Infant Interaction (parent/infant gaze, affect, vocalizations, touch) Yale Inventory of Parent Thought and Action Parenting Stress Index Questionnaire	OT; Saliva, Plasma and Urine; ELISA	Reported differences between the high- and low-Affect Synchrony groups were found for plasma and saliva OT. Plasma and saliva OT were correlated with parent Positive Engagement, Affect Synchrony, and Positive Communicative Sequences between parent and child. Plasma and saliva OT were associated with parents' attachment relationships to infant and saliva OT was correlated with Parental Preoccupations.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
Perini et al. (2012a, 2012b)	*n* = 37	T2: 2 months old	Examine if T levels during the transition to fatherhood are related to individual personality traits.	Longitudinal	N.A.	T determination: EIA	Lower repeated T levels in fathers compared to controls. Post hoc tests indicated that AUCg-T was significantly lower in fathers than in controls at T2. The changes in T levels did not reach statistical significance either within the group of fathers or within the group of controls.
Weisman et al. (2012)	*n* = 35	5 months (1.25)	To examine if OT administration to parent influences physiological and behavioral processes that support parental social engagement.	Double-blind, placebo-controlled, experimental	Positive and Negative Affect Schedule Coding of Parent–Infant Interaction (parent gaze, affect, touch and vocalizations; infant gaze, affect and exploratory play)	OT; Saliva; ELISA	Greater autonomic readiness for social engagement in the OT condition. Episodes of social reciprocity were longer in the OT condition. In the OT condition, fathers had longer episodes of touch (combined affectionate and stimulatory touch). Latencies to the first episode of father's touch and social gaze at the infant were shorter in the OT condition.
Weisman et al. (2013a)	*n* = 35	5 months (1.25)	To test whether intranasal OT administration to the parent modulates father's distance, motion characteristics and vocalization during interaction with his infant.	Double-blind, placebo-controlled, within-subject	Analysis of parent–infant motion (distance, speed and acceleration) Analysis of parent–infant speech turn-taking (father/infant vocalization; father/infant pause; silence, overlap ratio and synchrony ratio)	OT; Saliva; ELISA	OT modulates parental proximity to the infant, as well as the father's head speed and head acceleration but not the father's vocalization during dyadic interaction. Following OT administration, the maximum distance between father's head and the infant was greater, and minimum distance was reached earlier, compared with the placebo condition.
Weisman et al. (2013b)	*n* = 35	5 months (1.25)	To investigate whether intranasal administration of OT to the parent has an effect on the parent's and infant's CORT response to a social stressor and to test if the degree of parent–infant synchrony moderates this effect.	Double-blind, placebo-controlled, within-subject	Coding of Parent–Infant Interaction (indices of dyadic exchange—social gaze and gaze synchrony) Parenting Stress Index	OT and CORT; Saliva; ELISA	CORT levels at the end of interaction (T4) were significantly lower than at T1, T2, and T3. Fathers' CORT production was higher for the OT group compared to placebo. Fathers' CORT was negatively correlated with the mean durations of father's neutral affect; mean duration, frequency, total duration, and latency to father's proprioceptive touch; frequency of gaze synchrony between father and infant; and touch mys-synchrony.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
Weisman et al. (2014)	$n = 35$	4–8 months	Examine how OT administration change T levels and how T levels are related to parent–child social behaviors (gaze; parental touch; parental positive affect; parental vocalization; infant negative emotionality; infant object manipulation; infant negative vocalization).	Double-blind, placebo-controlled, within-subject	Coding of Parent–Infant Interaction (parental gaze, touch, affect and vocalization; infant gaze, negative emotionality, object manipulation and negative vocalization)	T and OT; Saliva; EIA	T was negatively correlated with the mean durations of parental vocalization and positively correlated with the latency to paternal vocalization. T correlated with frequency and proportion of father's gaze to infant's body. T marginally correlated with father's self-reported weekly hours spent with infant. OT-induced change in T levels correlated with parent–child social behaviors; when controlling for basal T levels, the unique contribution of T-change in predicting behavior remains in most cases.
Gordon et al. (2017)	$n = 80$	T1: 1 month old T2: 6 months old	Examine how OT and T levels in new fathers across the first six months of parenthood shape parental behavior at 6 months.	Non-experimental, prospective longitudinal	Coding of Parent–Infant Interaction (parent gaze, vocalization, affect, touch and parent–infant proximity)	T; Plasma; Chemiluminescent Immunoassay (CLIA) technology OT; Plasma; ELISA	T at T1 negatively correlated with Parent–Infant Synchrony. T at T2 negatively correlated with Stimulatory Affectionate Touch. No correlations between OT and parental behavior at both time points. There is an interaction of T and OT in predicting parental behavior across time. Father–Infant Synchrony best predicted by hormones from T1 with a significant negative association to T; Paternal Affectionate. Touch is best predicted by hormones from T2, with a significant negative main effect for T and a significant interaction effect between OT and T. When T was low or medium, OT was uncorrelated to Affectionate Touch. When T was above average, OT was negatively correlated with Affectionate Touch.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
							Stronger negative relation between T and quality of caregiving in fathers with lower CORT levels. Lower quality of postnatal caregiving associated with higher prenatal CORT levels.
Bos et al. (2018)	*n* = 56	6 weeks old	Examine the relation between observed quality of caregiving during parent–child interactions and pre- and postnatal T and CORT levels.	Longitudinal	Rating of Parent–Infant Interaction—quality of caregiving (sensitivity and cooperation)	T and CORT; Saliva; EIA	The quality of caregiving was unrelated to either postnatal T or CORT in the postnatal period. There was an interaction of quality of caregiving and T on CORT postnatally, caused by a stronger negative relation between CORT and quality of caregiving in fathers showing high T levels.
Kuo et al. (2018)	*n* = 298	Birth day—4 months	Examine how short-term hormonal changes during early dyadic interactions and fathers' basal hormone levels predict their later involvement with their infants.	Observational longitudinal	Skin-to-skin contact with newborn (1 h). Childcare Activities Scale (percentage of involvement in infant care tasks)	T and CORT; Saliva; ELISA	Higher basal CORT at infant's birth was related to greater involvement in direct care. Lower basal T at the second day after birth was related to greater involvement in direct care. Higher levels of basal CORT at the day of birth and at the second day were related to greater involvement in indirect care at follow-up. Lower levels of basal T on the second day were related to more involvement in indirect care. Fathers whose CORT increased more while holding their infants for the first time reported greater involvement in indirect care. Fathers with higher levels of basal CORT and increases in CORT while holding their infants for the first time, were more involved in play at 2–4 months postpartum.
Corpuz et al. (2020)	*n* = 220 (T2) *n* = 196 (T3)	T2: 3 months postpartum T3: 9–10 months postpartum	Examine how T levels are related to paternal care.	Longitudinal	The Laboratory Temperament. Assessment Battery Home Version (fear dimension). Coding Parent–Infant Interaction (Physical.	T determination: EIA	Although not significant, fathers with relatively accelerated T rebounds reported spending less time with their infants. Fathers who demonstrated accelerated T rebounds (from T2 to T3) exhibited significantly higher levels of paternal care quality.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
					Affection, Warmth/Support, Listener Responsiveness, Humor, and Endearment) Time invested in parent–infant interaction (experience sampling method)		
Corpuz and Bugental (2020)	*n* = 220 (T2) *n* = 196 (T3)	T2: 3 months old T3: 9–10 months old	Examine individual differences in T levels after childbirth.	Longitudinal	N.A.	T determination: EIA	Death of a sibling/friend and the upheaval of one's parental relationships each predict a younger age of sexual debut. Age of sexual debut did predict the rate of T recovery from T2 to T3: The younger one's sexual debut, the more accelerated their T "rebound" from T2 and T3.
Structural neuroimaging							
Kim et al. (2014)	*n* = 16	2/4 weeks and 3–4 months	Investigate structural changes in fathers' brains during the first 4 months postpartum.	Observational, longitudinal	Coding of Parent–Infant Interaction (Paternal sensitivity and intrusiveness)	GMV whole-brain Voxel-based morphometry; correlations between GMV and parenting behaviors	Decreased GMV in the OFC was associated with increased intrusive parenting behaviors.
Functional neuroimaging							
Atzil et al. (2012)	*n* = 15	4–6 months	Examine synchrony in mothers' and fathers' brain responses to own-infant cues.	Exploratory	N.A.	Whole-brain and ROI-based; contrasts; correlations between hormones and brain areas activation	Increased activations in cognitive areas related with decreased OT levels.
Kuo et al. (2012)	*n* = 10	2–4 months	Investigate neural responses to infants in fathers and the association between neural activity, T, and parental behavior.	Observational, cross-sectional	Coding of Parent–Infant Interaction (Parental Sensitivity and Parental Reciprocity)	Whole-brain and ROI-based; contrasts; correlations between ROI activation, parenting and hormonal measures	Increased activity in emotion regulation and mentalizing circuits in response to own infant. Increased activity in salience, reflexive caring, emotion regulation, and mentalizing circuits in response to baby (vs. doll). Decreased activation in right orbitofrontal cortex in response to own infant was associated with greater paternal sensitivity and reciprocity. Increased T levels after interaction with own infant were associated with increased activation in the left caudate in response to own infant.

