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From childbearing to childrearing: Parental mental health and infant development

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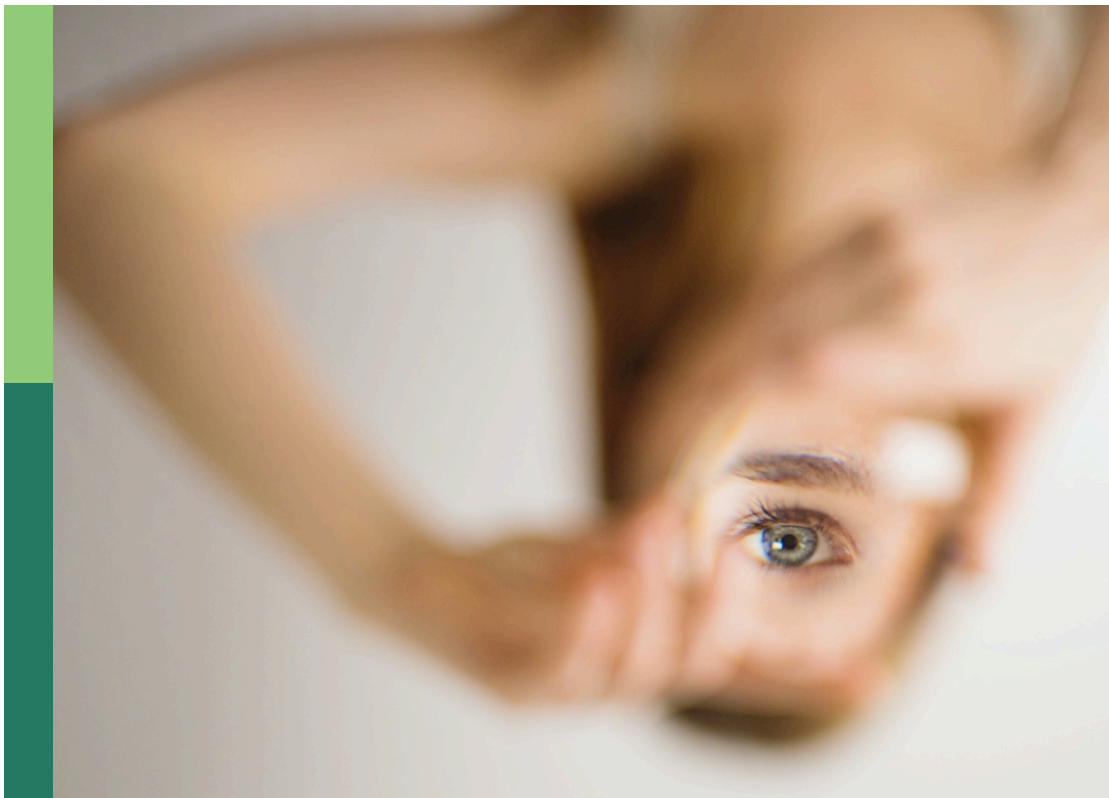

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From childbearing to childrearing: Parental mental health and infant development

Topic editors

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Editorial: From childbearing to childrearing: Parental mental health and infant development

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Editorial on the Research Topic
From childbearing to childrearing: Parental mental health and infant development

Every day, around 385,000 babies are born worldwide. Childbirth is culturally perceived as positive, yet it may be a challenging experience for mothers and fathers. It is estimated that up to one-third of parents have psychological difficulties during pregnancy and postpartum. These difficulties then often affect the relationships between the mother, co-parent, and infant. As the relationships and interactions with both parents are crucial for infant development, parental mental health difficulties may have adverse effects on the family dynamics and the infant. Furthermore, infant characteristics can also affect the relationships and interactions with their parents, making these interactions complex and important to investigate.

This Research Topic "From Childbearing to Childrearing: Parental Mental Health and Infant Development" presents 15 papers - 14 original quantitative studies and one narrative review - examining the associations between parental mental health and different parenting and infant outcomes. Of the original studies, two used experimental designs, six studies had longitudinal and six cross-sectional designs. All studies included mothers, and one study included both mothers and fathers. Regarding the geographical distribution of the papers, 10 papers were from Europe, one from North America and four were international collaborations between researchers from Europe, North America, and Asia. These are summarized below.

Maternal mental health in relation to infant behavior

Maternal mental health is intertwined with infant behavior problems. It was shown that mothers who report infant behavior problems also report more depression and anxiety symptoms and more mother-infant bonding problems in the first 6 months (Frankel et al.; Power et al.). However, this was established in cross-sectional studies, so the causality cannot be confirmed. Nevertheless, in a longitudinal study with mothers of preterm infants, maternal perception of the low infant self-regulation at 3 months predicted maternal depression symptoms at 6 months (Kmita et al.). Therefore, a bi-directional association between maternal mental health issues and infant behavioral or temperamental problems is probable.

Furthermore, it was reported that postpartum depression was related to the infant feeding method. However, no specific type of infant feeding method was a risk factor for postpartum depression *per se*. Other maternal experiences and infant-feeding cues played an important role for breast- and formula-feeding mothers (Kossakowska and Bielawska-Batorowicz). Mental health was intertwined with sleep, where poor sleep quality was both an antecedent and a consequence of impaired mental health. Mothers can be especially at risk because Sánchez-García et al. showed that mothers with children younger than 2 years had more disrupted sleep compared to the control group (women with children older than 6 years or no children). Mothers of infants were more likely to wake up more often during the night, report lower sleep quality, and sleep fewer hours, although different aspects of maternal sleep improved with infant's age.

Parent-infant bonding as an aspect of parenting

Several papers looked into different predictive mechanisms for parent-infant bonding. First, Kalfon Hakhmigari et al. found a possible intergenerational mechanism where maternal recollection of her own parents' parenting was associated with maternal insecure anxious adult attachment style, which was in turn associated with poorer mother-infant bonding two months after childbirth. Other studies focused on parental mental health as a predictor of parent-infant bonding. It was found that fear of childbirth during pregnancy was predictive of a negative birth experience assessed two months postpartum, which was, in turn, predictive of poorer mother-infant bonding at 14 months (Seefeld et al.). The next two studies were consistent with this, showing that both postpartum depression and anxiety were associated with worse bonding. In this association, parental responsiveness had a mediating role in mothers and fathers (Nakić Radoš), while self-criticism was especially detrimental to mother-infant bonding in women with a history of depression or anxiety (Beato et al.). Therefore, it seems that some personality traits have a modifying role in these multi-layered associations.

Parental mental health and infant outcomes

Maternal adverse experiences during her own childhood predicted more toddler emotional problems through their effect on maternal posttraumatic stress disorder (PTSD) symptoms (Ribaudo et al.). Also, maternal PTSD before or during pregnancy was associated with impaired peripartum mental health. Moreover, if mental health problems were comorbid with postpartum depression, mothers reported more feeding and sleeping problems in infants (Martini et al.). Maternal trait anxiety during pregnancy was associated with some infant development outcomes at 12 months (Jeličić et al.). An experimental study showed that exposure to acute maternal stress, measured with the experimental Caretaker Acute Stress Paradigm (CASP), affected infant autonomic nervous system regulation and behavior (Mueller et al.). Another experimental study with a longitudinal design showed that micro-temporal dyadic interaction patterns during the Still-Face paradigm in mid-infancy and maternal anxiety diagnosis predicted the development of insecure attachment in children aged 12–24 months. Moreover, an insecure attachment was associated with hormonal regulation in children at preschool age, showing a higher cortisol level during the stress paradigm compared to the children with secure attachment (Müller et al.).

Interventions for parents and children

The final two papers dealt with early interventions for parents with infants and toddlers. Infant mental health treatment provided at home, on a weekly basis, to parents who reported depression symptoms, parenting stress, or a child's behavioral problems resulted in more positive socioemotional wellbeing of the child (Ribaudo et al.). Stolper et al. provided a narrative review of reviews and meta-analyses of interventions for parents with psychopathology aiming at disrupting the intergenerational transmission of psychopathology. The review first categorized risk and protective factors during the peripartum period into parental, family, child, and environmental domains. The review concluded that no universal intervention for prevention would work for all different families and settings. Instead, effective interventions should be individually tailored, focused on resources, addressing changeable risk factors by using different ways of delivery (individual, dyadic or group).

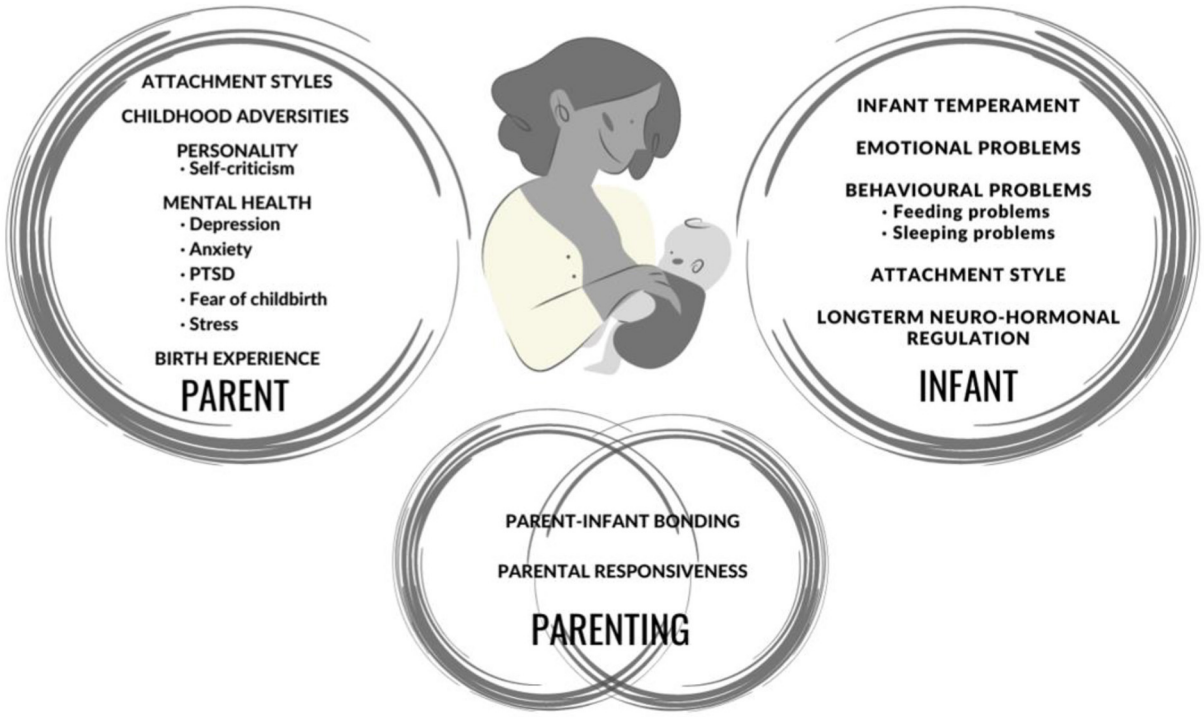

FIGURE 1
Schematic overview of the constructs examined within the Research Topic. (Figure created in Canva).

Gaps in the knowledge and directions for future research

The papers in this Research Topic and overview of the different variables measured in these studies in Figure 1 illustrate the need for greater consideration and understanding of the complexity of relationships between maternal, infant and parent-infant factors. These include pre-birth factors, such as maternal childhood adversity and health; epi-genetic factors, such as the intergenerational transmission of trauma; birth factors, such as complications and trauma; early environment; and ongoing parent-infant and parent-child interactions.

Theories are important to underpin and guide this research, particularly when trying to understand complex relationships such as those between parental mental health and infant outcomes, as well as inter-dependent outcomes, such as attachment style and infant emotional or behavioral problems. Relevant theories that have been applied to this area include the biopsychosocial approach (Blount et al., 2021), which encourages consideration of biological, psychological and social factors in maternal and infant outcomes. The importance of taking a biopsychosocial approach is evidenced by research showing the brain basis of early parent-infant interactions (Swain et al., 2007); intergenerational transmission of trauma (Bowers and Yehuda, 2016), and influence of stress during pregnancy on neonatal behavior (Rieger et al., 2004). An updated dynamic biopsychosocial model needs to be extended to consider the dynamic nature of systems that influence our health. The updated dynamic model proposes that health outcomes are due to reciprocal influences of biological, psychological, interpersonal and macrosystem contextual dynamics (Lehman et al., 2017). It also considers how these influences may vary for different individuals over time. This seems particularly relevant to understanding the complexity of parent and infant interactions and outcomes over the course of infant and child development.

Methodologically, a biopsychosocial or multi-system approach requires multi-method, whole family, longitudinal studies that recognize the importance of the father/partner and couple's relationship (whether co-habiting or separate) in infant outcomes and development (Bergunde et al., 2022). It would also be useful to widen this to include co-habiting family members such as step-parents or grandparents, which was highlighted by a review of risk factors for child maltreatment (Ayers et al., 2019). More large longitudinal cohort studies are therefore needed in this area, such as the Dresden

study on parenting, work, and mental health (Kress et al., 2019) and planned UK Early Life Cohort Study (Early Life Cohort, 2020), which provide multi-method, whole-family, longitudinal birth cohort studies. Such studies have the potential to generate a wealth of knowledge and understanding of biopsychosocial factors associated with infant outcomes and child development.

Also, common with research in other areas, the majority of research in perinatal mental health and infant outcomes is from high-income Western countries where samples are skewed toward White women, well educated, and higher income families, even when the population is more diverse. Thus, it is important to address gaps in knowledge in relation to minority groups and diversity.

In conclusion, this Research Topic presents a range of papers covering different aspects of the relationship between parental mental health and infant development, as shown in Figure 1. It highlights the complex dynamic systems and context, which are likely to influence infant development, and has identified ways in which future research can examine this to increase our knowledge and understanding.

Author contributions

SNR initiated the Research Topic. SNR, SA, and AH were topic editors and wrote the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.

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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ORIGINAL RESEARCH
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The Relationship Between a Baby's Age and Sleepiness in a Sample of Mothers

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One question of great practical importance for the parents, and especially the mother, after the birth of a baby, refers to how long the time during which they have to go with less and more fragmented sleep actually lasts. Most of the studies only explore this issue up to 6 months of the newborn's life, and less is known about the sleep problems the mothers may have after this initial period. The objective of this study is to examine the relationship between the sleep disruption and daytime sleepiness of mothers with infants until 2 years old compared to a group of women currently not at care of babies. To this end, a sample of 113 women, 67 currently bringing up a baby of under 2 years old, and the remainder without a baby at their care under 6 years old, reported sleep duration, sleep interruptions, sleep quality, and responded to questionnaires of sleep quality and daytime sleepiness. The relationship between the age of the children and the comparison between the groups was used to highlight the sleep problems of the mothers taking care of the infant. The results showed that there was a positive relationship between the age of the infant and the duration of the sleep of the mothers and that the duration of sleep for them was similar to those of the women in the control group about 6 months after the infant was born. However, fragmentation of sleep, daytime sleepiness, and sleep problems were still higher than in the control group for mothers with children between 6 and 12 months old.

Keywords: motherhood, fatigue, sleepiness, baby, age, developmental psychology

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1. INTRODUCTION

The birth of a child marks the beginning of a new phase in the lives of both parents, particularly for the mother. Throughout the first months in the life of a baby, the mothers undergo numerous changes, psychological, physiological and behavioral, and although these are partly understood, there are aspects to them that deserve to be studied in depth.

One question of great practical importance refers to how long the time during which mothers and fathers have to go with less and more fragmented sleep actually lasts. "Will this go on for 1 month, two, or even longer?" is something they often ask themselves. The reason for this is that, if an answer was available, parents could make crucial decisions, such as whether to call in extra help, return to work, carry on studying etc. What is more, when any positive expectations regarding maternity (among which is usually found the hope that the children "will sleep well" from an early age) are left unfulfilled, this leads to feelings of frustration. Nevertheless, given that this information usually comes from informal sources, such as friends, family or other parents of newborn children,

it may often be positively distorted and give rise to expectations that are not realistic. This is why it may be of great value to determine the length of this time objectively so as to be able to offer help to those who are going through this very situation enabling them to face up to it as best they can.

One estimation of the time that it may take the parents to return to their previous sleep patterns has usually been based on the postpartum, the duration of which is usually established as lasting for the first 6 months of a baby's life. It starts with the birth and the expulsion of the placenta-responsible for the secretion of many hormones that may alter the normal rhythms-and continues during lactation and until the child's sleep follows some predictable sleep-wake cycle patterns (Lee, 1998). Research into maternal sleep deprivation is usually centered around this time. For example, in an exhaustive review, Hunter et al. (2009) only mention studies in which the newborns are under 3 or 6 months old (Quillin, 1997; Matsumoto et al., 2003; Signal et al., 2007), and most of the recent studies published on this topic still focus on this period (Creti et al., 2013, 2017; Tran et al., 2015; Kenny et al., 2020; Cattarius and Schlarb, 2021; Da Costa et al., 2021). However, two recent studies have broken this trend and have provided evidence regarding parent's sleepiness when the newborns are over 6 months. So, Sivertsen et al. (2015) interviewed women 2 years after postpartum and found that "a large proportion still fulfilled the diagnostic criteria for DSM-IV insomnia," and Richter et al. (2019) examined changes in mothers' and fathers' sleep before pregnancy and the postpartum period of up to 6 years after birth and observed that, for the first childbirth, they had not yet fully recovered sleep satisfaction and hours of sleep at the end of the study. However, these studies use interviews set at specific points so that they do not provide fine-grained information about how the sleep indicators change in relation to the age of infants.

Although it is true that the internal factors determining the sleep-wake cycle in children do develop between 3 and 6 months of age and that mothers tend to sleep more as the child develops, focusing on this period of postpartum overlooks the fact that there other external factors that affect the mothers well-being: the style of child-rearing, for instance, whether the parents and child co-sleep, the type of lactation, the general organization of the household, the work outside the home, etc., all of these factors may continue to alter a mother's normal sleep rhythms. Moreover, it should not be forgotten that even after the children have managed to achieve an acceptable sleep rhythm, the mothers may still find it difficult to get enough sleep due to psychological problems that may arise associated with the pregnancy and the perinatal period (Fallon et al., 2016). That said, since there is evidence that sleeping habits —including the time people normally go to bed, the time they get up, and the time that passes between these moments— vary according to country and gender (Walch et al., 2016), it is of interest to evaluate whether the abovementioned results are reproduced in Spanish samples.

There are several milestones in the development of children after the 6 months of birth that may contribute to reducing the burden of the parents associated with caring for them. At 10-month postpartum the child's language begins to develop; at 14 months postpartum, the child is able to walk, to explore the environment, and attachment behavior is at its peak (Prenoveau et al., 2017). At 24 months old the children are more independent, have sufficient language skills to communicate with others which helps to manage their negative emotions, and can focus their attention away from stressful stimuli in order to manage their distress as well as to soothe themselves (Spinrad et al., 2004; Dennis, 2006). Thus, it seems of interest to extend the research of the sleep disturbances of mothers until at least the children are up to 24 months old.

There are several types of sleep disturbances that can affect the mothers such as sleep reduction, fragmentation of sleep, daytime sleepiness, etc. One well-identified problem is that of sleep deprivation, which is something common to mothers throughout the first months in the life of their baby (Hunter et al., 2009) and which is associated with the infant's nutrition, care, and sleep rhythm: since the sleep rhythms of the newborn are still not well-established and their need for nourishment, affection, cleanliness, and activity is not yet synchronized with the rhythm of the parents, both the mother and father are often sleep-deprived, in terms of both quantity and quality. This, in turn, may lead to there being many adverse effects on, among other things, their psychological and physical health, and their social relations (Moline et al., 2003; Sharma and Mazmanian, 2003). For example, Okun et al. (2018) found that symptoms of depression and anxiety in a group of 116 women were related to having poor sleep quality. Tham et al. (2016) found that poor subjective sleep quality during pregnancy was associated with borderline high postnatal depressive symptoms highlighting that the origin of the problem might be caused by disturbances that happen before birth delivery. Understanding and mitigating the impact of this sleep disruption is important for the health of the mother, as a large amount of wake after sleep onset and low sleep efficiency are predictive of postpartum fatigue severity and mood in general (Posmontier, 2008; Bei et al., 2010). New mothers usually do not expect the sleep disruption that they experience (Kennedy et al., 2007).

Disruption of sleep at night may cause daytime sleepiness, which may affect the daily activities of the mothers or turn into low productivity on the job and on accident rates, both occupational and non-occupational (Lee, 1998). At the beginning of the postpartum, mothers have less nighttime sleep and they spend a greater time awake following sleep onset (Gay et al., 2004), but it is sleep disruption rather than total sleep obtained that is more influential in daytime sleepiness (Insana and Montgomery-Downs, 2010). For instance, although Montgomery-Downs et al. (2010b) found that the quantity of sleep obtained by new mothers from postpartum weeks 2–16 was relatively consistent (7.2 h), the sleep quality improved over the same period due mainly to a reduction in sleep fragmentation and increase in sleep efficiency. However, this reduction in sleep fragmentation did not happen in the study of Filtness et al. (2014), as they did not observe significant differences in frequency of awakenings during nocturnal sleep between the weeks 6, 12, and 18, with averages of 1.9, 1.65, and 1.7, although they found differences in other indicators.

The objective of this study is to ascertain whether the quantity and quality of sleep in a sample of mothers of newborns in Spain

during the first 2 years of the baby's life differ from that of women of similar characteristics, but who are not raising a child, and to analyze whether any difference is limited to the first semester or carries on beyond this period.

2. MATERIALS AND METHODS

The design of this study corresponds to the description in Shadish et al. (2002) of a quasi-experimental post-test only study. Two groups (one treatment group and one control group) took part in the study, which was retrospective and questionnaire-based. The study consisted of obtaining answers from two groups of women to the questionnaires described in the measures section. Prior to the procedure, written consent was obtained from all of the participants for the aggregate use of the results for research purposes. This study was conducted following the guidelines set out by our institution.

To this end, a convenience sample of 113 women, 67 currently bringing up a baby of under 2 years old, and the remainder without a baby under 6 years old in their care, were interviewed as to a series of relevant variables related to the quantity and quality of sleep they usually enjoyed. The answers were assessed in order to evaluate the hypothesis that both the quality and quantity of sleep enjoyed by women with a baby in their care were reduced when compared to women who did not have a baby in their care during not only the first semester of the newborn's life but also the subsequent ones.

The participants were not furnished with any additional information on the study's objectives before their answers were registered. Once they had finished, the objective of the study was succinctly explained to them and they were compensated for the effort they had made in participating (30 €).

2.1. Participants

Women with babies in their care and willing to participate in a study into sleepiness were contacted while in the waiting room of a pediatrician, one of the co-authors of this article, located in a hospital in the city of Valencia. They were required to be between 25 and 50 years of age and to have no serious health problems. Additionally, their children had to be between 1 and 24 months old.

The women who had no babies in their care were firstly contacted in the pediatrician's waiting room but also through friends, relatives and workmates of the women who had already taken part in the study. The requirements for these women were the same as for the first group, except that they should not have children or that their children had to be at least 6 years old.

The total number of participants in the study was 113, of whom 67 met the requirements necessary to be classified as having children in their care. From now on, this sample will be referred to as "With infants" (for the women with babies in their care). The remaining 46 met the requirements needed to be classified as having no babies in their care and we shall refer to them as "Control" (for the women not currently with babies in their care).

2.2. Measures

Two types of variables were measured in this study: standardized questionnaires related to sleepiness and direct questions concerning night sleep. In addition, the demographic and behavioral variables of the participants were evaluated through *ad-hoc* questions.

2.2.1. Sleepiness Scales

Three scales were used to evaluate the mothers' sleepiness.

- General Sleep Disturbance Scale (GSDS): This scale (Lee, 1992; Shahid et al., 2012) was designed to evaluate the incidence and nature of sleep alterations in working women. The GSDS is a self-report, paper- and-pencil measure requiring 5–10 min for completion. The GSDS queries respondents regarding the frequency with which they've experienced certain sleep difficulties within the previous week. Respondents use an eight-point, Likert-type scale ranging from 0 (meaning "never") to 7 ("every day") to respond to each item. The GSDS is a 21-item scale initially designed to evaluate the incidence and nature of sleep disturbances in employed women. Questions pertain to a variety of general sleep issues, including problems initiating sleep, waking up during sleep, waking too early from sleep, quality of sleep, quantity of sleep, fatigue and alertness at work, and the use of substances to induce sleep. Researchers have suggested that individuals with an average score of three (averaged by number of items) on the GSDS should be considered at risk for sleep disturbance (following guidelines set in the Diagnostic and Statistical Manual of Mental Disorders). A psychometric evaluation of the scale carried out by Lee (1992) found an internal consistency of 0.88 for the whole scale. This scale was used in Sánchez-García (2017).
- Epworth Sleepiness Scale (ESS): This scale (Johns and others, 1991) was designed to evaluate daytime sleepiness by asking the respondents to evaluate the probability of falling asleep in eight different situations. It uses a 0–3 scale. Scores range from 0 to 24, with higher scores indicating a higher propensity for sleepiness and a score of >10 indicating excessive daytime sleepiness (Johns and Hocking, 1997). Each situation represents a moment of relative inactivity, from sitting down reading to sitting in a stationary car at a traffic light. The scale was validated using an adult population of between 18 and 78 years old. As far as its reliability and validity are concerned, it exhibits high internal consistency and good test-retest reliability Test-Retest Reliability of the Epworth Sleepiness Scale in a Sleep Clinic Population (Lee et al., 2018); it also correlates positively with the probability of falling asleep at the wheel (Maycock, 1997). The ESS is significantly correlated with sleep latency as measured by objective measures such as the multiple sleep latency test (MSLT) and overnight polysomnography (PSG), and it can detect changes following continuous positive airway pressure (CPAP) treatment (Johns and others, 1991). It remains one of the most widely used measures of habitual daytime sleepiness (Kaplan and Gasperetti, 2020).

- Karolinska Sleepiness Scale (KSS): The Karolinska Sleepiness Scale(KSS) is a single-item self-report measure of situational "state" sleepiness (Åkerstedt and Gillberg, 1990). This scale measures the subjective level of sleepiness state in the last 10 min. The KSS measures situational sleepiness and, therefore, is sensitive to momentary fluctuations that occur in short time periods. Individuals rate their current level of alertness on a 9-point ordinal scale (1 = "extremely alert," 5 = "neither alert nor sleepy," 9 = "extremely sleepy—fighting sleep"). The KSS is strongly correlated with time of day, and scores increase as the period of wakefulness extends (Kecklund and Akerstedt, 1993). The KSS is significantly correlated with electroencephalographic (EEG) and the psychomotor vigilance task (PVT), indicating that it is a valid measure of sleepiness (Kaida et al., 2006). This scale was used in studies into shift-workers and drivers and is useful to evaluate any changes in the response to environmental influences, circadian rhythm and the effects of drugs. In a validation study, Kaida et al. (2006) found a close correlation between electroencephalographic measurements and behavioral variables. KSS is indicated as a measure of momentary sleepiness (Kaplan and Gasperetti, 2020).

There are many scales for measuring sleepiness (over a 100 according to Shahid et al., 2012) and, as a consequence, choosing one over the others can be difficult—for a recent review of the pros and cons of 24 of these measures see Kaplan and Gasperetti (2020)—. The three scales mentioned before were chosen because they measured different aspects of sleep disruption. The GSDS asks mainly for nighttime sleep problems in the past week such as awakenings, use of alcohol or other substances for sleeping, and sleep satisfaction (Lee et al., 1991). The ESS instead is indicated for measuring habitual daytime sleepiness or average sleep propensity (Johns, 2008). Finally, the KSS asks for momentary sleepiness at the time of responding (Kaplan and Gasperetti, 2020). As the participants filled the questionnaires during the mornings, approximately between 10 a.m. and 1 p.m. the scores in the KSS can be taken as an indicator of sleepiness in the first part of the day.

2.2.2. Evaluation of Night Sleep

We mentioned in the introduction that disruption of sleep in mothers may happen in different ways: reduction of time and fragmentation of sleep being the most common. Fragmentation is the result of awakenings in response to noises made by the baby, that may involve getting off the bed in some cases. Also, mothers can be too alert during the night for deep sleep and experience a low quality in their sleep as a consequence. Nighttime number of hours of sleep is also important but it is common among mothers to recover some of the sleep lost with naps taken in the daytime. Researchers that have explored these aspects of maternal sleep have often used diaries in which mothers recorded the events related to sleep (Insana and Montgomery-Downs, 2010; Filtness et al., 2014). However, as our study was based on an interview we simply asked questions directly to the participants. The questions in our case were:

- How many times do you wake up during the night?
- How many times do you get up during the night?
- How would you rate the quality of your sleep? (Ratings from 1 = very bad, 2 = bad, 3 = normal, 4 = good, 5 very good)
- In total, how many hours do you sleep a night?
- The number of hours you sleep during the day (naps).
- The total number of hours of sleep: Unlike the previous questions, this was not asked directly but was obtained by adding up the answers to the previous two questions.

2.3. Data Analysis

For data analysis purposes, the scores from the scales were added up after inverting the negative items. The data were analyzed graphically (scatter and box plots), *t*-tests, and analysis of variance, using the correction for non-homogeneity of variance (Welch or Games-Howell). Post hoc comparisons were adjusted using the Holm's procedure. Significance was always evaluated at $p < 0.5$. All of the calculations were done and the graphs plotted using R (Team, 2020). There was a very small number of missing values, but given that the analyses were exclusively univariate, the impact was very limited.

The relationship between the age of the baby and the indicators of sleepiness is displayed graphically in **Figure 1**. This figure has a couple of plots per indicator, with a total of eight indicators corresponding to the three sleepiness scales plus the answers to the questions evaluating night sleep. The first plot of each couple is a scatterplot in which the age of the baby is set in the horizontal axis and the indicator is set in the vertical axis. As the relationship between the age of the baby and the indicators was found to be non-linear in many cases, we overimposed a non-parametric loess curve in all the plots to better visualize the relationship between the variables (Cleveland and Devlin, 1988). The second plot of the couple is a boxplot for comparing the two groups of women in our study: the control group (mothers without infants under 24 months old at the time of the study) and mothers with infants. Each boxplot shows overimposed the result of a *t*-test comparing the means of the groups in each indicator. As the scatterplots and the boxplots share the same vertical axis, it is possible to assess when the values of the scatterplot are over or under the median values of the indicators for the two groups of mothers.

Additionally, the mothers were grouped according to if their babies were <6 months old, between 6 and 12, 12 and 18, and 18 and 24 months old. ANOVA tests for each indicator among these four groups plus the women in the group control are shown in **Figure 2**. This figure has a plot per indicator, with five boxplots in each of the plots. Means are displayed with a black dot overimposed on the boxplot. Results of ANOVA tests are shown on the top of each plot. *Post-hoc* comparisons are shown overimposed on the plots with lines indicating pairs of groups whose mean were significantly different between them.

3. RESULTS

There are four parts in this section: Sample description in terms of demographic variables, description of sleepiness variables, comparison between groups of women and relationship with the

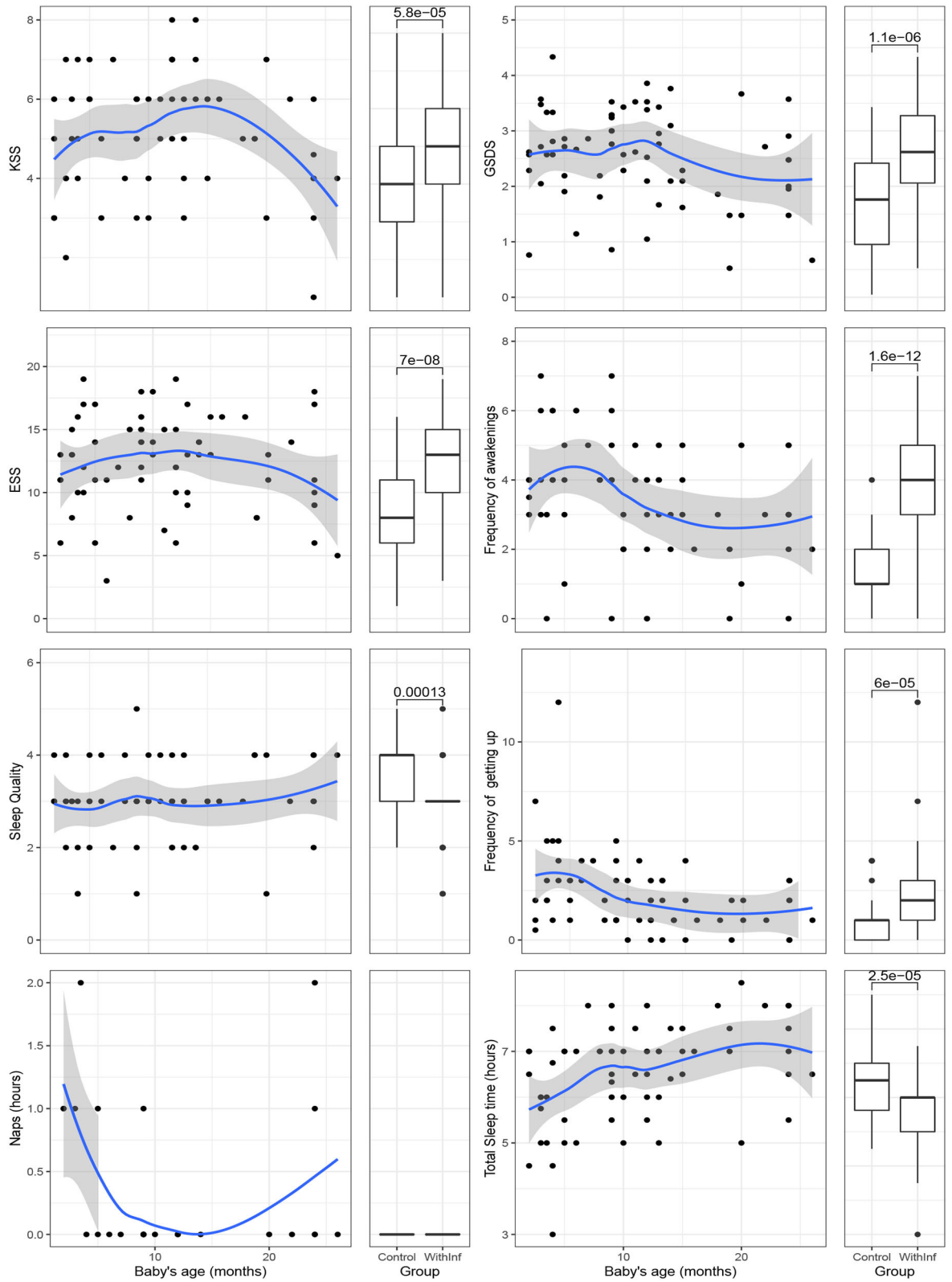

FIGURE 1 | Scatter plots showing relationship between sleepiness variables in mothers with babies of under 24 months old and the normal values of women without babies and box plots showing the same comparison.