(Continued)

TABLE 1 | Continued

Authors	Father's sample size	Infant's age Mean (SD)	Aim	Study design	Assessment of parenting	Analysis	Main findings
Abraham et al. (2014)	*n* = 21	11 (6.67) months	Investigate parental brain responses to infant stimuli.	Observational	Coding of Parent–Infant Interaction (Parent–Infant Synchrony)	ROI-based contrasts and connectivity; correlations between brain activation, parenting and hormones; mediation analysis.	Increased activation in socio-cognitive and mentalizing networks was associated with OT levels and parent–infant synchrony.
Kim et al. (2015)	*n* = 19	T1 = 1 month T2 = 3/4 months	Investigate associations between parental thoughts/actions and neural activation in fathers in the neonatal period with infant outcomes.	Prospective longitudinal	Yale Inventory of Parental Thoughts and Actions—Revised (YIPTA-R)	Whole-brain; contrasts; correlation of neural responses with positive parenting	Increased activity in the auditory cortex, thalamus/hypothalamus and caudate in response to own infant baby cries at the first month postpartum were associated with positive parenting in fathers.
Abraham et al. (2018)	*n* = 21	11 (6.67) months	Investigate the neurobiological basis of parental empathy.	Longitudinal	N.A.	ROI; connectivity	Increased connectivity within and between two empathy networks (embodied simulation and mentalizing) when viewing own infant videos.
Li et al. (2018)	*n* = 39	<4 months	Investigate variation in paternal neural responses to infant crying.	Observational	Parenting Stress Index—Short Form	Both whole-brain and ROI-based; contrasts; correlations between paternal characteristics and neural responses.	Own and unknown infant cries activate empathy and approach motivation circuits. Decreased dorsal anterior cingulate cortex and anterior insula activity in response to infant cries in older fathers. Increased neural responses were associated with lower infant age. Increased activation of right posterior temporal gyrus in fathers who reported negative emotions in response to own infant's cry.
Paternina-Die et al. (2020)	*n* = 20	70.25 (49.21) days	Investigate changes in cortical volume, thickness, and area in fatherhood and their association with indicators of paternal experience.	Longitudinal	N.A.	Whole-brain (cortical regions); contrasts.	Increased activity in default mode and dorsal attention networks in response to own baby (vs. unknown baby).

SNPs, Single nucleotide polymorphisms; OT, Oxytocin; PRL, Prolactin; CORT, Cortisol; T, Testosterone; GMV, Gray matter volume; OFC, Orbitofrontal cortex; and ROI, Region-of-interest.

et al., 2012b). Others observed variables related to the infant, such as infant's sex (Kuo et al., 2018) and age (Gordon et al., 2010c). Similarly, a couple of studies observed variables related to the parental marital relationship, such as: relationship duration (Perini et al., 2012a,b), time spent together as a couple and with significant others (Perini et al., 2012b), marital status (Kuo et al., 2018); and finally, a few other variables were considered across studies, such as consumption of caffeine (Perini et al., 2012a,b), activities during the day of saliva sampling (e.g., time with partner and baby; Perini et al., 2012b); hormone levels (Weisman et al., 2014); drug order (i.e., OT first vs. placebo first; Weisman et al., 2014); and maternal care (Corpuz et al., 2020).