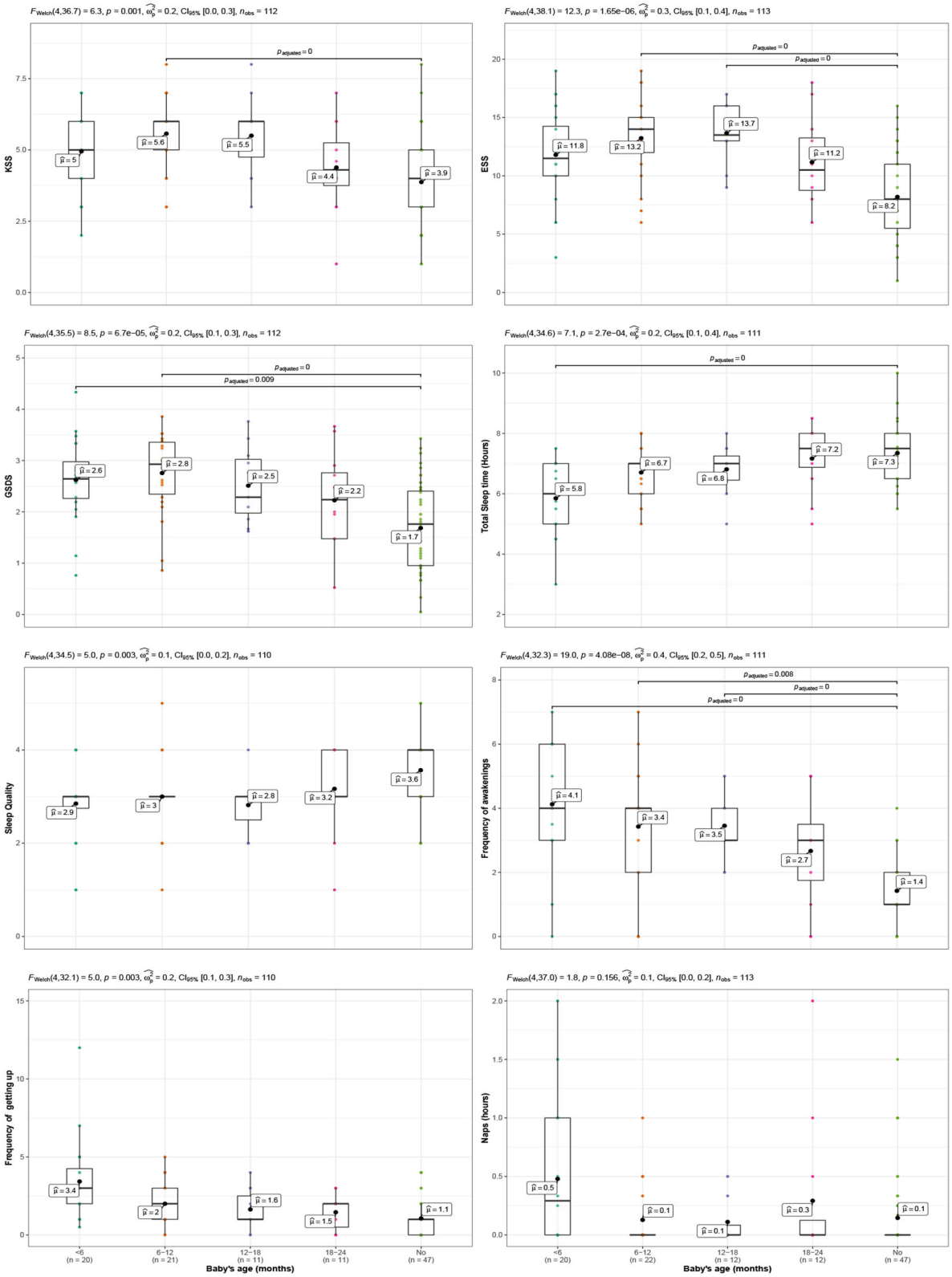

FIGURE 2 | Comparison of sleepiness variables in two cases: that of mothers of newborn babies, whose ages are split into four groups (groups <6 months old, 6–12 months old, 12–18 months old, 18–24 months old) and that of women who have not been mothers recently (No group). Each variable is shown in a panel and each of the panels includes information on the result of an ANOVA test, eta squared, its confidence interval, the sample size, and inter-group comparisons -only shown if significant- assuming unequal variances (Games-Howell) and adjusting for the number of comparisons using the Holm's method.

TABLE 1 | Description of the samples of women taking part in the study who did not have a baby of under 24 months old in their care when the study was carried out (Control) and of those who did (With Infants).

Descriptive variables	Total N		Control	With infant	Total	Stat	*p*
Age	111	Mean (SD)	36.9 (7.9)	34.6 (5.1)	35.5 (6.5)	1.8	0.061
Age of first child	87	Mean (SD)	12.4 (7.7)	12.6 (10.0)	12.6 (9.5)	−0.1	0.909
Married or equivalent relationship	111	Not	10 (22.2)	4 (6.1)	14 (12.6)		0.026
		Yes	35 (77.8)	62 (93.9)	97 (87.4)		
Unemployed?	113	Yes	9 (19.6)	17 (25.4)	26 (23.0)		0.622
		Not	37 (80.4)	50 (74.6)	87 (77.0)		
Currently employed or maternity leave	88	Full time	19 (51.4)	17 (33.3)	36 (40.9)	13.2	0.001
		Part time	18 (48.6)	19 (37.3)	37 (42.0)		
		Maternity leave	0 (0.0)	15 (29.4)	15 (17.0)		
Health problems	112	Yes	0 (0.0)	1 (1.5)	1 (0.9)		1.000
		Not	45 (100.0)	66 (98.5)	111 (99.1)		
Total N (%)			46 (40.7)	67 (59.3)	113		

p value corresponds to a mean difference t-test or a chi-squared test.

TABLE 2 | Descriptive statistics for the sleepiness variables.

Variable	Mean	*SD*	Min	Q1	Med	Q3	Max	Asimmetry	valid n	valid pct
Scales										
GSDS: Do you experience these problems when getting to sleep?	2.2	0.9	0	1.5	2.3	2.9	4.3	–0.2	112	99.1
ESS: What is the likelihood of you falling asleep in situation x?	10.7	4.2	1	8.0	11.0	14.0	19.0	–0.1	113	100.0
KSS: Level that reflects your state in the last 10 min.	4.6	1.6	1	3.0	5.0	6.0	8.0	–0.1	112	99.1
Questions about nigh sleep										
How would you rate the quality of your sleep?	3.2	0.8	1	3.0	3.0	4.0	5.0	–0.5	110	97.3
How many times do you wake up during the night?	2.6	1.8	0	1.0	2.0	4.0	7.0	0.4	111	98.2
How many times do you get up during the night?	1.8	1.7	0	1.0	1.0	3.0	12.0	2.3	110	97.3
In total, how many hours do you sleep a night?	6.7	1.1	3	6.0	7.0	7.5	9.0	–0.8	111	98.2
How long are your naps during the day (in minutes).	12.8	25.3	0	0.0	0.0	20.0	120.0	2.3	113	100.0
Total hours of sleep	6.9	1.1	3	6.3	7.0	7.5	10.0	–0.5	111	98.2

age of the baby, and comparison of women according the baby's ages groups.

3.1. Sample Description

Table 1 shows a comparison between the samples of the two groups of women participating in the study. As can be seen, the age of the two sample groups was similar. In the group without babies, the percentage of women who were married or in an equivalent relationship was slightly lower than in the group with babies, which is what could be expected given that women with infants are more often in a relationship than women without infants. It would be interesting to check the sleepiness of mothers without significant others supporting them but we only had 4 in our study so this was not possible in our case. The percentage of unemployed women (and, therefore, the opposite case, of women who were in a job when the study was carried out) was similar. Lastly, both samples of women were generally free from health problems except for one case, but after an in-depth analysis of this case we included her as the problem did not affect her day-to-day activity.

As this was a pilot study and the sample size was not large, we could not test the relationship between some of the demographic variables and the sleepiness of the mothers with infants.

3.2. Description of Sleepiness Variables

Table 2 shows the descriptives for the sample used in this study.

- GSDS: The mean is 2.2, below the threshold of three that is considered as at risk of sleep disturbance. The standard deviation is 0.9. The minimum value was one and the maximum is 4.3, and 50% of the scores lying between 1.5 and 2.9. This variable was very close to normal as its asymmetry is close to 0 (–0.2).
- ESS: The mean is 10.7, which is slightly over the threshold of excessive sleepiness (10). The standard deviation is 4.2. The minimum value is 1 and the maximum 19, and 50% of the scores lying between 8 and 14. This variable is very close to normal as its asymmetry is close to 0 (*Skew* =–0.1).
- KSS: The mean is 4.6 which is between the "Rather alert" and "Neither alert nor sleepy" categories of this scale. The

minimum value is one and the maximum is eight. This variable is very close to normal as its asymmetry is close to 0 (*Skew* =–0.1).

- Quality of sleep: The mean is 3.2 which is near the "Normal" category. The minimum is one and the maximum is five. This variable was is close to normal as its asymmetry is close to 0 (*Skew* =–0.5).
- Frequency of awakenings: The average frequency of awakenings was 2.6, with a minimum of zero and a maximum of 7. This variable is very close to normal as its asymmetry is close to 0 (*Skew* = 0.4).
- Frequency of getting up during the night: The mean was 1.8, with a minimum of zero and a maximum of 12. This variable shows positive asymmetry (*Skew* = 2.3) due to the outlier.
- Total hours of sleep by night: The mean was 6.7 h, with a minimum of 3 and a maximum of 9. This variable is moderately asymmetric (*Skew* = –0.8).
- Minutes of naps per day: The mean is 12, with a minimum of 0 and a maximum of 120 min. This variable shows positive asymmetry (*Skew* = 2.3).
- Total hours of sleep: This variable was computed summing the two previous variables. The mean is 6.9. The minimum is 6.3 and the maximum is 10. This variable is very close to normal as its asymmetry is close to 0 (*Skew* = –0.5).

As a whole, the data did not show special characteristics apart from one outliers in number of awakenings (7) and other in times getting up (12). Interestingly, some women got up from bed more times than they woke up by night, which can be interpreted as that despite of lying in bed they remained alert without actually falling slept.

3.3. Comparison Between Groups of Women and Relationship With the Age of the Baby

Figure 1 shows the comparison of the women in the group control with the mothers with infant babies (under 24 months old). We will comment on the figures from left to right, top to bottom:

- KSS: The mothers with infant babies with ages under 6 months old had scores near 5. Mothers with babies between 6 and 12 months old had higher scores than those with younger babies and older babies. Mothers with babies older than 12 months old had scores close to the group of mothers with infant babies under 6 months old and the relationship decreases for mothers with babies over 18 months old. The scores for the mothers in the KSS are over the median of the women in the control group except for mothers with children over 18 months old. The global differences between the two groups of women were significant [$\Delta M = -1.26$, 95% CI [$-1.85, -0.67$], $t_{(90.92)} = -4.22$, $p < 0.001$] with women in the control group having lower scores than mothers attending infant babies.
- GSDS: The scatterplot for the GSDS measure shows values between 2 and 3 for mothers with babies under 1 year old, which is below the score of 3, regarded as the threshold for problems of sleep, although the 95% interval of confidence band overimposed on the loess line includes this value during the first year. Then, there is a decrease in scores for mothers with babies over 12 months old but in average they are still higher than the scores of women without infants. The global differences between the two group of women were significant [$\Delta M = -0.84$, 95% CI [$-1.16, -0.52$], $t_{(97.37)} = -5.21$, $p < 0.001$] with women in the control group having lower scores than mothers attending infant babies.
- ESS: The scatterplot for the Epsworth questionnaire measure shows that the mothers with children have scores generally higher than the threshold of 10, which is regarded as the cut-off for sleep problems. The loess curve bends down for mothers with babies over 18 months old, remaining stable for children under this age. The global differences between the two group of women were significant [$\Delta M = -4.13$, 95% CI [$-5.53, -2.73$], $t_{(96.02)} = -5.84$, $p < 0.001$] with women in the control group having lower scores than mothers attending infant babies.
- Frequency of awakenings: Mothers with infant children under 10 months old reported waking up about four times per night, but those with children older than 10 months had only approximately three awakenings per night. The frequency of awakenings for mothers with 24 months old babies was higher than for women without infants. The global differences between the two group of women were significant [$\Delta M = -2.07$, 95% CI [$-2.58, -1.56$], $t_{(103.46)} = -8.03$, $p < 0.001$] with women in the control group having 1.41 awakenings in average vs. 3.48 awakenings of mothers.
- Sleep quality: The relationship between the sleep quality of the mothers and the age of their infants is close to zero as the loess line in the plot is almost horizontal. The global differences between the two group of women were significant [$\Delta M = 0.59$, 95% CI [$0.29, 0.88$], $t_{(104.95)} = 3.98$, $p < 0.001$].
- Frequency of getting up: Mothers get up by night more times when their infants are under 5 months old. One case stands out because one mother reported getting up 12 times per night. Mothers with children over 5 months old children drop the frequency in which they get up. The global differences between the two group of women were significant [$\Delta M = -1.21$, 95% CI [$-1.78, -0.64$], $t_{(100.64)} = -4.19$), $p < 0.001$], with women in the control group having an average frequency of 1.07 in the control group vs. a frequency of 2.27 in the group of mothers with infants.
- Naps: The naps that mothers took varied considerably among them. Two of them reported 2 h of nap and five reported 1 h but the majority indicated zero o close to zero nap time. No discernible relationship between the age of the infant and the nap duration was observed. Also, the differences between the women with and without infants were not significant [$\Delta M = -6.53$, 95% CI [$-15.54, 2.47$], $t_{(110.72)} = -1.44$, $p = 0.153$].
- The total sleep time: The total sleep time was calculated by summing the hours slept by night plus the naps. The relationship between the age of the babies and the total slept time of their mothers is positive and only bends down slightly once the children are 20 months old or over. However, at this point, the mothers slept about the same as the women in the

control group. The differences between the two groups were significant [$\Delta M = 0.79$, 95% CI [0.42, 1.16], $t_{(107.25)} = 4.25$, $p < 0.001$] with women in the control group having an average frequency of 7.34 in the control group vs. a frequency of 6.55 in the group of mothers with infants.

3.4. Comparison Between Babies' Age Groups

The results until here suggest that the mothers may experience sleepiness-related problems that last beyond 6 months, which is what is considered to be the moment when the babies should have regularized their sleeping habits, and consequently their mothers could return to previous sleep habits. In order to verify this hypothesis more accurately, the mothers with infants were split into four groups according to the age of their babies: from 0 to 6, 6 to 12, 12 to 18, and 18 to 24 months. The group of mothers without babies (Control group) was added to these four groups and comparisons were carried out between these five groups through ANOVAs and a posteriori comparison tests (assuming unequal variances and adjusting for the number of comparisons using the Holms method). The results are summarized in the eight panels of **Figure 2**, in which the upper part of each panel shows the result of the analysis of variance, the size of the effect, its confidence interval, and the number of cases used each time.

- KSS: The results of the ANOVA were significant [($F_{(4, 36.73)} = 6.34$), $p = 0.001$] with eta-squared equal to 0.2. The group of mothers with infants between 6 and 12 months old was different from the control group but any other group showed differences.
- ESS: The results of the ANOVA were significant [$F_{(4, 38.10)} = 12.28$, $p < 0.001$] with eta-squared equal to 0.3. The group of mothers with infants between 6 and 12 months old, and between 12 and 18 months old showed differences with the control group.
- GSDS: The results of the ANOVA were significant [$F_{(4, 35.46)} = 8.46$), $p < 0.001$] with eta-squared equal to 0.2. The group of mothers with infants between under 6 months old, and between 6 and 12 months old showed differences with the control group.
- Total sleep time: The results of the ANOVA were significant [$F_{(4, 34.62)} = 7.12$, $p < 0.001$] with eta-squared equal to 0.2. The *post hoc* comparison showed differences between the group of mothers with infants under 6 months old and the control group.
- Sleep quality: The results of the ANOVA were significant [$F_{(4, 34.49)} = 5.01$, $p = 0.003$] with eta-squared equal to 0.1 but its interval of confidence included 0 $CI = [0, 0.2]$. Also, the *post hoc* comparison did not show differences between any of the groups.
- Frequency of awakenings: The results of the ANOVA were significant [$F_{(4, 32.33)} = 18.97$, $p < 0.001$] and the eta-squared was equal to 0.4. All the groups of mothers showed significant differences from the control group except the one with babies between 18 and 24 months old.
- Frequency of getting up: The results of the ANOVA were significant [$F_{(4, 32.15)} = 4.99$, $p = 0.003$] with eta-squared equal to 0.2. However, the *post hoc* comparison did not show differences between any of the groups.
- Naps: The results of the ANOVA were not significant [$F_{(4, 37.01)} = 1.77$, $p = 0.156$].

4. DISCUSSION

The results have shown that mothers with infants have their sleep disrupted in comparison with a group of normal women. So, the mothers had higher scores with respect to nighttime sleepiness problems (GSDS), daytime sleepiness (Epworth), and current sleepiness (KSS). Also, they woke up more times per night, rated their sleep quality lower than the control group, got up more times, and slept fewer hours. Only the time employed in naps did not differ between the mothers and the control group.

The relationship between the sleepiness variables and the age of the infant was non-linear for many of the indicators. So, the nighttime sleep problems (GSDS), the daytime sleepiness (ESS), and the instant sleepiness (KSS) were at their highest point when the infants were about 10 months old. The frequency of awakenings was at its highest point when the children were <6 months, although it remained significantly different from the control group for mothers with children between 6 and 18 months old. The sleep quality ratings however did not show any relationship with the age of the infant, while the total hours of sleep increased almost linearly.

The results are consistent with previous research in several aspects. So, the reduction in sleep during the first months after birth is well established (Gay et al., 2004) and we have found it also in this study. Reduction of sleep after the first 6 months is less studied but (Sivertsen et al., 2015) found that the sleep duration and the time in bed of the mothers at 2 years postpartum were higher than at 8 weeks. Richter et al. (2019) also found that the reduction of sleep was significant after 1 year of birth respect to 1 year before pregnancy and only recovered partially, but not at levels before birth, after the second year. This result is not consistent with ours, as in our case the sleep duration of the mothers with 1 years old children was similar to the women not taking care of infant children but the different methodology (longitudinal study vs. cross-sectional) might lead mothers to provide the information in a different way. A sound methodological design would involve following two groups of women (with and without babies) during the same period of time so that comparisons within and between groups could be carried out.

We did not find a relationship between the rating of the quality of sleep and the age of the infant. Sivertsen et al. (2015) also did not find differences between the week 8 and the year 2 postpartum in two similar indicators (non-restorative sleep, and sleep dissatisfaction), but they found differences with pre-pregnancy levels. Richter et al. (2019) found that the first year was characterized by low levels of sleep satisfaction in comparison with years 2–6 but differences were not significant between 1 and year 2. So, in summary, it looks like the mothers' perception of an improvement in quality of sleep in mothers does not come probably until after the second year postpartum. This finding

should be confirmed with more studies that followed mothers for more than the 2 years limit used in this study.

That the subjective perception of quality of the sleep of mothers does not improve as quickly as the duration of the sleep has been connected with sleep fragmentation (Insana and Montgomery-Downs, 2010; Montgomery-Downs et al., 2010a). In our case, mothers with infant children had more awakenings than women without children with an average of 4 vs. 1. The peak of this problem occurred during the first 6 months of the postpartum period, decreasing afterwards. However, the average of awakenings was still well above of the women without infant children for all the groups of mothers with children under 18 months old. There were also significant differences in the frequency that the mothers got up during the night but no specific age of the children was identified as the cause of this difference.

One important consequence of sleep disruptions is the daytime sleepiness that mothers may experience. This sleepiness may reduce their performance in many tasks and may constitute a safety hazard in the job (Lee, 1992). Our results point out that the KSS, which is an indicator of the instant sleepiness, had its highest value when their children were between 6 and 12 months old. The Epworth daytime sleepiness was also significantly different for the mothers with children between 6 and 12 months and 12–18.

All in all, our study puts into question the assumption that any sleepiness-related problems a mother may have will be resolved by the end of the first semester of a baby's life. So, our results signal that the mothers with children of 12 months old are the ones with more sleep problems, interruptions, and daytime sleepiness despite that their sleep time is not at its worst.

There are several limitations to this study that we shall now comment on. Firstly, both the size of the sample and the method of gathering data mean that generalization to a the reference population cannot be ensured; so, this study should be considered as a pilot study which would mainly be of interest to lay the foundations for a wider-ranging study to evaluate the problems related with sleep-deprivation suffered by mothers of newborns in Spain. Secondly, the variables analyzed herein essentially refer to sleepiness and, although it is known that this is closely related to fatigue, either of which may occasionally be cause or consequence of the other, they should not be mixed up as there is at least one very important difference: fatigue may become chronic and not even rest may help a person to recover from it whereas sleepiness can be alleviated more quickly (Shen et al., 2006). Another limitation is related to the use of subjective measures, which could be substituted for more objective measures using actigraphy that recorded the sleep cycles.

Lastly, this study does not include a bigger number of variables which would help to understand why problems of sleepiness persist beyond the postpartum even though the initial reason, the baby's lack of maturity, should no longer represent a problem. Our recommendation, therefore, is that future research into sleepiness-related problems in mothers should enlarge the size of the sample, improve the sampling method and cover a broader spectrum of variables. Ideally, this research should be longitudinal, include a control group, and follow the evolution of the mothers both before and during the birth and throughout the child-rearing phase for as long as possible.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

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

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Anxious Attachment Mediates the Associations Between Early Recollections of Mother's Own Parental Bonding and Mother–Infant Bonding: A 2-Month Path Analysis Model

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Parental bonding (recollection of own parents' parenting), adult attachment, and mother–infant bonding are all closely related yet distinct concepts of the parent–child relationship, sometimes used interchangeably in the literature. This study aimed to examine the associations between these concepts in a longitudinal path analysis design. A total of 262 postpartum women who gave birth at the maternity ward of a large tertiary health center in Israel completed a demographic questionnaire, the Experiences in Close Relationships Scale (ECR), the Parental Bonding Instrument (PBI) at 1–4 days postpartum, and the Postpartum Bonding Questionnaire (PBQ) at 2 months postpartum. Parental care factor (PBI) was found to be associated with mother–infant bonding (PBQ), directly and indirectly through insecure anxious attachment (ECR). Denial of autonomy factor (PBI) was found to be associated with mother–infant bonding (PBQ) only through insecure anxious attachment (ECR). Encouragement of behavioral freedom factor (PBI) was found to be associated with mother–infant bonding (PBQ) in a simple correlation but not in the complete model. The results highlight the intergenerational aspects of parenting and suggest that early childhood interventions with parents may have a long-term impact on child-rearing though generations, and by that on children's development.

Keywords: mother–infant bonding, parental bonding, adult attachment, postpartum, childbirth

INTRODUCTION

Parental bonding, adult attachment, and mother–infant bonding are central concepts of the parent–child relationship (across generations) and are all related to children's development, growth, and wellbeing. These similar yet distinct concepts are sometimes used interchangeably in the literature while not clearly and consistently treated as different concepts (1–4).

In the present study, we aim to expand the understanding of the associations between these concepts by examining how parental bonding and adult attachment are associated with mother–infant bonding. Using a longitudinal path analysis design, we examine whether women's adult attachment orientations measured shortly after birth possibly mediate the associations between parental bonding (the new mother's recollection of the way she was mothered) and mother–infant bonding (her cognitions and feelings toward her infant) at 2 months postpartum. To our knowledge, this study is the first to describe the paths between these close yet different concepts using a longitudinal design.

Mother–infant bonding refers to the emotions and the feelings a mother has toward her infant and herself as a parent. Bonding is believed to emerge during pregnancy or immediately after birth (1). The quality of mother–infant bonding is considered central to infant wellbeing and the child's cognitive and emotional development (5, 6) and was found as an important factor in mothers' later relationships with their children (7–9). Postpartum bonding was found to be associated with a host of factors such as abuse in childhood, family psychiatric history, mother's psychopathology, as well as personality variables [e.g., (6, 10, 11)]. In this study, we focused on the possible associations of mother–infant bonding with the mother's caring model as evolving from her experiences with her own mother, experiences that may have shaped her internal working models of relationships—attachment orientations.

Although similar in name and conceptually closely related to mother–infant bonding, parental bonding refers to the way adults retrospectively report the quality of their parents' parenting, i.e., their childhood relationships and experiences with their parents (12). It was found that mothers' parenting history was associated with the quality of parenting they provide to their infants (13), as mothers who remembered being accepted by their mothers as children were more sensitive and less intrusive with their infants (14). On the other hand, lower recalled care in childhood by the own mother predicted higher dissatisfaction with overall own motherhood (15), while maternal experiences of emotional neglect in childhood were associated with more mother–infant bonding impairments (16).

The Parental Bonding Instrument (PBI) is a scale designed for assessing parenting style retrospectively. Despite its widespread use, there is no consensus regarding its factor structure (17). It was initially conceptualized and assessed as compromised from two factors, care and overprotection (12). However, recent studies reported a different factor structure [e.g., (17)]. In this study, we intend to verify the often reported three-factor structure of PBI: care (reflecting perceptions of the mother as warm and understanding), denial of autonomy (reflecting perceptions of the mother as controlling and overprotective), and encouragement of behavioral freedom (reflecting perceptions of the mother as granting autonomy) (11, 17–19). With regard to parental bonding and mother–infant bonding associations, mothers' perceptions of their child-rearing history (both care and overprotectiveness) were found to be associated with mother–infant bonding (20). However, a later study found that only higher overprotection measured during pregnancy was associated with bonding failure in the postpartum period (21). These findings underscore how the retrospective perception of parenting from own childhood may be relevant to the postpartum mother–infant relationship.

According to the Attachment Theory, early experiences with significant others are internalized and formulate working models that shape individuals' behaviors (22, 23). Those early relations create prototypes for later relationships with close others (24). Attachment with mother/primary caregiver, who can be sensitive and responsive to one's need or not be reliably available and supportive, contributes to the development of internal working models (25). These can mediate the relationship between mothers' early experiences to various aspects of current motherhood (3, 26).

Attachment and maternal–infant bonding refer to different aspects of the parent–child relationship, as bonding emphasizes the mother's tie to her infant, and attachment in general refers to the child's tie to his mother and other caregivers (1, 9). Several studies examined the association between those concepts with inconclusive results pattern. On the one hand, during the transition to motherhood, insecure attachment (anxious and avoidant) was associated directly with bonding difficulties among parents (27) and indirectly mediated by postpartum depression among mothers (28) or mediated by parenting stress (29). On the other hand, Van Bussel et al. (9) reported a weak correlation between mother–infant bonding and attachment style while maternal romantic attachment style predicted attachment with the fetus in the antenatal, but not with the baby in the postpartum period (30) and only women with a dual/disorganized attachment style reported lower bonding than with women with secure and insecure attachment styles (31). This inconclusive results pattern may be explained by the different measures used for attachment and bonding.

In this study, we refer to adult attachment orientations (32)—the internal working models of the mother herself. In order to examine these internal working models in adulthood, researchers focused on a *person's attachment orientation*, which is compromised from two dimensions: *attachment-related avoidance*, which reflects the extent to which a person mistrusts others' intention and therefore defensively strives to maintain behavioral and emotional independence, and *attachment-related anxiety*, which reflects the extent to which a person worries that others will not be available in times of need and anxiously seeks love and care (33).

Past research that examined the relationship between adult attachment and parental bonding during the transition to motherhood revealed that mothers' recollections of their own mothers as supportive and non-intrusive differentiated between securely and insecurely romantic attached participants (3). A recent study reported correlations between recalled care and overprotection in childhood (in opposite directions) and both anxious and avoidant attachment in a sample of pregnant women (15). These findings adhere to the results of several other studies that examined the relationship between parental bonding and adult attachment in diverse populations (2, 34–36). It should be noted that we were interested in the association of recollections of parental bonding and adult attachment orientation, rather than

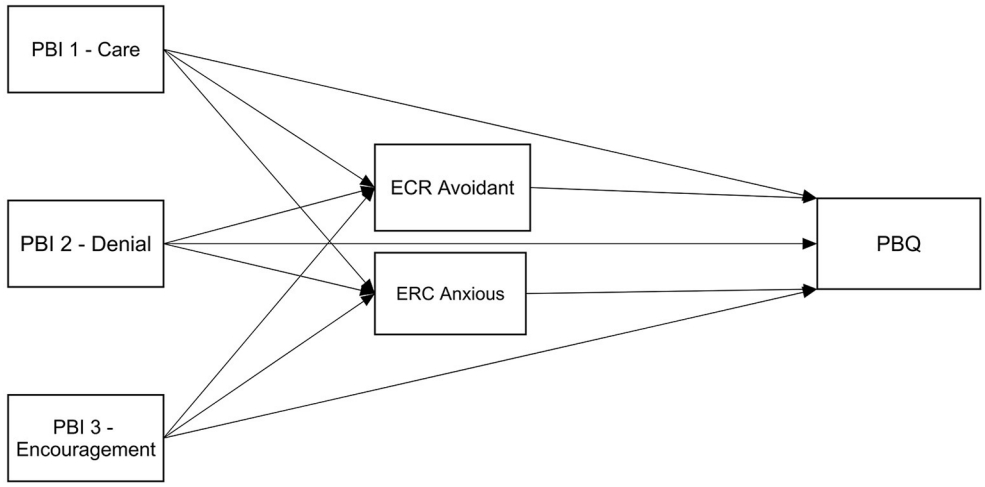

FIGURE 1 | Hypothesized mediation model; Insecure attachment orientations (ECR) will mediate the association between parental bonding (PBI) and mother-infant bonding (PBQ).

the association of parental bonding and attachment to the fetus or attachment behaviors that are often studied (28, 37).

This study aimed to examine the associations between parental bonding, adult attachment orientations, and maternal–infant bonding of postpartum mothers. Despite the review presented here, to the best of our knowledge, although close by describing parent–child relationships (inter-generationally), these are distinct concepts. Parental bonding refers to the way the mother (in our sample) recalls the relationship with her mother in childhood (12). Her adult attachment orientation refers to the way these recollections, among other factors, have shaped the working models she has for relationships with others in adulthood (33). Finally, mother–infant bonding refers to the emotions and the feelings a mother has toward her infant and herself as a parent (1).

We propose a model in which the mother's childhood recollections of her mother parenting her influence her bonding with her infant, and this association is mediated by her adult attachment orientation. While we study parental bonding and adult attachment orientations shortly after birth (along with other demographic and obstetric control variables), we measure their influence on mother–infant bonding at 2 months postpartum. Hence, we hypothesize that insecure attachment orientations (both anxious and avoidant) will mediate the association between recalled parenting by the mother and mother–infant bonding, as higher levels of parental bonding (PBI) will be associated with lower levels of anxiety or avoidance attachment orientation, which will be associated with better mother–infant bonding at 2 months postpartum (see **Figure 1**).