Genetic Studies

To our knowledge, only two studies addressed the association between genetic variability in two different genes (CD38 and OXTR) and paternal behavior and endocrine changes. Specifically, Feldman et al. (2012, 2013) showed both fathers and non-fathers carriers of the C allele in a particular SNP (rs3796863) of the CD38 gene produced lower plasma OT levels. The same profile was observed for carriers of the GG (rs2254298) and TT

(rs1042778) genotypes of the OXTR gene. Additionally, fathers with CD38 CC genotype showed smaller frequency in touch toward their children, compared to those carrying the AA/AC genotype, and fathers with OXTR rs1042778 TT genotype also provided less touch to their infant. Furthermore, among fathers, longer parent–infant gaze synchrony was predicted by the combination of CD38 low-risk A allele and high plasma OT.

Endocrine Studies

Oxytocin. Only one study compared OT levels between fathers and non-fathers, showing that parents had higher OT levels than non-parents (Feldman et al., 2012). Father's OT hormone basal levels differ in terms of tissue used for OT collection, with a range of 306.01–405.10 pg/ml for plasma (Feldman et al., 2010b, 2011; Gordon et al., 2010a,b) and 7.09–23.20 pg/ml for saliva samples (Feldman et al., 2010a, 2011; Weisman et al., 2012), with results showing that plasma and saliva OT levels are interrelated (Feldman et al., 2010a, 2011). One study reported values for basal OT urine samples ($M = 9.81$ pg/ml, SEM = 2.03), which does not correlate with both saliva and plasma OT levels (Feldman et al., 2011). There is a time effect in OT levels in fathers, in that its values rise from the first week postpartum up to 6 months postpartum (Gordon et al., 2010b). Additionally, OT levels show high intraindividual stability across time in fathers (Feldman et al., 2010a, 2011, 2013; Gordon et al., 2010b; Weisman et al., 2012) and basal levels of this hormone increase after interactions with own infants (Feldman et al., 2010a, 2011; Gordon et al., 2010b; Weisman et al., 2012).

Furthermore, higher OT levels in fathers correlate with increased time spent in father-to-infant touch (Feldman et al., 2012), related with stimulatory contact (proprioceptive contact, tactile stimulation, and object presentation), but not with affectionate touch (Gordon et al., 2010b). Moreover, fathers with high levels of stimulatory contact show an increase in OT after parent–infant interaction compared to fathers with low levels of stimulatory contact (Feldman et al., 2010a). Feldman et al. (2011) showed that both plasma and salivary OT correlated with positive engagement, affect synchrony, and positive communicative sequences between parent and child. Higher OT levels in fathers were also associated with early parental care (Feldman et al., 2013). Furthermore, in a mother–father–infant interaction, Gordon et al. (2010a) showed that father's OT independently predicted triadic synchrony, suggesting that greater OT levels in fathers contribute to increased synchrony in triadic interactions.

In an OT administration paradigm, Weisman et al. (2012) showed that fathers in the OT condition revealed higher respiratory sinus arrhythmia (a measure of the parasympathetic activity that relates to orientation, attention, and social engagement; Porges, 1995), suggesting that increased OT levels are associated with higher fitness for social engagement between father and infant. Furthermore, fathers in the OT condition showed more infant-oriented positive vocalizations, higher father's social reciprocity, encouragement of infant orientation to the social context, and extended periods of touch. On the contrary, Weisman et al. (2013a) showed that OT administration seems to have no effect on vocalizations toward the child, but instead was associated with increased father's head motion (head speed and acceleration during dyadic interaction), and shorter distance toward the child, reflecting a more pronounced infant-directed repertoire, which contributes to the affiliative process.

Moreover, no correlation was found between OT and father's state or trait anxiety or stress in parenting role (Gordon et al., 2010c).

Prolactin. Two studies analyzed changes in PRL in fathers during the first 6 months postpartum (Delahunty et al., 2007; Gordon et al., 2010c). PRL baseline plasma levels differed in each study, with average values ranging from 10.6 ng/ml (Delahunty et al., 2007) to 317.356 ng/ml (Gordon et al., 2010c). In an experimental setting, no differences emerged in PRL levels between non-fathers holding a doll and fathers holding their infants in the early postpartum period (first 2–3 weeks after birth; Delahunty et al., 2007). However, significant differences emerged with the second child of these same fathers, reflected in a greater increase in PRL levels after holding their second babies compared to the PRL levels registered after holding their first child (Delahunty et al., 2007). In line with this result, a non-significant trend emerged showing that men who have above average contact with children have a greater percentage increase in PRL, compared to men with less contact with children (i.e., considering the estimated percentage of time over their lifetimes that had spent with infants and how many younger siblings did they have; Delahunty et al., 2007). Furthermore, the quantity of time spent with one's own infant seems to influence PRL levels. Fathers who spent all day at home with their infants had smaller PRL increases compared to fathers who had spent less than 3 h with their newborn at the 2–3 weeks postpartum period, and no differences in baseline PRL levels were found between groups (Delahunty et al., 2007). On the contrary, at 2 months postpartum, fathers having less time holding their babies showed higher baseline PRL levels compared to men who held their babies for longer periods, and no differences were found in percentage change of PRL levels (Delahunty et al., 2007). In Gordon et al. (2010c), PRL levels were stable over time (at 2 and 6 months postpartum) and higher PRL average scores correlated and significantly predicted father's coordinated exploratory play with own infant. Average PRL also correlated marginally with affect synchrony between father and infant in a social play interaction (Gordon et al., 2010c).

Testosterone. Apart from one study, which used plasma as the tissue for T determination (Gordon et al., 2017), all other studies collected saliva samples. Perini et al. (2012b) compared fathers at 2 months postpartum with no-fathers as controls, reporting that T was significantly lower in fathers. Longitudinal quantitative data revealed paternal T rebounds across the postpartum period (Gordon et al., 2017; Corpuz and Bugental, 2020; Corpuz et al., 2020). This recovery is observed already at the postpartum day two, where paternal T was significantly higher ($M = 94.39$ pg/ml, $SE = 2.57$ pg/ml) when compared to the infant's birth day ($M = 82.18$ pg/ml, $SE = 2.48$ pg/ml; Kuo et al., 2018). Four studies explored the differences in paternal T while taking into account father–infant interaction. Fathers who reported spending more time in childcare activities revealed significantly lower T levels

compared to fathers with no involvement (Gettler et al., 2011). Fathers with lower T on their children's second day of life reported greater involvement in direct (e.g., bathing) and indirect (e.g., washing infant's clothes) childcare at approximately 16 weeks after postpartum (Kuo et al., 2018). Although it did not reach statistical significance, fathers with relatively accelerated T rebounds (i.e., higher increase of T levels after the descent of male T from pre-birth to the postpartum period and first year of infant's life) reported spending less time with their infants (Corpuz et al., 2020). Regarding the quality of care, Bos et al. (2018) reported that at 6 weeks postpartum parental sensitivity and cooperation were unrelated to paternal T. In contrast, higher quality of paternal care was reported by fathers with accelerated T rebound (Corpuz et al., 2020). This result might be unexpected taking into account the previous findings on decreased time spent with infants associated with accelerated T rebounds, as well as the results found in two other studies, pointing to negative correlations between paternal T and fathers' affectionate touch (Weisman et al., 2014; Gordon et al., 2017). Gordon et al. (2017) also reported a negative correlation between paternal T levels and parent–infant behavioral synchrony at 1 month postpartum, even though this correlation did not emerge at 6 months postpartum.