MATERIALS AND METHODS

Sample

The final sample included 262 postpartum women who gave birth in the maternity wards of the Rabin Medical Center (RMC), a large tertiary health center in Israel. Eligibility criteria included delivering at least at 37 weeks' gestation, a singleton pregnancy, and Hebrew speaking. Information about recruitment, data collection, and dropout rates can be seen in **Figure 2**. Comparing dropouts (women who completed only the first time point) to women who completed the second time point with sufficient data showed that completers were less avoidant (ECR) [$M = 2.5$, $SD = 0.9$ vs. $M = 2.8$, $SD = 1.0$, $F_{(1, 481)} = 8.6$, $p = 0.003$], lower in PBI denial factor [$M = 0.7$, $SD = 0.1$ vs. $M = 0.9$, $SD = 0.9$, $_{F(1, 540)} = 12.0$, $p = 0.001$], and older [$M = 32.0$, $SD = 4.7$ vs. $M = 31.0$, $SD = 5.4$, $F_{(1,587)} = 4.5$, $p = 0.035$]. In addition, primiparous women were less likely to complete the second time point (41 vs. 50%, $p < 0.001$), as were women with less than university educational level (38 vs. 53%, $p < 0.001$) and with below average income (43 vs. 56%, $p = 0.002$).

The average age of the participants was 31.7 (±4.8), most (94%) were married, 84% were born in Israel, and 92% were Jewish. Most women (76%) had vaginal births, 9% had elective cesarean section, 10% had emergency cesarean sections, and 6% had an assisted vaginal birth. Just over half of all women (53% of the whole sample, 61% if excluding women who had elective CS) were administered an epidural, and 43% (49% if excluding women who had elective CS) had oxytocin for labor augmentation. For participants' demographic data, see **Table 1**.

Procedure

The study is part of a larger longitudinal study aimed at understanding associations between factors associated with birth and postpartum mental health during the first 6 months postpartum conducted between July 2018 and July 2019. Ethical approval for this study was obtained from the RMC and the Academic College of Tel-Aviv Yaffo institutional review boards. Research assistants, graduate students with appropriate training in research ethics, approached all women at the maternity ward

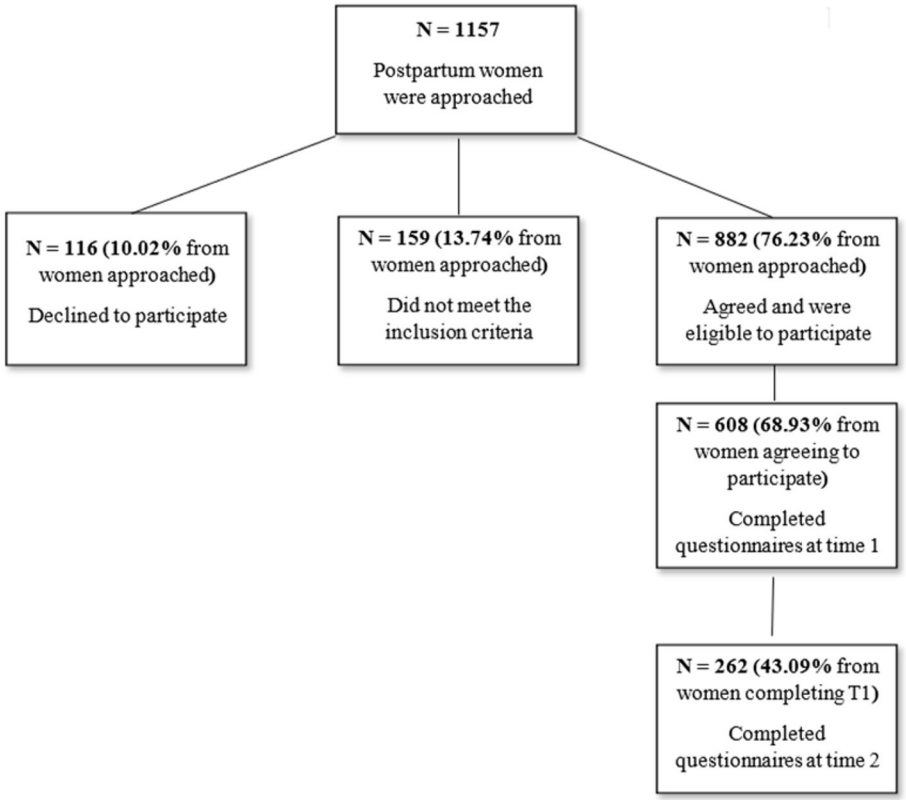

FIGURE 2 | Recruitment and data collection.

on a random day of the week, and after giving informed consent, the participants answered questionnaires at two time points:

T1 (1–4 days postpartum) in person at the maternity ward—obstetric data were taken from the medical files and women completed demographic questions, the Experiences in Close Relationships Scale (ECR) and the PBI.

T2 (2 months postpartum)—using online questionnaires, the participants completed the Postpartum Bonding Questionnaire (PBQ).

Participants who did not respond to the email invitation were reminded once with a phone call. Questionnaires and data output were generated using Qualtrics© 2015 (Qualtrics, Provo, UT, USA; http://www.qualtrics.com).

Measures

Sociodemographic Questionnaire

Sociodemographic questionnaire included questions about age, education level, marital/co-habiting relationship, income level (as compared to the national average per household at the time of the study), religious affiliation, country of origin, and the history or current existence of psychiatric disorders.

Obstetric Data

Obstetric data were extracted from medical records, recording number of previous births, infertility treatments, pregnancy risks, past abortions or miscarriages, and current birth data: type of birth as well as epidural and oxytocin administration. We treated "birth type" as a dichotomous variable for statistical reasons and according to relevant literature that claims that the importance of the birth type variable is whether it was expected or not (38–40). Thus, vaginal birth and elective cesarean sections are considered "Expected birth," while emergency cesarean section and vaginal assisted birth are considered "Unexpected birth." Being primiparous, having higher education, having above average income, being married, having a psychiatric diagnosis, and having an unplanned birth type were dummy-coded as "1" while other values were coded as "0."

Parental Bonding

Parental bonding was assessed with the PBI (12), a 25-item scale designed to measure retrospective recollections and perceptions of early parental attitudes and behaviors that has been widely used for assessing recollections of parent–child relations (41). We used the Hebrew version (42) and inquired only about recollections of mother's parenting. Participants were asked to rate the degree to which each item describes their mother's early behavior and attitudes, on a four-point scale, ranging from 0 (not at all) to 3 (very much). In order to verify the three-factor solution of the scale, we performed parallel analysis, a more accurate method for determining the number of factors in a set of items than the commonly used criterion of eigenvalue >1,

TABLE 1 | Sample demographic characteristics and correlations with PBQ score.

	N (%)	*M* (*SD*), Range	Correlation with PBQ
Age		31.7 (4.8), 20-43	0.03
Primiparous			0.22**
Yes	67 (26)		
No	195 (74)		
Higher education			0.14*
Yes	187 (71)		
No	75 (29)		
Income level			−0.05
Average or below	145 (55)		
Above average	112 (43)		
Unknown	5 (2)		
Marital status			−0.09
Married	246 (94)		
Not married	16 (6)		
Psychiatric diagnosis			0.26**
Yes	10 (4)		
No	252 (96)		
Unplanned birth type			0.18**
Yes	42 (16)		
No	220 (84)		

*$p < 0.05$, **$p < 0.01$.

TABLE 2 | Factor loadings for principal components analysis of PBI with Varimax rotation.

	Care	Denial	Encouragement
FACTOR 1			
Item 6 Was affectionate to me	**0.77**	0.07	−0.29
Item 11 Enjoyed talking things over with me	**0.74**	0.05	−0.22
Item 18 Did not talk with me very much	**0.73**	−0.19	−0.01
Item 12 Frequently smiled at me	**0.70**	0.03	−0.17
Item 1 Spoke to me in a warm and friendly voice	**0.69**	−0.06	−0.28
Item 17 Could make me feel better when I was upset	**0.69**	−0.05	−0.30
Item 5 Appeared to understand my problems and worries	**0.69**	0.04	−0.33
Item 4 Seemed emotionally cold to me	**0.64**	−0.19	−0.01
Item 24 Did not praise me	**0.62**	−0.31	0.00
Item 2 Did not help me as much as I needed	**0.58**	−0.13	0.16
Item 16 Made me feel I wasn't wanted	**0.55**	−0.32	−0.04
Item 14 Did not seem to understand what I needed or wanted	**0.52**	−0.47	−0.24
FACTOR 2			
Item 19 Tried to make me feel dependent on her	−0.14	**0.74**	0.07
Item 13 Tended to baby me	−0.09	**0.70**	0.06
Item 20 Felt I could not look after myself unless she was around	−0.17	**0.69**	0.04
Item 9 Tried to control everything I did	−0.24	**0.64**	0.28
Item 8 Did not want me to grow up	0.00	**0.59**	0.01
Item 10 Invaded my privacy	−0.20	**0.57**	0.36
Item 23 Was overprotective of me	0.16	**0.54**	0.19
FACTOR 3			
Item 22 Let me go out as often as I wanted	−0.09	0.06	**0.83**
Item 21 Gave me as much freedom as I wanted	−0.09	0.14	**0.82**
Item 15 Let me decide things for myself	−0.22	0.27	**0.72**
Item 25 Let me dress in any way I pleased	−0.08	0.08	**0.69**
Item 7 Liked me to make my own decisions	−0.11	0.25	**0.66**
Item 3 Let me do those things I liked doing	−0.36	0.04	**0.54**
Cumulative Explained Variance	**23%**	**52%**	**38%**

Item loadings in bold indicate the subscale in which the item was included.

which tends to extract too many factors (43). Parallel analysis indicated three underlying factors. Exploratory factor analysis using principal components analysis with varimax rotation provided a corresponding solution, almost identical to the factors found in a recent large population-based psychometric validation of the scale as well as other studies [see (17)] apart from item 3 that loaded in our study on the encouragement factor and in the mentioned research loaded on both encouragement and care and item 8 that loaded on the denial of autonomy scale in our study and on the encouragement factor in the mentioned study. These three factors were also found in our previous study of different sample (11). The three factors together explained 52% of the variance in the responses (see **Table 2**): (1) *PBI-Care*, reflecting perceptions of the mother as warm and understanding (12 items; $\alpha = 0.90$); (2) *PBI-Denial of autonomy*, reflecting perceptions of the mother as controlling and overprotective (7 items; $\alpha = 0.79$); and (3) *PBI-Encouragement of behavioral freedom*, reflecting perceptions of the mother as granting autonomy (6 items; $\alpha = 0.85$). Scores were computed by calculating an average for each subscale with higher scores reflecting stronger perceptions. The intercorrelations between the three factors were significant yet moderate (0.23–0.38), supporting their use as three separate factors (see **Table 2**).

Adult Attachment

Adult attachment was assessed by the ECR (44), which assesses the dimensions of anxious and avoidant adult attachment. For the purpose of the study, we used an abbreviated, validated Hebrew version that consists of 24 items divided into two dimensions: anxious (12 items, e.g., "I worry about being abandoned") and avoidant (12 items, e.g., "I feel discomfort when others get close to me") (45). Participants rated the extent to which an item described themselves on a seven-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree). A high score indicates higher anxious or avoidant attachment. This scale has been used in previous studies with postpartum women [e.g., (46, 47)]. In the current study, the internal reliability was good ($\alpha = 0.84$ for anxiety and $\alpha = 0.83$ for avoidance).

Mother–Infant Bonding

Mother–infant bonding was assessed by the Hebrew version of the PBQ (48, 49). This 25-item scale assessed the mother's feelings

or attitudes toward her baby (e.g., "I feel close to my baby"). Statements are presented on a six-point scale, ranging from 0 (always) to 5 (never), with reverse coding of positive items. Responses are summed so that higher scores denote **greater** bonding difficulties (poorer bonding). Two items relating to the risk of abuse were not included due to ethical considerations (50). Internal reliability of the total scale was good ($\alpha = 0.89$).

Statistical Analysis

Data were described as *M*(*SD*) and range or as counts and percentages. Correlations between the study variables were assessed using the Pearson correlation coefficient. Exploratory factor analysis for determining the factor structure of the PBI questionnaire used principal components analysis with varimax rotation. Items were assigned to factors on which their loading was 0.5 or higher. Path analysis with 1,000 bootstrap samples was used to test the mediation model. Data were analyzed using SPSS v.25 and AMOS v.25. Using the 15 observations per measured variable rule, we concluded that a sample of about 200 observations should be sufficient for testing our hypothesized model including possible covariates.

RESULTS

Table 1 shows the sample demographics as well as correlations between the demographic characteristics and the outcome variable. The correlations between the study variables, as well as their means and standard deviations, are shown in **Table 3**. All study variables significantly correlated with each other.

Given the correlations shown in **Table 1**, the hypothesized model was tested with being primiparous, education, psychiatric diagnosis, and birth type as covariates, linked to the study variables with which they had significant correlations. The results showed that birth type and the PBI Encouragement factor had no significant effects on any of the other model variables, and so were excluded from the model. The resulting model is shown in **Figure 3**. Results show that the model had good fit [$\chi^2_{(3)} = 1.95$, $p = 0.58$, NFI = 0.99, TLI = 1.04, CFI = 1.00, RMSEA = 0.00] and accounted for 25% of the PBQ variance. PBI Care factor had both direct [$\beta = -0.16$, $p = 0.02$, 95% CI = (-0.28, -0.02)] and indirect effects on PBQ, going through anxious attachment [$\beta = -0.03$, $p = 0.03$, 95% CI = (-0.08, 0.00)]. We found no direct effect of the PBI Denial factor on PBQ, yet we found an indirect effect through anxious attachment [$\beta = 0.04$, $p = 0.04$, 95% CI = (0.00, 0.10)]. While PBI Encouragement factor was significantly correlated with PBQ as can be seen in **Table 3**, this correlation diminished in the presence of the other factors in the final model. Avoidant attachment did not serve as a mediator despite its correlations with the PBI factors and PBQ (see **Table 3**), as anxious attachment accounted for the mediation effect.

In sum, we learn that anxious attachment mediates the relationships between PBI factors (Care Denial) and PBQ: lower PBI care factor was related to higher ECR attachment anxiety, which in turn was related to higher PBQ score, resulting in a negative indirect effect. In contrast, high PBI denial factor was related to higher ECR attachment anxiety, which was followed by higher PBQ score, hence the positive indirect effect. In addition, in the final mode, PBI Encouragement factor was not associated with PBQ and avoidant attachment was not found to be a mediator between PBI factor and PBQ.

DISCUSSION

The current study aimed to examine the associations between parental bonding (PBI), adult attachment orientations, and mother–infant bonding (PBQ) among mothers, in a longitudinal design from childbirth to 2 months postpartum. Our findings indicate that parental bonding care factor was associated with mother–infant bonding both directly and indirectly through anxious attachment, while parental bonding denial of autonomy factor was associated with mother–infant bonding only indirectly through anxious attachment. The third factor, parental encouragement of behavioral freedom was associated with bonding in a simple correlation but was not associated with mother–infant bonding in the complete model. Additionally, parental care and parental denial of autonomy factors were associated with avoidant attachment, though avoidant attachment was not associated with mother–infant bonding. The study findings contribute to the existing literature in several aspects. First, our findings emphasize that parenting models that new mothers have absorbed from their mothers may have shaped their internal working models and, through those, but also directly, may be associated with the way they perceive their bond with their new infant. In particular, we found that childhood recollections of mothering that lack warmth and understanding or are characterized as controlling and overprotective may be associated with higher levels of anxious attachment orientation, which in turn may increase mother–infant bonding difficulties. Our results are in line with previous findings that emphasize that parents' recollections of the way they were parented are important to their postpartum parenthood mental health and psychological wellbeing (51–53). This intergenerational perspective emphasizes that early childhood caretaking experiences of mothers may continue to compromise the mother's capacity to cope during her own parenthood (20) through her internal working models and the bond she perceives with her new infant (28). This finding is of importance as the quality of the maternal infant relationship postpartum, and in particular mother–infant bonding, is considered central to infant wellbeing, cognitive and emotional development, and adaptation throughout life (54–56).

In addition, the findings contribute to the literature regarding the PBI factor structure by replicating the PBI's three factors structure as reported in recent studies [e.g., (17)]. Our study results put a spotlight on parental care, which was the only factor associated directly and indirectly through anxious attachment with mother–infant bonding. It emphasizes parental care as a possible distinct concept from the other two PBI factors (vis-à-vis bonding) and in line with previous studies that report parental care as a clear, cohesive, and stable factor (18, 41, 57). We suggest that anxious attachment orientation may explain the association between parental care and bonding, but our model

TABLE 3 | Descriptive statistics and Pearson correlations between the study variables.

	2	3	4	5	6	*M* (*SD*)
1. PBQ	−0.24**	0.25**	0.17**	0.24**	0.32**	0.4 (0.4)
2. PBI factor 1: Care		−0.23**	−0.37**	−0.31**	−0.27**	2.6 (0.5)
3. PBI factor 2: Denial			0.35**	0.22**	0.33**	0.9 (0.5)
4. PBI factor 3: Encouragement				0.15*	0.23**	0.7 (0.6)
5. Avoidant attachment					0.51**	2.5 (0.9)
6. Anxious attachment						2.6 (1.1)

*$p < 0.05$, **$p < 0.01$.