Cortisol. Studies show that on the infant's birth day, father's basal CORT levels measured immediately before holding their newborns for the first time decline significantly after, and rebound close to the mentioned father's basal CORT baseline levels ($M = -2.23$ μg/dl, $SD = 0.80$) on day two postpartum (Kuo et al., 2018). As reported in Gordon et al. (2010a), CORT levels are described to be higher at two (5.38 pg/ml, $SD = 2.14$) and 6 months post-partum (5.60 pg/ml, $SD = 1.39$). Furthermore, a greater father's involvement in play and childcare at 2–4 months postpartum was associated with father's greater basal CORT levels and reactivity to first time holding their babies at infant's birth day (Kuo et al., 2018). Also, father's CORT levels significantly drop after parent–infant interaction across the first 4–8 months postpartum (Weisman et al., 2013b). At 4–8 months postpartum period, father's CORT basal level (pre-parent–infant interaction) negatively correlated with father's proprioceptive touch (mean duration, frequency, proportion, and latency) toward the child; with father's neutral affect toward own infant; with frequency of gaze synchrony between father and child and with touch mys-synchrony (i.e., father's proprioceptive touch toward the child coinciding with infant's avert gazing from father; Weisman et al., 2013b).

Interactions Between Different Hormones

Six studies analyzing more than one hormone and possible interactions between them are described in this section.

Oxytocin and Cortisol. Relative to OT and CORT, the results are somewhat contradictory. In Weisman et al. (2013b), fathers who had self-administered OT showed an increased CORT response to a stress paradigm (face-to-face still-face paradigm). Nevertheless, in Gordon et al. (2010a), father's plasma OT and salivary CORT were not correlated at both 2 months and 6 months postpartum, and OT and CORT interaction did not predict additional variance over and above the two hormones relative to synchrony in a triadic interaction.

Oxytocin and Prolactin. In the 2 months postpartum period, no association between PRL and OT was found in the Gordon et al. (2010c) study. However, by the sixth month postpartum, the authors found a positive association between the two hormones. Furthermore, in combination, PRL and OT explained 38 and 26% of the variance in Affect Synchrony and Coordinated Exploratory Play, respectively, in a father–infant interaction paradigm.

Oxytocin and Testosterone. One study (Gordon et al., 2017) reported no association between paternal T and OT *per se*. Nevertheless, the authors explored the interaction of T and OT in predicting parental behavior. At 6 months postpartum, when T was low or medium, OT was uncorrelated to paternal affectionate touch. However, when T was above average, OT was negatively correlated with paternal affectionate touch.

When OT was self-administered (Weisman et al., 2014), fathers at 4–8 months postpartum revealed higher T levels, compared to the placebo condition. The OT-induced change in paternal T levels was correlated with positive affect, social gaze, touch, and vocal synchrony observed during a father–infant interaction conducted 45 min after OT administration. The unique contribution of T-change remained in most cases even when controlling for basal T levels.

Cortisol and Testosterone. Bos et al. (2018) found a negative relation between CORT and quality of caregiving (i.e., parental sensitivity and cooperation) in fathers with higher T, at 6 weeks postpartum.

Structural Neuroimaging Research

Only one longitudinal study used structural MRI data to assess brain changes during the postpartum period (Kim et al., 2014), examining gray matter volume (GMV) data (voxel-based morphometry) in 16 fathers, assessed at two timepoints (2–4 weeks and 12–16 weeks postpartum). While controlling for father's age, parity (primiparous or multiparous status), and scan intervals, the study showed that the decrease in the OFC volume was associated with higher paternal intrusiveness levels, especially with forcing behaviors (i.e., the physical manipulation of the infant's body).

Functional Neuroimaging Research

Seven studies included functional neuroimaging methods. Of those, three (43%) followed a longitudinal design (Kim et al., 2015; Abraham et al., 2018; Paternina-Die et al., 2020; for the purpose of this review, only data collected within the 0–12 months postpartum period were included) and four (57%) followed a cross-sectional design (Atzil et al., 2012; Kuo et al., 2012; Abraham et al., 2014; Li et al., 2018). Samples ranged from 10 to 48 participants, with father's mean age ranging from

29.3 to 37.68 years. Overall, studies included both first-time and veteran parents. Regarding the inclusion of covariates (either prior to the data analysis or in the models), besides controlling for diurnal variability in hormones when applicable, studies considered the father's age (Paternina-Die et al., 2020), hormone plasma levels (Atzil et al., 2012), head motion parameters (Kuo et al., 2012; Paternina-Die et al., 2020), parity (Kim et al., 2015), paternal and infant characteristics (Li et al., 2018) and principal components for cry ratings (Li et al., 2018).

Infant stimuli were used across studies to evaluate fMRI responses, with two studies using auditory stimuli (baby-cry; Kim et al., 2015; Li et al., 2018) and five using visual stimuli, either pictures of the infant (Paternina-Die et al., 2020), videos of parent–infant interactions (Abraham et al., 2014, 2018) or infants' emotional faces (Atzil et al., 2012; Kuo et al., 2012).

Neural Activity—BOLD Response

Neural responses to diverse infant stimuli have been investigated in five studies. The study by Li et al. (2018) reports brain function of first-time fathers in response to their own infant cry, a standardized unknown infant cry, and an auditory control stimulus. In this study, fathers were also asked to subjectively rate each infant cry stimulus, as annoyed, distressed, upset, angry, irritated, and aversive. The authors found widespread activations in response to both own and unknown infant cries in regions underlying empathy and approach motivation networks. Specifically, activations were observed in the medial prefrontal cortex, the bilateral anterior insula and the inferior frontal gyrus, the bilateral striatum, bilateral thalamus, bilateral auditory cortex, bilateral posterior cingulate, and bilateral midbrain. Additionally, the authors found that infant age, paternal age, and paternal emotional reactions influenced the neural responses of fathers to infant cries. Specifically, results showed that fathers who rated the unknown infant cry as more aversive exhibited greater neural activation in auditory cortices and decreased activation in motivation networks (thalamus and left caudate). In relation to parent characteristics, the authors also found that paternal age was negatively correlated with the neural response to own infant cries in both the dorsal anterior cingulate cortex and the right postcentral gyrus. Finally, younger infant age was found to be associated with increased neural responses in fathers.