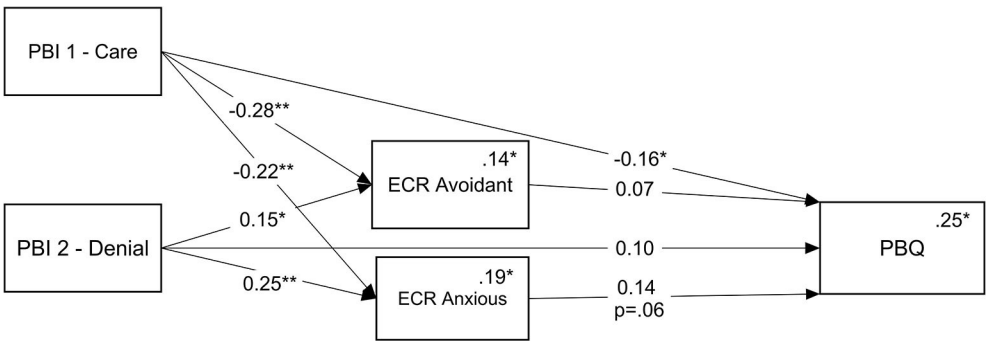

FIGURE 3 | Final mediation model; ECR (anxious attachment orientation) mediating the association between PBI factors (parental bonding care and denial of autonomy) and PBQ. *$p < 0.05$, **$p < 0.01$. While not shown on the graph, this model was analyzed with being primiparous, education, and having a psychiatric diagnosis as covariates. Numbers above the lines are standardized regression weights, and numbers above the endogenous variables and multiple squared correlations.

also alludes to the possible direct association between parental care and mother–infant bonding. It underscores parental care as a significant variable in parenting (15) and as meaningful during the transition to parenthood (11).

In the complete model, the second PBI factor, parental denial of autonomy, was related to mother–infant bonding only through anxious attachment. This finding adds to the literature regarding this factor role, as a previous study found an association between parental denial of autonomy and maternal–fetal attachment (11). The third factor, parental encouragement of behavioral freedom, was not associated with mother–infant bonding in the model. Thus, the third factor, which is relatively new, is yet to be studied with relation to other variables in general and parenting in particular.

Although we hypothesized that both insecure attachment orientations (anxious and avoidant) would mediate the associations between parental bonding and mother–infant bonding, the results indicated differential mediation; only anxious attachment mediated this association in the overall model. It is important to note that we found a simple correlation between anxious as well as avoidant attachment orientations and mother–infant bonding while both parental bonding care and denial factors were associated with both anxious and avoidant attachment orientations. In general, our findings adhere to the literature linking insecure attachment orientations and parenting variables (58) and emphasized that insecure attachment has an important role during the transition to parenthood (59). Our findings demonstrate adult attachment and maternal–infant bonding as different aspects of the intergenerational perspective of parent–child relationship, as adult attachment orientations refer to the internal working models of relationships in adulthood and mother–infant bonding refers to the mother's tie to her infant (1, 9). However, various studies investigating the specific associations of avoidant and anxious attachment orientations and mother–infant bonding report inconsistent findings, similarly to our findings. For example, only avoidance was a significant predictor of mother–infant bonding when controlling for demographic variables and maternal mental health history (29). In another study, there was no direct relationship between attachment and mother–infant bonding; however, anxious attachment was associated with postpartum depression, and depressive symptoms predicted impaired bonding (30). Other studies investigated associations between other attachment orientations (secure attachment and dual/disorganized attachment) with bonding [e.g., (27, 31)]; therefore, more research is clearly needed to elucidate the role of the different insecure attachment orientations vis-à-vis parenting in general and the mediation of the association between parental bonding and mother–infant bonding in particular. Our model suggests that the way mothers report about the mothering they have received in childhood retrospectively may shape their anxious and avoidant orientations, but only anxious orientation was found to have a significant association with bonding to the infant in our model.

Although our study was in a longitudinal design using a relatively large sample, it is not without limitations. First, the study participants were mothers asked to report their childhood recollections of the way their mothers cared for them. Further research is needed both regarding fathers and memories of parenting experiences with fathers. Furthermore, the PBI is a self-report measure of parental bonding reported retrospectively that might be influenced by recall biases, though parental bonding recollections as measured by the PBI exhibited stability over a 20-year period, suggesting that recall biases of parental bonding may be modest (60). Second, in this study we used only self-report measures. Future research could use observational measures of attachment or mother–infant interactions as well as study the participants' mothers and infants to further learn about intergenerational perspectives in more ecological designs. Third, we measured our variables in the first 2 months' time frame, while future research could study parenting perceptions in longer periods after childbirth. Fourth, there was a difference between the first time point assessment that was done in-person and the second time point that was done online, causing a potential confounding. This difference in assessments is a result of following up on a fairly large sample. Recent research of offline vs. online assessment of the PBQ found no difference between assessment modalities in terms of associations with sociodemographic, reproductive, obstetric, and psychological outcomes (61). Lastly, our participants were mostly Jewish, sampled from one health center only, and this may impair our ability to generalize our findings, as parenting practices may be different across cultures.

In conclusion, the present study examined the associations between the close yet distinct concepts of the parent–child relationship: parental bonding, adult attachment orientations, and mother–infant bonding. Our findings demonstrate the associations between those three separate concepts in a longitudinal design, as our model emphasizes that parenting models mothers have received from their mothers may shape their internal working models and those in turn were associated with the way they perceive the bond with the new infant. These findings highlight the intergenerational conceptualization of parenting (62) and emphasize that early childhood interventions with parents might be significant for a long-term impact on the development of future generations.

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 Rabin Medical Center and the Academic College of Tel-Aviv Yaffo institutional review boards. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JH, MK, HK, and YP contributed to the conception and design of the study. MM-L and SL organized the database. SL performed the statistical analysis. MK and JH wrote the first draft of the manuscript. JH, MK, and YP wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Parental Sensitivity and Responsiveness as Mediators Between Postpartum Mental Health and Bonding in Mothers and Fathers

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Background: There is a lack of studies that examine the complex relationship between parental mental health, parental sensitivity and responsiveness, and parent-infant bonding. This study aimed to test whether parental sensitivity and responsiveness were mediators between postpartum mental health (depression, anxiety, and stress) and parent-infant bonding in mothers and fathers.

Method: Mothers (n = 427) and fathers (n = 170) of infants aged up to 1-year-old participated in an online study. The parents completed questionnaires on depression (Edinburgh Postnatal Depression Scale, EPDS), anxiety and stress (Depression, Anxiety, and Stress Scale, DASS-21). Parent-infant bonding was measured by Postpartum Bonding Questionnaire (PBQ) that has three components: Impaired bonding (PBQ1), Anxiety about care and parental distress (PBQ2), and Lack of enjoyment and affection with infant (PB3Q). Parental sensitivity was measured as the number of correct recognitions of infant facial expressions (City Infant Faces Database, CIFD). Responsiveness was measured as a self-report with two subscales of responsiveness and non-responsiveness (Maternal Infant Responsiveness Instrument, MIRI).

Results: The path analysis showed that the model had a good fit to the data. Parental sex was a significant moderator, indicating different paths in mothers and fathers. In mothers, responsiveness and non-responsiveness were significant mediators between depression symptoms and three dimensions of bonding. In fathers, only non-responsiveness was a significant mediator between anxiety and PBQ3. Although recognizing infant facial expressions directly affected PBQ3 in mothers (but not in fathers), it was not a significant mediator between mental health and bonding.

Conclusion: Higher levels of parental mental health problems (depression and anxiety) were associated with lower levels of parental responsiveness, which is, in turn, related to poor parent-infant bonding. Prevention and intervention programs should be offered for both mothers and fathers, focusing on postpartum mental health promotion and enhancing responsiveness in infant care.

Keywords: postnatal depression, anxiety, stress, responsiveness, fathers, mother-infant bonding, maternal sensitivity

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INTRODUCTION

Maternal sensitivity and responsiveness have been identified as crucial for secure infant attachment. Maternal sensitivity seems to be a stable maternal characteristic during infancy (1). It refers to the maternal ability to perceive the infant cues and signals, interpret them correctly, and respond to them timely and adequately (2–4). These iterative processes in mother-infant interactions are essential for infant development as infants learn that their actions affect the environment, especially the secure figure, which gives them a sense of efficacy. Consequently, an infant who feels secure will explore the environment more, which will increase their socio-emotional and cognitive competencies (2).

Shin et al. (5) pointed out that the conception of maternal sensitivity has changed over time. Based on their conceptual analysis, four aspects of maternal sensitivity have been pointed out. These refer to maternal sensitivity as (i) dynamic process, (ii) including reciprocal exchanges between mother and infant, (iii) contingent with infant's previous behavior, and (iv) including appropriate responses based on specific infant cues. Maternal responsiveness is one aspect of sensitivity (5) and refers to maternal prompt and frequent responses to the infant's cues about physical and emotional states (3).

Shin et al. (5) provided a conceptual structure of maternal sensitivity describing its antecedents, affecting factors and consequences. Antecedents are described as maternal identity or identification of self as a mother, and of course, the infant's needs and cues upon which mother will express her sensitivity. One of the consequences of maternal sensitivity is the development of secure mother-infant relationships and higher quality of infant-to-mother attachment. Indeed, there is a bulk of literature showing the association between maternal sensitivity and secure attachment in infancy (1, 6), early childhood (7), and young adulthood (6).

Bonding is sometimes erroneously used as a synonym with attachment (8–10). However, the former can be defined as the maternal feelings and thoughts about the infant (9, 11), while attachment refers to the relationship between the child and the parent and makes the child feel secured (12). Furthermore, the methods of measures differ between the two, with questionnaires to measure bonding (13) and the observational method of Strange Situation Task (14) as a gold standard to measure attachment. As a strong mother-infant relationship, bonding is considered crucial for postpartum development (15). A recent literature review has also shown that maternal sensitivity is sometimes used as a synonym for bonding (16). However, although these are different constructs, there is a lack of studies looking at maternal sensitivity and responsiveness in relation to mother-infant bonding.

As affecting factors on maternal sensitivity, Shin et al. (5) distinguished some positive, such as social support and high self-esteem, and negative factors, such as maternal depression, stress, and anxiety. Maternal mental health in the postpartum period can be seriously challenged, with one in three primiparous women having symptoms of depression, anxiety or stress (17). A recent meta-analysis revealed that around 17% of healthy women report postpartum depression (18) and 8–10% report one or more anxiety disorders (19, 20). Also, comorbidity between postpartum depression and anxiety has been established (21–23).

Poor parental mental health is one of the main risk factors for disrupted parent-infant interactions and may negatively affect bonding and attachment (24). Postpartum depression symptoms diminish the quality of bonding (25–28). However, there are inconsistencies in respect to anxiety and bonding. Namely, some studies showed that anxiety is associated with poor bonding (29), while other studies showed that this relationship is fully mediated by depression. Moreover, once depression was controlled for, anxiety was not associated with poor bonding anymore (28, 30). Nevertheless, one study showed that anxiety was associated with improved mother-infant bonding (31), which the authors attributed to the increased maternal sensitivity. Although, the other study with mothers with social phobia did not show the difference in sensitivity compared to healthy controls (32). A meta-analysis showed that maternal depression symptoms were associated with diminished sensitivity during the first postpartum year (33). However, inconsistencies concerning postpartum depression and responsiveness are evident, as well. It was shown that postpartum depressive symptoms were associated with lower levels of maternal responsiveness (34, 35), or no association was found (36). However, the latter was established in a small sample of mothers with preterm infants.

There is a lack of studies that examines the complex relationship between maternal mental health, maternal sensitivity and responsiveness, and mother-infant bonding. Furthermore, in previous studies, self-report measures of sensitivity and responsiveness or observation during mother-infant interaction have been applied. Although observation is preferred over the self-report measured, the former can also be jeopardized due to personal bias of observer, the difficulty of coding, and change of behavior in the presence of the observer. On the other hand, objective measures of sensitivity, such as facial expression recognition, has been rarely applied. Nevertheless, several new databases of infant facial expression photographs have been developed (37, 38), which could be used as an objective measure of maternal sensitivity. This kind of measures was proven to be sensitive for maternal mental health, as it was shown that, e.g., mothers with postpartum depression tended to rate negative infant faces more negatively (39). Also, previous studies have mainly addressed the quality of bonding as unidimensional, although measured with the Postpartum Bonding Questionnaire (PBQ) (40), which measures different aspects of bonding difficulties. Thus, the role of parental mental health and sensitivity should be examined concerning varying dimensions of bonding.

Finally, previous research on perinatal mental health problems or parental sensitivity has mainly focused on women, thus unjustifiably neglecting fathers (41, 42). Paternal role in the family functioning has substantially changed over the last several decades, with fathers becoming more involved and engaged nowadays (43). Although mothers are rated as more responsive to their preschool children needs than fathers (44), maternal and paternal sensitive parenting have comparable effects on children's cognitive ability (45). Furthermore, it was found that

parental sensitivity was a full mediator between parenting stress and child cognitive abilities and prosocial behavior in both mothers and fathers (46). Also, for parental sensitivity, the vital is the parental ability to mentalize a child's thoughts, emotions, and needs that drive their behavior, the so-called reflective functioning, is essential (47). It was shown that the paternal reflective functioning was associated with their toddler's distress, even after accounting for maternal reflective functioning, and it also buffered the adverse effects of low income (41), thus implying the importance of the father's sensitivity for child development. Furthermore, there is a growing body of literature on paternal mental health in recent years, with a meta-analysis showing that around 8% of fathers have postpartum depression (48). In a recent large study of fathers, several depression profiles emerged with substantial stability from pregnancy to 2 months postpartum, although the depression levels decreased in the perinatal period (49). Another meta-analysis showed similar maternal and paternal depression effects on parenting behavior where depressed parents express less positive and more negative behaviors toward their children (50). Also, postpartum mental health difficulties in fathers extend to anxiety and stress (51), with paternal stress mediating the effect of anxiety on father-infant bonding (51). Parent-infant bonding is similar in mothers and fathers, although fathers report less fear and higher emotional involvement with the newborn in the first days after delivery (52). However, studies that would encompass mental health, sensitivity and responsiveness, and parent-infant bonding in fathers, are still scarce, as well as the studies in mother.

Therefore, this study aimed to examine the mediational role of parental sensitivity and responsiveness in a relationship between parental mental health and parent-infant bonding in both mothers and fathers. Also, we wanted to investigate different aspects of mental health, including depression, anxiety, and stress, as the conceptual analysis (5) pointed out as the affecting factors on maternal sensitivity. Furthermore, we wanted to provide different measures of parental sensitivity, including both objective measures of infant facial expression recognition and a self-report measure of responsiveness concerning various aspects of parent-infant bonding. The hypothesis was that parental sensitivity and responsiveness would mediate the relationship between mental health and parent-infant bonding in mothers and fathers.

MATERIALS AND METHODS

Sample

A sample of mothers ($n = 427$) and fathers ($n = 170$) participated in the study. The inclusion criterium was having an infant of 1–12 months. The sample was predominantly married or cohabiting, highly educated, average to above-average self-reported socioeconomic status and lived in a city (**Table 1**). Approximately 60% of the sample had the first child.

The sample of mothers and fathers did not differ in marital status, education level, socioeconomic status, number of children, and psychiatric heredity (**Table 1**). However, mothers were on average 2.5 years younger than fathers [$M_{\text{mothers}} = 30.80$, $M_{\text{fathers}} = 33.19$, $t_{(595)} = 4.94$, $p = 0.000$] and less mothers than fathers were from the city larger than 100,000 citizens [mothers: 46.4%, fathers 57.6%, $\chi^2_{(2)} = 7.57$, $p = 0.0228$]. Also, more mothers reported psychiatric treatment during lifetime [mothers: 6.1%, fathers 1.8%, $\chi^2_{(1)} = 4.03$, $p = 0.0447$].

TABLE 1 | Sociodemographic data for the sample of mothers ($n = 427$) and fathers ($n = 170$).