The study by Kim et al. (2015) also assessed the neural responses of fathers to own and unknown infant cry sounds. Results showed that positive parenting (i.e., the positive experiences of parenting) was positively associated with brain activations in the right middle temporal gyrus (the auditory cortex), the thalamus, the hypothalamus, and the left caudate.

Abraham et al. (2014) measured parental brain responses to infant-related cues in secondary caregiving fathers, defining these as the father raising the infant within heterosexual relationships. Parent–infant interactions at the homebound were videotaped and used as stimuli during the fMRI scanner session, and the following contrasts were observed: Self–Infant Interaction > Self, and Self–Infant Interaction > Unfamiliar Parent–Infant Interaction. Passive viewing of the videotapes elicited activations in areas related to emotional processing and mentalizing networks: the bilateral amygdala, the ventral anterior cingulate cortex, the left inferior frontal gyrus/insular cortex, the ventral tegmental area, the bilateral superior temporal sulcus, the ventromedial prefrontal cortex, the temporal poles, and the lateral frontopolar cortex. Moreover, Abraham et al. (2014) observed that parent–infant synchrony was correlated with superior temporal sulcus activation in secondary caregiving fathers.

Another study reported on the neural responses of fathers to videos of their own neutral or smiling infant (OWN), other unknown matched infant (OTHER), as well as control stimuli (DOLL; Kuo et al., 2012). Whole-brain analysis for OWN > OTHER contrasts showed increased activity in regions underlying emotion regulation (bilateral inferior frontal gyrus) and empathic/mentalizing networks [bilateral supramarginal (parietal) gyrus and bilateral middle temporal gyrus]. Region-of-interest analysis for OWN > OTHER showed greater activations to own baby in the right superior frontal gyrus, the right inferior frontal gyrus, the right caudate, the left caudate, and the right orbitofrontal cortex. In relation to the contrast of baby (average of both own and other infant) vs. DOLL, greater activation was reported in fathers in the sensory/salience, reflexive caring, emotion regulation, and empathic/mentalizing networks, namely in the bilateral caudate, the orbitofrontal cortex, the superior frontal gyrus, the bilateral middle temporal lobes, the bilateral superior parietal lobules and a network of lateral frontal regions. Kuo et al. (2012) additionally found that the activation in the right orbitofrontal cortex was negatively correlated with parental sensitivity (i.e., the parent's ability to perceive the infant's signals and to respond adequately to the infant, allowing the latter to determine the process of the interaction) and parental reciprocity (i.e., reciprocal interactions between parent and infant).

The whole-brain study by Atzil et al. (2012), used similar stimuli and found that fathers showed greater activation in socio-cognitive regions (e.g., left medial prefrontal cortex and left precuneus) in response to their infant (OWN infant > standard infant contrast).

Finally, in the whole-brain study by Paternina-Die et al. (2020), neural responses of first-time fathers were assessed using pictures of their own and unknown infants' faces. Regarding the OWN > OTHER contrast, activations were found in brain regions that overlap with the default mode and the dorsal attention networks, including bilateral precuneus, middle temporal gyrus, posterior cingulate cortex, middle occipital lobes, and right-sided activations in the inferior frontal/parietal gyrus, the angular/pre-central gyrus, the inferior/posterior temporal gyrus, and the superior occipital lobe.

Functional Connectivity

The study by Abraham et al. (2014) analyzed functional connectivity between the amygdala and the superior temporal sulcus in fathers which was found to be correlated with the time spent in direct infant care.

Abraham et al. (2018) examined the connectivity in three brain networks of interest, among secondary caregiving fathers, in response to neutral natural interactions and attachment-related video vignettes (fathers were instructed to interact freely with their own infant—Self–Infant Interaction) and found increased

connectivity within and between embodied simulation and mentalizing networks in fathers when viewing their interactions with their own infant (vs. unknown infant interactions).

Interaction Between Endocrine and Neural Correlates

Two studies observed associations between the hormone OT and neural responses. The study by Abraham et al. (2014) suggested that the neural activity of the superior temporal sulcus was correlated with OT levels in secondary caregiving fathers and the father–infant synchrony was indirectly affected by the superior temporal sulcus, through increases in OT. Atzil et al. (2012) observed that decreases in OT were associated with higher activations in cognitive areas (e.g., dorsolateral prefrontal cortex, dorsal anterior cingulate cortex, and pre-central gyrus) in response to own-infant videos. Finally, T levels following father–infant interactions were positively correlated with the left caudate activation in response to own infant videos in the Kuo et al. (2012) study.

DISCUSSION

In our scoping review, we identified 29 primary studies published between 2005 and 2020 addressing neurobiological correlates of fatherhood. Specifically, 19 studies were retrieved for neuroendocrine biomarkers, two for SNPs of candidate genes, one for structural neuroimaging, and seven for brain activity or functional connectivity. Overall, there seems to exist some evidence in favor of significant neuroendocrine and neurofunctional changes, as well as a role for genetic variability in the transition to parenthood in fathers. On the contrary, there was limited or non-existent research focusing on structural brain changes and other molecular mechanisms such as epigenetic modifications associated with fatherhood outcomes (e.g., the quality of subjective paternal care and paternal behaviors reported) during the postpartum period.

Regarding the neuroendocrine changes and genetic variability, we found 19 studies focusing on hormonal alterations in fathers and two studies focusing on polymorphic variations on candidate genes that influence paternal behavior. Paternal caregiving behaviors in human fathers toward their infants were shown to be associated with paternal hormonal levels, such as OT, CORT, T, and PRL. Findings suggest that positive engagement, father–child touch, stimulating contact, parental care, affect synchrony, and positive communicative sequences are related to higher OT levels (Feldman et al., 2010b, 2011, 2012, 2013). Furthermore, studies where OT was experimentally increased *via* nasal administration also show that this hormone increases paternal caregiving behaviors such as touch, social reciprocity, greater physical proximity to the child, and readiness for social engagement (Weisman et al., 2012, 2013a).