	Mothers ($n = 427$)	Fathers ($n = 170$)	Comparison
	M (SD)	***M (SD)***	
Parental age (age)	30.80 (4.56)	33.19 (5.63)	**$t_{(595)} = 4.94$, $p = 0.000$**
Infant age (months)	6.55 (3.23)	6.15 (3.32)	$t_{(595)} = -1.34$, $p = 0.172$
	***n* (%)**	***n* (%)**	
Marital status			
Married or cohabiting	422 (98.8)	170 (100.0)	$\chi^2_{(1)} = 0.85$,
Separated/divorced/single	5 (1.2)	0 (0)	$p = 0.3579$
Education			
Secondary school	107 (25.1)	54 (31.8)	$\chi^2_{(2)} = 3.76$, $p = 0.1529$
College	62 (14.5)	27 (15.9)	
University or higher	258 (60.4)	89 (52.3)	
Socioeconomic status			
Below average	54 (12.7)	21 (12.4)	$\chi^2_{(2)} = 0.60$,
Average	214 (50.1)	80 (47.0)	$p = 0.7420$
Above average	159 (37.2)	69 (40.6)	
Place of living			
Village	74 (17.3)	29 (17.1)	**$\chi^2_{(2)} = 7.57$,**
City (<100,000 citizens)	155 (36.3)	43 (25.3)	**$p = 0.0228$**
City (more than 100,000 citizens)	198 (46.4)	98 (57.6)	
Number of children			
One	252 (59.0)	105 (61.8)	$\chi^2_{(2)} = 1.69$,
Two	119 (27.9)	39 (22.9)	$p = 0.4296$
Three or more	56 (13.1)	26 (15.3)	
Psychiatric heredity[a]	55 (12.9)	13 (7.7)	$\chi^2_{(1)} = 2.80$, $p = 0.0942$
Psychiatric treatment[a]	26 (6.1)	3 (1.8)	**$\chi^2_{(1)} = 4.03$, $p = 0.0447$**

[a]*Answer "yes". Bold font indicates statistical significance.*

Instruments

Edinburgh Postnatal Depression Scale [EPDS; (53)] is a self-report measure of depression symptoms after childbirth. It consists of 10 items with four options different for each item, rated from 0 to 3, out of which seven items are reversely scored. The total possible score ranges from 0 to 30. A higher score indicates a higher level of depression symptoms, and the recent individual patient data meta-analysis established 11 as a cut-off score (54). The EPDS was previously translated and validated in the Croatian perinatal population with a one-factor structure and Cronbach $\alpha = 0.86$ (55). In the current study, McDonald's ω coefficient was 0.86, respectively.

Depression, Anxiety, and Stress Scale [DASS-21; (56)] is a self-report measure with three subscales for depression, anxiety and

stress symptoms presented during the previous week. Each item was rated on a four-point scale (0—*Did not apply to me at all* to 3—*Applied to me very much or most of the time*). The scale was translated to Croatian (57). In the current study, a short version with 21 items (7 per subscale) was used, where the final score for each subscale is multiplied by 2 to be comparable to the full scale with a possible range from 0 to 42 where a higher score indicates a higher level of symptoms (56). The anxiety and stress subscales were used in the current study, with McDonald's ω coefficient of 0.84 and 0.88, respectively.

Maternal Infant Responsiveness Instrument [MIRI; (36, 58)] is a self-report measure of maternal responsiveness to the infant cues and perception of infant's response. The MIRI consists of 22 items rated on a 5-point scale (1—*strongly disagree* to 5—*strongly agree*), where a higher score indicates higher responsiveness. Six items are reversely scored. In the original study, a total score was calculated as a unidimensional construct, and the Cronbach's was α = 0.87–0.89 (36, 58). The MIRI was previously also administered in fathers, with = 0.88 (59). In the current study, to be comparable to both mothers and fathers, we excluded three items referring to the feeding items (e.g., *I believe I know when my baby wants me to feed him/her*). The CFA showed poor fit with the one-factor model [$\chi^2_{(152)} = 1624.12$, $p < 0.001$; $\chi^2/df = 10.69$, RMSEA = 0.127, SRMR = 0.100, CFI = 0.803]. Therefore, exploratory factor analysis was performed where the scree plot indicated two factors: positively framed items loaded onto one factor (Responsiveness) and reversely coded items loaded on the second (Non-responsiveness). The CFA was re-run testing the two model with better fit [$\chi^2_{(151)} = 857.05$, $p < 0.001$; $\chi^2/df = 5.68$, RMSEA = 0.088, SRMR = 0.064, CFI = 0.905] and showed non-significant correlation between the subscales ($r = -0.03$, $p = 0.4850$). The score on the Responsiveness (13 items) and Non-responsiveness subscale (6 items) could range from 13 to 65 and 6 to 30, respectively. Items on the Non-responsiveness scale remained reversely coded. Hence, a higher score on this subscale indicates a higher Non-Responsiveness (exemplary item: *I believe my baby wants me to touch her/him too often*). The McDonald's ω coefficient of internal consistency + was 0.96 for the Responsiveness and 0.77 for the Non-responsiveness.

City Infant Face Database [CIFD; (38)] is a set of 154 black-and-white photographs of infant emotional expressions. Photos were collected from infants varied in sex, age (1–12 months), and cultural background where infants express different emotional states, from positive (smiling and laughing), neutral to negative (sad, angry, scared etc.). In this study, we used a previous selection of 139 photographs validated in the sample of Croatian mothers, fathers, and students (60). In the current study, each participant rated the infant expression on 20 randomly chosen photographs (*negative*, *neutral,* or *positive*). The correct answer was scored with 1 point, so the total possible score ranged from 0 to 20.

Postpartum Bonding Questionnaire [PBQ; (40)] is a self-report measure of difficulties in the maternal-infant relationship and has been validated in the sample of mothers with different forms of maternal-infant disorders. The PBQ has 25 items rated on a 6-point scale (0—*never* to 5—*always*), with several reversely scored items, where a higher score indicates more disturbed bonding. Four subscales measure General Factor (12 items), Rejection and pathological anger (7 items), Anxiety about infant (4 items), and Incipient abuse (2 items) (40, 61). The Cronbach's α of the four factors ranged from 0.35 to 0.75 and was 0.78 for the total scale (40). The PBQ was validated in a large sample of Croatian mothers and fathers, where modified 20-item scale showed the excellent fit of both three-factor and one-factor structure: Impaired bonding (10 items, α = 0.94), Anxiety about care and maternal distress (6 items, α = 0.81), Lack of enjoyment and affection with infant (4 items, α = 0.77) (62). In the current study, the same three-factor structure was followed. McDonald's ω coefficient of internal consistency was 0.93, 0.94, 0.81, and 0.77 for the total scale, Impaired bonding, Anxiety about care, and Lack of enjoyment, respectively.

The sociodemographic questionnaire comprised question on age, marital status, level of education, employment status (before maternity leave for mothers), perceived socioeconomic level, and place of living. Furthermore, psychiatric history was examined. Participants could report a previous episode of depression or changed mood (*no; yes, shorter than 2 weeks; yes, longer than 2 weeks*), receiving psychiatric treatment (*yes, no*), and psychiatric heredity in the family (*yes, no*). A final set of questions referred to the pregnancy and the infant regarding the number of children, having twins from the last pregnancy, the infant age, and sex.

Procedures

The study was conducted following Helsinki 1964 Declaration. The Ethical Committee of the Catholic University of Croatia granted the ethical approval for the research. This cross-sectional study was conducted online via Google Forms with separate links for mothers and fathers. It was advertised on social networks (Facebook groups for parents) and shared through personal communication. The data were collected from May 2018 to May 2019. Each participant read the informed consent and by clicking the "Next" button gave their consent to participate in the study. It took ∼20 min to fill in all the questionnaires.

Statistical Analysis

Samples of mothers and fathers were compared in sociodemographic and psychological variables using the *t*-test and χ^2-test (with Yates' correction when necessary) with SPSS Statistics 21.0 for Windows and GraphPad Prism version 9.0 for χ^2-test. Correlations between the studied variables were examined using the Pearson *r* correlation coefficient. The factor structure of the examined constructs was examined by confirmatory factor analysis (CFA) by MPlus 8.2 software or exploratory factor analysis (Principal Axis Factoring) when necessary.

All variables were normally distributed with skewness and kurtosis index (**Table 2**) within the suggested 3 and 10, respectively (63), except for the parent-infant bonding. Data on Impaired bonding (PBQ1) and Lack of enjoyment and affection with infant (PBQ3) exceeded both skewness index above 3 and kurtosis index above 20, which indicate serious non-normality (63).

TABLE 2 | Descriptive data for psychological variables with comparison between mothers ($n = 427$) and fathers ($n = 170$).

	Possible range	Sample	Observed range	*M*	*SD*	Skewness	Kurtosis	Comparison	Effect size
1. Depression symptoms	0–30	Mothers	0–24	7.04	4.72	0.88	0.87	**$t_{(595)} = -2.99$,**	$r = 0.12$
		Fathers	0–20	5.78	4.52	0.93	0.40	**$p = 0.003$**	
2. Anxiety	0–42	Mothers	0–34	3.47	5.51	2.37	6.49	$t_{(595)} = 0.69$,	$r = 0.03$
		Fathers	0–32	3.51	5.95	2.47	6.92	$p = 0.945$	
3. Stress	0–42	Mothers	0–38	9.18	7.96	0.97	0.79	**$t_{(595)} = -2.12$,**	$r = 0.09$
		Fathers	0–36	7.65	7.83	1.18	1.12	**$p = 0.035$**	
4. Responsiveness	13–65	Mothers	27–65	59.83	8.09	−2.06	3.20	**$t_{(595)} = -5.55$,**	$r = 0.22$
		Fathers	25–65	55.69	8.53	−1.36	1.46	**$p = 0.000$**	
5. Non-responsiveness	6–30	Mothers	6–26	11.04	4.37	0.86	0.07	**$t_{(595)} = 2.91$,**	$r = 0.12$
		Fathers	6–26	12.18	4.14	0.71	0.28	**$p = 0.004$**	
6. Facial expression recognition	0–20	Mothers	5–20	16.52	2.52	−1.59	3.42	$t_{(595)} = 0.45$,	$r = 0.02$
		Fathers	6–20	16.62	2.45	−1.72	3.99	$p = 0.655$	
7. PBQ 1	0–50	Mothers	0–50	2.78	6.12	5.25	32.15	$t_{(595)} = -0.63$,	$r = 0.03$
		Fathers	0–50	2.41	6.98	5.46	31.54	$p = 0.527$	
8. PBQ 2	0–30	Mothers	0–28	4.81	4.14	1.96	6.55	$t_{(595)} = 0.34$,	$r = 0.01$
		Fathers	0–30	4.94	4.69	2.56	9.91	$p = 0.737$	
9. PBQ 3	0–20	Mothers	0–20	0.77	1.85	5.35	40.59	**$t_{(595)} = 2.91$,**	$r = 0.12$
		Fathers	0–16	1.35	2.32	3.31	15.14	**$p = 0.004$**	
10. PBQ total scale	0–100	Mothers	0–95	8.35	10.58	4.19	24.05	$t_{(595)} = 0.35$,	$r = 0.01$
		Fathers	0–88	8.70	12.20	4.33	22.81	$p = 0.730$	

PBQ—Postpartum Bonding Questionnaire: PBQ1—Impaired bonding; PBQ2—Anxiety about care and parental distress; PBQ3—Lack of enjoyment and affection with infant. Bold font indicates statistical significance.

Path analysis of the associations between parental mental health (depression and anxiety), parental sensitivity, and bonding (three aspects) was performed in MPlus 8.2. The maximum likelihood estimation with robust standard errors—the MLR estimator—was used as this procedure takes into account non-normality induced bias in the standard errors (64, 65). The goodness of fit was evaluated by several indices χ^2-test, Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI). Acceptable model fit is indicated when RMSEA and SRMR values are below 0.08, and CFI values are above 0.90 (66), while a very good fit is displayed when the RMSEA is below 0.06, SRMR is below 0.08, and CFI values are above 0.95 (67). Reliability of measures was calculated as the internal consistency via McDonald ω coefficient, as a better alternative to Cronbach α (68) using the OMEGA macro for SPSS (69). Sample size calculation was performed as per the general rule of thumb to have at least 50 participants per variable in the path analysis and to have a medium sample size of 100–200 per group (70). Given that nine variables were examined, at least 450 participants were necessary, which was exceeded with 597 participants, out of which 170 were fathers.

RESULTS

Descriptive Data

Descriptive data for all psychological variables is presented in **Table 2**. A somewhat reduced range was obtained for depression and anxiety in both mothers and fathers. However, 20.8% of mothers and 14.7% of fathers reported depression symptoms above the proposed cut-off of 11 on the EPDS (54). A full range of observed data was obtained for bonding scores, and the almost whole possible range was obtained for responsiveness and facial expression recognition. The scores were compared between mothers and fathers, showing that mothers reported higher depression symptoms, stress, responsiveness, and a lower level of non-responsiveness. On the other hand, fathers expressed more inferior bonding in the Lack of enjoyment and affection with the infant. However, all effects were small (**Table 2**).

Associations Between Examined Variable

Very similar patterns of associations were established for mothers and fathers (**Table 3**). Higher levels of depression symptoms were associated with higher anxiety and stress levels in both samples with modest correlations. Also, in both mothers and fathers, higher parental mental health difficulties (depression, anxiety, and stress) were related to poor bonding but with small correlations. Further, higher levels of mental health difficulties were associated with lower responsiveness and higher non-responsiveness. Facial expression recognition was not related to parental mental health or responsiveness. However, it had a slight negative correlation with non-responsiveness, indicating that poor facial expression recognition was associated with higher non-responsiveness. Also, poor facial expression recognition was related to a Lack of enjoyment and affection with the infant, in mothers only, but with a small correlation.

TABLE 3 | Pearson's correlation coefficients between psychological variables in mothers ($n = 427$, above diagonal) and fathers ($n = 170$, below diagonal).

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Depression symptoms	–	0.57**	0.67**	−0.17**	0.30**	−0.03	0.21**	0.40**	0.14**
2. Anxiety	0.60**	–	0.66**	−0.13**	0.17**	−0.07	0.16**	0.27**	0.09
3. Stress	0.69**	0.70**	–	−0.10	0.21**	0.03	0.21**	0.43**	0.15**
4. Responsiveness	−0.16*	−0.16*	−0.17*	–	0.02	0.07	−0.30**	−0.33**	−0.30**
5. Non-responsiveness	0.37**	0.44**	0.37**	0.00	–	−0.11*	0.09	0.27**	0.02
6. Facial expression recognition	0.08	−0.03	0.11	0.10	0.09	–	0.11*	−0.06	−0.17**
7. PBQ 1	0.30**	0.29**	0.20*	−0.39**	0.18*	−0.08	–	0.70**	0.52**
8. PBQ 2	0.40**	0.31**	0.35**	−0.42**	0.26**	0.05	0.83**	–	0.46**
9. PBQ 3	0.23**	0.29**	0.29**	−0.25**	0.29**	0.06	0.34**	0.35**	–

*$p < 0.05$ and **$p < 0.01$. PBQ—Postpartum Bonding Questionnaire: PBQ1—Impaired bonding; PBQ2—Anxiety about care and parental distress; PBQ3—Lack of enjoyment and affection with infant.*

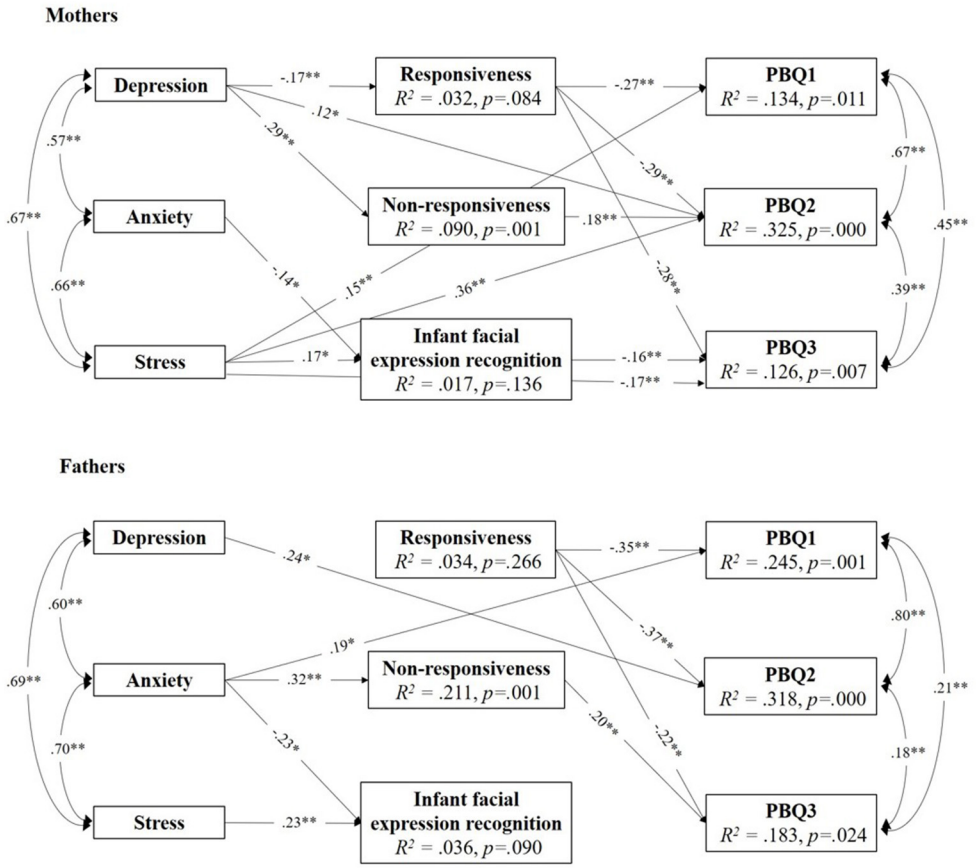

FIGURE 1 | Model paths predicting parent-infant bonding from parental mental health via parental sensitivity and responsiveness in mothers and fathers. Only significant paths are presented. All coefficients are standardized. *$p < 0.05$ and **$p < 0.01$.