This evidence emphasized how OT is relevant for paternal behavior toward their children, corroborating the vast literature within the scope of maternal behavior which consistently demonstrated that OT correlates with mother–infant attachment and interaction quality (Feldman et al., 2007). Moreover, OT can also affect paternal behavior indirectly by altering other hormones' levels. Indeed, OT administration increases CORT (Weisman et al., 2013b) and T levels (Weisman et al., 2014). These OT-induced changes in CORT were associated with lower paternal social interaction behavior with their babies, which may suggest an important integration of both stress and bonding neuro-endocrine systems in the transition to parenthood. Additionally, OT-induced changes in T correlated with greater paternal behavior, including positive arousal, social gaze, and vocal synchrony. These results go in line with Weisman and Feldman (2013), who suggest that OT manipulation, especially the one with T levels, increases reward and social salience in the context of social interactions through interactions with the dopamine mesolimbic pathway (Hermans et al., 2010), possibly facilitating father's caregiving commitment.

In fact, OT and T do not operate independently, but instead they interact with each other which collectively may influence parenting behavior. An Estrogen Response Element was already identified in the human OT gene and estrogens were found to upregulate oxytocin production in specific subpopulations of OT neurons (Richard and Zingg, 1990). More recent findings also point out the possibility of a direct regulation of androgens on the OT gene, through the evidence of a co-localization of androgen receptors (AR), in OT neurons of the paraventricular nucleus of the hypothalamus (Dai et al., 2017). Additionally, T is known to be metabolized to estradiol, which in turn increases the synthesis of OT (Cornil et al., 2006), a mechanism hypothesized to mediate maternal behavior. In this regard, an fMRI study with young women revealed increased activation of the limbic-related structures after T administration in response to infant crying when compared to a control sound, shedding light on the neuroendocrine regulation of maternal care (Bos et al., 2010). Regarding fathers, a study included in the current review also calls attention to this interplay, showing that intranasal OT administration, compared to placebo, leads to a short-term alteration in T levels among fathers while socially interacting with their infants (Weisman et al., 2014). Taken together, this evidence highlights a complex hormonal control of parenting behavior and urges future studies to explore this interplay to provide a more comprehensive understanding of the mechanisms underlying parenting behavior.

Despite the above-reported evidence about the interplay between OT and T, the studies looking at the individual role of T and parenting behavior yield some inconsistent results. Whereas some studies reported that lower T levels are related to greater father involvement in childcare (Gettler et al., 2011; Weisman et al., 2014; Gordon et al., 2017; Kuo et al., 2018), others report no relationship between these two variables (Bos et al., 2018) or even contrasting results (Corpuz et al., 2020). One possible caveat accounting for some of the results' discrepancies could be the fact that the measurements and behaviors analyzed are different among studies, ranging from questionnaires to father–infant interaction paradigms. Furthermore, a common feature of most of these studies is that they assessed the relationship between T levels and father's involvement with their first child. The evaluation of whether the number of children influences father's involvement in childcare and whether this is related to higher or lower T levels should be tackled by future studies. Nevertheless, it

should be acknowledged that the relationship between T and paternal behavior is not unidimensional. Parenting involves not only nurturant but also competitive phenomena (e.g., infant defense), which could be translated in different T levels (van Anders, 2013). Through partitioning intimacy and aggression, the Steroid/Peptide Theory of Social Bonds (van Anders et al., 2011) hypothesized that low T is only linked to parental contexts perceived as nurturant, while high T is linked to the invocation of defense or protection in the parental context (e.g., infant crying). Finally, cultural norms can also count on the paternal T variation, namely in terms of the degree of involvement with direct care (Gettler, 2014).

Regarding PRL, we found two conflicting studies, whereas in Gordon et al. (2010c) higher PRL levels seem to be related to greater involvement of the father in play moments with the child, Delahunty et al. (2007) found that lower PRL levels were related with increased time spent with the child. In fact, literature has been showing that higher levels of PRL in human males after childbirth seem to be associated with higher paternal behaviors, by decreasing parents' libido, contributing to a shift from reproductive to nurturing behavior (Hashemian et al., 2016). Nevertheless, the biological role of PRL in human fathers is still under investigation and so novel studies are needed in order to clarify this association.

With regards to CORT, levels of this hormone tend to remain stable throughout the postpartum period (Gordon et al., 2010a). However, some authors suggest that higher basal CORT levels are related to greater paternal involvement in caregiving between two and 4 months postpartum (Kuo et al., 2018) and this pattern seems to take the opposite direction between four and 8 months postpartum in what concerns measures of father–infant interaction (i.e., touch frequency, gaze synchrony, and social gaze; Weisman et al., 2013b). Future studies should be able to disentangle the contribution of CORT levels to fatherhood by observing the associations between CORT levels and each dimension of interest (measures of caregiving vs. measures of father–infant interaction) across time.

Including neurogenetic studies in addition to peripheral measures is an important strategy in understanding the role of OT in parenthood. Polymorphisms in genes such as the OXTR or CD38 that encode elements of oxytocinergic brain pathways are shown to be plausible key regulators of paternal behavior and investment. As described in the present review, carriers of the CC genotype of the CD38 gene, as well as OXTR rs1042778 TT genotype carriers, showed to be fathers displaying low touch frequency toward their children. Empirical studies with mothers show that OXTR SNPs also play a role in maternal behavior, including more sensitive and more positive parenting (Bakermans-Kranenburg and Van Ijzendoorn, 2008; Michalska et al., 2014), which reinforces the importance to look for such dimension also among fathers. Furthermore, there is evidence showing how SNPs on the OXTR associate with structural brain changes, including greater gray matter and smaller volumes of both left and right amygdala (Furman et al., 2011). Taken together, these findings suggest that these genetic variations may contribute to individual variability in paternal behavior by altering OT release patterns.

Surprisingly, we did not find any evidence for epigenetic mechanisms related to fatherhood which we consider to be a relevant gap in the literature given the fact that some of the existing studies do point to the influence of these mechanisms in maternal behavior. A recent study from Toepfer et al. (2019) points to dynamic DNAm changes in the maternal OT gene during pregnancy, which predicts postpartum maternal intrusiveness. Additionally, Feldman et al. (2012) showed that parents who reported greater parental care received from their own parents had higher plasma OT levels and showed more behaviors of touch toward their infants. These data may be the result of how fathers' environmental factors during their own neurodevelopmental trajectories are embedded in molecular mechanisms such as epigenetics modifications, contributing to higher/lower gene expression and consequently influencing hormonal response and parental behavior. Indeed, akin to the mother–daughter transmission of maternal care and behavior seen in mammals (Champagne, 2008), paternal care can also impact biological systems underneath stress reactivity and social behavior in offspring. This, in turn, can reflect meiotic and transgenerational epigenetic mechanisms associated with paternal behavior patterns, requiring further investigation. In fact, animal research is considerably advanced and refined in terms of mechanistic details on how paternal germ cells imbeds information from the environment and further passes it to future generations, making them more vulnerable or resilient to stress and/or psychopathology (for a review, see Cunningham et al., 2021). Given the lack of literature and work done with human fathers regarding how epigenetic mechanisms influence paternal caregiving, rodent work should be considered not only as an essential theoretical background for future work in human fathers, but also as a crucial source to inform and interpret future human studies results. Indeed, rodent work in this area is very much advanced and has isolated physiological mechanisms related to epigenetic that will be difficult to replicate in humans. Focus on animal research should then never be ignored in future human studies.

Regarding brain structure changes associated with fatherhood, we only found one study (Kim et al., 2014), highlighting the scarcity of research on specific postpartum brain changes in fathers in the postpartum period. The included study is distinguished by its longitudinal design showing that GMV decrease in the right orbitofrontal cortex was associated with paternal intrusiveness, confirming that structural brain plasticity is associated with caregiving processes. Overall, these structural alterations may constitute a mechanism for the functional adaptations observed in fathers during the postpartum period, increasing parenthood-related repertoires (e.g., for parental motivation; resource allocation). More longitudinal studies that investigate the association between neurostructural changes and fatherhood repertoire in the postpartum period are deemed necessary to further progress in the field.

Brain activity using fMRI in the one-year postpartum period in response to an infant's auditory or visual stimuli was observed by five studies. Underlying the expression of parental behavior, activity in several networks that share common brain regions and that can be coactivated was reported. Namely, empathy and approach motivation (Li et al., 2018), emotional processing and mentalizing (Atzil et al., 2012; Kuo et al., 2012; Abraham et al., 2014), emotion regulation (Kuo et al., 2012), and dorsal attention and default mode networks (Paternina-Die et al., 2020). Brain activity findings seem to be in accordance with those arising from structural neuroimaging (Kim et al., 2014). For example, right orbitofrontal cortex activation was associated with lower paternal sensitivity and reciprocity (Kuo et al., 2012) and gray matter volume increases in the same brain region with parental intrusiveness (Kim et al., 2014). Also, the caudate was activated while watching video clips of own (vs. control) infants (Kuo et al., 2012), and the caudate GMV was found to be increased during the postpartum period (Kim et al., 2014) which may well be the result of increased synaptogenesis and neurogenesis mechanisms associated to the acquisition of new caregiving skills and parental behaviors in the transition to fatherhood. Further studies observing the association between structural and functional brain changes and its effect on parenthood in fathers would progress the field.

The methodology applied to fMRI data was relatively consistent throughout the literature, with comprehensive descriptions of the contrasts carried out and the image analysis methods. The use of whole-brain and ROI approaches was balanced, with the latter generally justified across studies. However, caution should be warranted to the use of different statistical thresholds, as well as the correction for multiple comparisons across studies. Also, the majority of studies assessed fathers' responses in comparison to mothers or between fathers' groups, lacking research exploring differences between fathers and non-fathers as controls.

Research on parenting is limited by the complexity and difficulty in its definition, reflected in the variety of methods of assessment of different parental dimensions (e.g., parenting behavior, attitudes, satisfaction, and beliefs, stress; Smith, 2011; Hurley et al., 2014). In our review, measurements ranged from questionnaires or rating scales (e.g., Gettler et al., 2011; Li et al., 2018), to semi-structured interviews (e.g., Feldman et al., 2011; Kim et al., 2015) and father–infant interaction paradigms (i.e., home naturalistic observations or structured observations while undergoing a task), with different composites (e.g., Gordon et al., 2010a; Feldman et al., 2012; Weisman et al., 2013a). Consequently, the difference in operationalization of parenting and quality of parental care may contribute to the observed discrepancies in results.

In addition, another factor that may impact the quality of the available findings across the neurobiological correlates is the consideration of confounding variables. While the majority of the reviewed studies included covariates in their models that have been shown to impact results (e.g., age, diurnal variability of collection of hormone levels) or examined potential correlations with those prior to data analysis, future research should consider other covariables that importantly impact parenting, such as the level of father's investment in child's care (individually and inter-correlation of maternal and paternal investment), as well as measures of relationship functioning and satisfaction. Indeed, both relationship effort and parental effort are thought to influence male parental care (Anderson et al., 1999; Hofferth and Anderson, 2003), with parental investment being differently determined by individual and shared couple factors, such as parental wellbeing, marital relationship, and social support (Parke, 2002; Cox et al., 2004; Gameiro et al., 2011). For example, a study by Saxbe et al. (2017) found that hormonal changes (decline in T during pregnancy) and degree of synchrony with mothers (correlations with mothers' T) predicted father's paternal investment.

During the postpartum period, endocrine regulation arising from parent–infant interactions may influence complex structural and functional changes in the brain, mediating caregiving responses. Differences in fathers' hormonal levels during the postpartum period were found to be associated with neural activation to infant stimuli in several brain regions (Atzil et al., 2012; Kuo et al., 2012; Abraham et al., 2014). Overall, the studies reviewed suggest that the experience of fatherhood and exposure to infant cues are associated with neuroplasticity and significant changes in fathers' hormones and neural responses related to reward, attachment, and emotion processing. Parent–infant interactions may be an important contributor to the neuroendocrine changes, which in turn influence parenting behaviors (Rajhans et al., 2019). However, the current research cannot ascertain the direction of causality present: if changes in neurobiological components lead to differences in parenting repertoires or if the latter contributes to changes in hormonal and brain circuits. The findings highlight the need for more longitudinal experimental research evaluating the association between hormones, brain structure and function, and paternal behaviors.

Although not in the scope of our review (for a review see Rajhans et al., 2019), evidence indicates that mothers and fathers' experiences are somewhat comparable, with both parents displaying brain activations in parenting-related networks when viewing their own infant and increases in OT (Atzil et al., 2012). However, important differences in parenting behaviors due to neuroendocrine responses to own infant stimuli have been observed (Rajhans et al., 2019). For example, gray matter decreases reported seem unique to fathers (Kim et al., 2014). Overall, the literature suggests that mothers' changes may be more related to affectionate and warm maternal behavior, while fathers underlie stimulatory and exploratory play paternal behavior (Rajhans et al., 2019). Rajhans et al. (2019) importantly highlight that the type and amount of contact between parent and infant during the early postpartum period may also critically influence parental sex differences, alongside gender-specific biology. This is in accordance with findings observed in endocrine and functional connectivity domains.

TABLE 2 | Systematic framework for future directions.

Identified gaps in research
Influence of number of children in father's involvement in childcare and its association with T levels
Direction of the association between PRL levels and the experience of fatherhood
Associations between CORT levels and each dimension of interest (measures of caregiving vs. measures of father–infant interaction) across time
Neurogenetic studies in addition to peripheral measures in OT assessments
Studies evaluating evidence for molecular mechanisms (e.g., epigenetic modifications) related to fatherhood
Cross-sectional and longitudinal studies that investigate the association between neurostructural changes and fatherhood
Association between structural and functional brain changes and its effect in parenthood in fathers
Studies exploring functional brain activity differences between fathers and non-fathers as controls
Longitudinal experimental research evaluating the association between hormones, brain structure and function and paternal behaviors
Further inclusion of different family organizations in research
Inclusion of measures of father's investment in child's care (individually and inter-correlation of maternal and paternal investment) and measures of relationship functioning and satisfaction

T, Testosterone; PRL, Prolactin; CORT, Cortisol; and OT, Oxytocin.

Our review provides a broad overview of published primary studies related to neurobiological correlates of fatherhood, updating and extending existing reviews (e.g., Swain, 2011; Feldman, 2015; Swain and Ho, 2017). In our integrative and comprehensive review, we intended to additionally organize a systematic framework for future directions (for a detailed framework for future research in the field, see **Table 2**). Despite the rigorous methodology, this study is not without limitations. Due to our research question, our inclusion criteria were strict, and we only described changes reported in the defined postpartum window (e.g., studies that did not report results specifically and independently for the 0–12 months postpartum period were not considered). Thus, even though we attempted to have a search strategy as comprehensive as possible, we understand that by skipping the prepartum period we might not have identified all relevant studies in the field. Evidence for changes in fathers during pregnancy has been emerging (e.g., Bakermans-Kranenburg et al., 2019; Diaz-Rojas et al., 2021) and should be considered in future reviews. Also, we did not report results concerning homosexual primary caregiving fathers, due to the possible underlying differences in the organization of care behaviors. We recognize the existence of different family organizations (e.g., adoptive parents), and this study is not representative of this diversity. It is also important to highlight that it is increasingly necessary to actively implement efforts to make research more inclusive in this regard and so we added this vector of interest to **Table 2**. In addition, for practical reasons, the search was limited to English language. As it is not required for scoping reviews, we did not perform a quality assessment of the included studies. We did not include grey literature as well, as our main aim was focused on published reports. Finally, as we did not perform an updated second search, our results are only up to date as of December 2020.

Fathers' parental brain is an emerging area of research. The postpartum period is a critical stage for the development of father–infant interactions and attachment. Across studies, findings have provided strong evidence for neuroplasticity changes in fathers during the postpartum period. The endocrine, structural and functional changes that occur during this period critically contribute to fathers' caregiving repertoires and the quality of paternal care. The presence of plasticity in the postpartum period indicates that fathers' brains may be changed by their parenting experiences. Despite the challenges in studying the neurobiological mechanism of paternal behavior due to tissue changes specificities, the studies present in this review highlight the consistency of OT among biological tissues, namely saliva and plasma levels (Feldman et al., 2010a,b, 2011). This finding is of special relevance in the field of attachment neurobiology studies, allowing for non-invasive (i.e., saliva samples) and reliable methodologies in assessing this biological marker in the context of paternal behavior. Future research should continue to longitudinally explore the normative changes associated with the experience of fatherhood across the peripartum period.

In conclusion, the current review highlights the multi-dimensional interplay accounting for parenting behavior, shedding light on the neuroendocrine, molecular, and brain mechanisms with relevance for the understanding of an evolutionary human social behavior.

AUTHOR CONTRIBUTIONS

MS, FP, JA, BP, SM, RG, IS, AS, AM and AG-Á: conceptualization. MS, AG-Á, and AM: methodology. AG-Á, RG, and AM: validation. MS, FP, JA, BP, and SM: formal analysis, investigation, and writing-original draft preparation. AG-Á, RG, AM, IS, and AS: writing-review and editing. MS and FP: visualization. AG-Á and AM: supervision. All authors have read and agreed to the published version of the manuscript.

FUNDING

AM was supported by the Portuguese Foundation for Science and Technology (FCT) and EU through the European Social Fund and the Human Potential Operational Program – IF/00750/2015. JA was supported by the Psychology Research Centre (UI1662), University of Minho, through an individual Research Fellowship (UMINHO/BIM-CNCG/2021/28), framed by the Multiannual Funding of R&D Units (UIDB/01662/2020), and supported by the Portuguese Foundation for Science and Technology (FCT)/Ministério da Ciência, Tecnologia e Ensino Superior (MCTES) through national funds (PIDDAC). RG, BP, and MS are supported by a Ph.D. Grant (SFRH/BD/5099/2020; 2020.10167.BD; 2021.07006.BD, respectively) and sponsored by the Portuguese Foundation for Science and Technology. AG-Á is supported by the Portuguese Foundation for Science and Technology [Individual Call to Scientific Employment Stimulus – 3rd Edition 2019 – 2020.02059.CEECIND].

AM, AS, and IS are also supported by the Psychology Research Centre (PSI/01662), School of Psychology, University of Minho, through the Portuguese Foundation for Science and Technology by the Portuguese State Budget (Ref.: UIDB/PSI/01662/2020). The Center for Research in Neuropsychology and Cognitive and Behavioral Intervention (CINEICC) of the Faculty of Psychology and Educational Sciences of the University of Coimbra is supported by the Portuguese Foundation for Science and Technology and the Portuguese Ministry of Education and Science through national funds and co-financed by FEDER through COMPETE2020 under the PT2020 Partnership Agreement [UID/PSI/01662/2013].

ACKNOWLEDGMENTS

This paper arises from contributions provided through COST Action Riseup-PPD CA18138 (https://www.cost.eu/actions/CA18138/).

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.745767/full#supplementary-material

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