Parental Sensitivity and Responsiveness as Mediators

The model of parental sensitivity as a mediator between parental mental health and bonding was tested. Depression symptoms, anxiety, and stress were entered as predictors; responsiveness, non-responsiveness, and facial expression recognition were entered as mediators; and three aspects of bonding were entered as the outcome. All possible direct and indirect effects were defined in the model. The model was saturated with excellent fit to the data [$\chi^2_{(6)} = 14.47$, $p = 0.0248$; $\chi^2/df = 2.41$, RMSEA = 0.069, SRMR = 0.021, CFI = 0.989].

The parental sex was examined as the moderator in the model. This was tested with the nested model with specified parameters set to be equal between mothers and the fathers [$\chi^2_{(48)} = 117.77$,

$p < 0.0001$; $\chi^2/df = 2.45$, RMSEA = 0.070, SRMR = 0.062, CFI = 0.906]. This model was significantly different from the initial model [Satorra-Bentler Scaled χ^2 difference was SBS-$\chi^2_{(42)} = 103.26$, $p < 0.0001$; CD = 1.1766], indicating that the parental sex was a significant moderator. Thus, different paths were established in mothers and fathers (**Figure 1**).

In mothers, responsiveness was a significant mediator between postpartum depression symptoms and all three bonding dimensions (**Table 4**). Namely, higher levels of depression symptoms were associated with lower levels of responsiveness, which was, in turn, associated with Impaired bonding, Anxiety about care and maternal distress, and Lack of enjoyment and affection with the infant. Furthermore, non-responsiveness was a significant mediator between maternal depression and one aspect of bonding. More specifically, higher levels of depression were associated with higher levels of non-responsiveness, which was, in turn, related to poor bonding concerning Anxiety about care and maternal distress.

In fathers, the only significant indirect path was for non-responsiveness. Higher levels of anxiety were associated with higher levels of non-responsiveness, which was, in turn, related to poor father-infant bonding concerning Lack of enjoyment.

Finally, facial expression recognition did not mediate mental health and bonding in mothers or fathers. Nevertheless, it did directly affect bonding in mothers so that mothers who were less accurate at recognition reported higher levels of Lack of enjoyment and affection with baby. Also, even though anxiety and stress did not correlate with infant facial expression recognition in mothers or fathers, in the model, these direct effects were significant, indicating possible suppressor effect (71, 72). Direct effects from parental mental health on all three dimensions of bonding were established (**Figure 1**). However, it is interesting to note that anxiety did not directly affect bonding concerning the Anxiety about care. Also, responsiveness had a direct effect on all dimensions of bonding, both in mothers and fathers.

TABLE 4 | Model estimates of multigroup path analysis: Depression symptoms and anxiety on bonding via responsiveness and facial expression recognition ($N = 603$).

	Mothers			Fathers		
	Path estimates	SE	*p*	Path estimates	SE	*p*
Indirect effects via responsiveness						
Depression → PBQ1	**0.05**	**0.02**	**0.038**	0.02	0.04	0.592
Depression → PBQ2	**0.05**	**0.02**	**0.020**	0.02	0.04	0.592
Depression → PBQ3	**0.05**	**0.02**	**0.043**	0.01	0.03	0.603
Anxiety → PBQ1	0.02	0.02	0.340	0.02	0.04	0.527
Anxiety → PBQ2	0.02	0.02	0.329	0.03	0.04	0.529
Anxiety → PBQ3	0.02	0.02	0.339	0.02	0.03	0.532
Stress → PBQ1	−0.02	0.02	0.377	0.03	0.04	0.528
Stress → PBQ2	−0.02	0.02	0.365	0.03	0.05	0.523
Stress → PBQ3	−0.02	0.02	0.372	0.02	0.03	0.526
Indirect effects via non-responsiveness						
Depression → PBQ1	0.01	0.02	0.386	0.01	0.02	0.541
Depression → PBQ2	**0.05**	**0.02**	**0.004**	0.02	0.02	0.322
Depression → PBQ3	−0.01	0.01	0.664	0.03	0.03	0.211
Anxiety → PBQ1	0.00	0.00	0.908	0.02	0.04	0.489
Anxiety → PBQ2	−0.00	0.01	0.908	0.04	0.03	0.186
Anxiety → PBQ3	0.00	0.00	0.911	**0.07**	**0.03**	**0.034**
Stress → PBQ1	0.00	0.00	0.788	0.00	0.01	0.678
Stress → PBQ2	0.00	0.02	0.775	0.01	0.01	0.666
Stress → PBQ3	0.00	0.00	0.811	0.01	0.02	0.669
Indirect effects via facial expression recognition (CIFD)						
Depression → PBQ1	0.01	0.01	0.468	−0.00	0.01	0.652
Depression → PBQ2	0.00	0.00	0.615	0.00	0.01	0.639
Depression → PBQ3	0.01	0.01	0.387	0.00	0.01	0.666
Anxiety → PBQ1	0.01	0.01	0.313	0.01	0.01	0.494
Anxiety → PBQ2	0.01	0.01	0.564	−0.01	0.02	0.474
Anxiety → PBQ3	0.02	0.01	0.074	−0.01	0.02	0.473
Stress → PBQ1	−0.02	0.01	0.286	−0.01	0.02	0.526
Stress → PBQ2	−0.01	0.01	0.552	0.01	0.02	0.450
Stress → PBQ3	−0.03	0.02	0.077	0.01	0.02	0.448

Standardized coefficients are presented. SE, standard error; PBQ—Postpartum Bonding Questionnaire: PBQ1—Impaired bonding; PBQ2—Anxiety about care and parental distress; PBQ3—Lack of enjoyment and affection with infant. Bold font indicates statistical significance.

DISCUSSION

There was a lack of studies looking into the role of maternal sensitivity for mother-to-infant bonding in the literature, and even more, there was a neglect of fathers. Therefore, this study aimed to examine parental sensitivity as a mediator in the relationship between parental mental health and parent-infant bonding in both mothers and fathers. The model had a good fit to the data, and parental responsiveness was a significant mediator between postpartum mental health and bonding quality. However, different paths were established for mothers and fathers, which will be discussed further.

First, parental sensitivity in the current study was measured by a self-report measure of responsiveness as one aspect of sensitivity (5) and an objective measure of infant facial expression recognition. Also, before going further, it should be noted that the Maternal Infant Responsiveness Instrument was previously used as a unidimensional measure (34–36, 58, 59) without questioning its factor structure. However, the initial psychometric evaluation in the current study showed a poor fit of the unidimensional model to the data. This secondary finding highlights the need for psychometric testing of instruments at each administration. Namely, psychometric properties are not fixed characteristics of the instrument, as they also reflect the sample characteristics and administration circumstances (73). The two-factor structure of the MIRI had a better fit and resulted in subscales of responsiveness and non-responsiveness. These two were mutually uncorrelated, indicating that the non-responsiveness subscale is not a mere negative pole of responsiveness. Moreover, non-responsiveness taps different responsiveness aspects, reflecting fear of taking care of the infant and appraisals of the infant as being too demanding. Furthermore, it was interesting that these two subscales had

a unique role in the relationship between mental health and bonding in mothers and fathers.

In mothers, responsiveness was a significant mediator between depression symptoms and bonding. Higher levels of depression symptoms were associated with lower levels of responsiveness, which was, in turn, related to poor bonding on all three dimensions, i.e., Impaired bonding, Anxiety about the care, and Lack of enjoyment with the infant. In fathers, responsiveness was not a significant mediator between mental health and bonding. However, non-responsiveness was a significant mediator both for mothers and fathers. Despite specific differences in the patterns of mediational pathways, we can summarize that both for mothers and fathers, (non)responsiveness has an important role in the shape of parent-infant bonding.

These findings are somewhat difficult to relate to previous research on bonding, as these constructs have not been examined all together in a mediational model, especially not in fathers. However, previous studies demonstrated an adverse effect of maternal depression symptoms on maternal sensitivity (33) and maternal responsiveness (34). On the other hand, it is not easy to compare findings on parental sensitivity and parent-infant bonding, as previous studies have mainly investigated maternal sensitivity observationally with infant-mother attachment (1, 6, 7). The same goes for examining the relationship between responsiveness and mother-infant bonding. However, Tester-Jones et al. (35) did investigate depression symptoms, maternal responsiveness, and bonding, but they did not relate these constructs in the same model but on the bivariate level. They did show that maternal depression was associated with lower levels of responsiveness and bonding, and these relationships were mediated by infant temperament.

On the other hand, another study did not show an association between maternal depressive symptoms and responsiveness but found a more dominant role of stress for responsiveness (36). However, the latter finding comes from a small sample of mothers with preterm babies who have specific childbirth and postpartum experience. It is known that mothers with preterm delivery are at higher risk of posttraumatic stress disorder following birth (74), which is, in turn, associated with impaired bonding in mothers (75).

The ability to recognize infant facial expressions was previously suggested to reflect maternal sensitivity (38). However, the mediational role of infant facial expression recognition was not established in the current study, either for mothers or fathers. It was expected that depression symptoms would be associated with facial expression recognition, but this was not evident. This finding was unexpected as previous studies showed that depressed mothers were less likely to identify happy infant faces (76) and rated negative infant faces more negatively (39). Different attentional processing of positive and negative infant emotions associated with depression symptoms was evident even during pregnancy (77, 78). A similar effect of depression was demonstrated in fathers, as well. A recent study showed that depressed fathers recognized happy faces with more difficulty but negative faces more easily, which, in turn, affected negatively on the father-infant interaction (79). On the other hand, some studies did not show attentional bias toward negative infant faces in mothers with affective disorders (80). So, the infant facial expressions recognition remains to be demonstrated as a measure of maternal sensitivity to infant's cues and its role in predicting parent-infant bonding.

The findings of this study have several implications for clinical practice. First, the study highlights the need for screening for a wide range of mental health difficulties. In addition to depression symptoms that most screening attempts are focused on (81), anxiety and stress also contributed to parental sensitivity and parent-infant bonding. Also, the screening should be applied to both mothers and fathers (82, 83). Because of the contributing effect of the partner depression (84), both parents can get into a vicious circle of depression, where a parent has a higher probability of developing depression symptoms if their partner also shows depression symptoms. Also, fathers should be provided with the same opportunities in the (prenatal) classes as mothers have to learn about newborn care, parenting sensitivity, and parent-infant bonding. Bonding between fathers and infants is a process that develops over the first year of the infant's life, as shown in the meta-synthesis of paternal experiences (43). The process progresses by getting to know the infant and having physical contact and interaction with the infant, which is especially rewarding for fathers. Therefore, courses for paternal engagement and enhancement in bonding should encourage fathers to take care of infants, play with them, or simply hold them. As they may feel the lack of knowledge and skills in infant care, they should be taught about this in (prenatal) classes and supported by their spouses, as fathers found their partners' support very encouraging (43). Particular focus should be on fathers whose infants are breastfed, as they may feel excluded and may need some additional time to catch up with their infant. Also, concerning the parental role in fathers, future studies should shift more from mere involvement, i.e., quantity, to the father-child relationship quality (42). Furthermore, sensitive parenting should be promoted to ensure a safe environment that is supportive and stimulating for the child development. Parents should comfort the child and provide a secure base for their exploration and autonomy (41, 42).

Several limitations of the study should be discussed. First, this sample of mothers and fathers was a non-clinical sample. Therefore, other possible conclusions could be withdrawn if the sample included parents with clinical depression, anxiety, or a bonding disorder. Nevertheless, at least one part of the parents from the sample struggled with depression symptoms, as one in five mothers and one in six fathers reported clinically significant depression symptoms. Furthermore, the sample was recruited online via social network groups for parents, so one can argue that this sample is self-restricted. Indeed, the sample was urban, highly educated; almost all parents were married or cohabiting, with the majority reporting average to above-average socioeconomic status. As they have decided to participate in this study, they were probably interested in content about parenting and more engaged in their parental role. The sample of fathers was smaller than the sample of mothers; therefore, future studies would benefit from including the larger samples of fathers in order to replicate these findings. Also, the cross-sectional design was applied so one can speculate that different directions of

associations could work as well. For instance, Brockington et al. (40) highlighted that depression in mothers could be caused or exaggerated by bonding problems. Although the model has a solid theoretical background, it was not previously tested for bonding, and future studies should confirm the model in longitudinal studies. Maternal interpersonal sensitivity measured during pregnancy was a stronger predictor of the mother-infant interaction quality than perinatal depressiveness (85), so it would be beneficial to measure maternal sensitivity even during pregnancy.

In this study, the role of anxiety for responsiveness and bonding was found only in fathers. However, it should be noted that a general measure of anxiety (DASS-21) was used in this study, which mainly covers somatic symptoms. Recent research has shown that anxiety specific for the postpartum period has a predictive value for bonding over general measures (86). Future studies could benefit from applying specific measures of anxiety that grasp the parental perinatal experience with more focus. Also, it should be noted that bonding was measured up to 12 months of the infant's age (with a mean at 6 months). However, the PBQ was designed for use in the early postpartum period (40, 61), and it has been mostly used and validated within the first 3 months after childbirth (87–90). Nevertheless, some other studies applied the PBQ within the first postpartum year [e.g., (91, 92)]. Still, the factor structure and reliability across the first year postpartum should be examined in future studies. Furthermore, the infant facial recognition task included the recognition of unknown infant faces. As postpartum mothers have specific dopaminergic reward-related brain network activation when viewing their infants compared to unknown infant's faces (93), future studies should preferably include expressions of their infant.

Finally, it should be noted that the examined set of variables explained up to 32% of the parent-infant bonding variance. It means that two-thirds of the variance remains unexplained, and future studies should include other variables into the model. A recent cross-sectional study showed the interrelation of maternal mental health and bonding with perceived infant temperament (94). Infant temperament has been shown to affect the parent-infant bonding in a prospective study in mothers and father (95, 96). It also mediates the relationship between maternal depression and responsiveness (35) and might have a more substantial effect on infant-mother attachment than maternal sensitivity (97).

Also, previous studies have established the association between breastfeeding and maternal sensitivity. Longer breastfeeding was associated with higher maternal sensitive responsiveness levels during infancy (98) and even increased maternal sensitivity in middle childhood (99). Nevertheless, in the current study, different infant feeding methods were not considered as we wanted to test the same model in both mothers and fathers. The study's strength is including both parents, and further studies should focus on fathers in more depth. Also, future studies would benefit from pairing mothers and fathers so the dyadic relationships within the couple can be examined. A dyadic analysis on first-time parents revealed that postpartum depression levels are affected by own anxiety and parenting stress and partners' depression in both mothers and fathers (84). A recent study showed that mother-infant bonding contributes to father-infant bonding (51), and dyadic relationships of parental mental health and bonding should be further examined. Finally, some more stable characteristics, such as life satisfaction and self-esteem, seem to be more important predictors of maternal responsiveness (58), so the range of examined variables could be expanded.

To conclude, the current study showed that responsiveness has an important mediational role in the relationship between parental mental health and parent-infant bonding, both for mothers and fathers. This finding fits into Shin et al.'s (5) conceptual analysis of maternal sensitivity affected by maternal mental health. The model can be extended to apply not only for attachment as an infant-to-mother relationship but also to bonding as a mother-to-infant relationship and for fathers. However, theoretical and empirical work is needed to provide a solid theoretical basis for future studies on parent-infant bonding. It could have a crucial impact on developing interventions for parents and infants to alleviate mental health problems and their reflection on the bonding issues. A promising early intervention for reinforcing maternal sensitivity, especially in women with psychosocial vulnerability, has been tested recently (100). Future studies should continue developing such programs to help parents enjoy this transition to parenthood and provide safe and warm family relations for the growth of the child.

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 Ethical Committee of the Catholic University of Croatia. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SNR devised the main conceptual idea, supervised the project, performed the analysis, and wrote the manuscript.

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BRIEF RESEARCH REPORT
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Maternal Perceptions of Infant Behavior as a Potential Indicator of Parents or Infants in Need of Additional Support and Intervention

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The goal of the present study is to examine the relationship between early infant behaviors, which can be easily reported by parents, with parent-infant bonding and maternal mental health. It has long been established that child characteristics and behaviors have a significant impact on parent well-being and how parents respond to their infants. Examining parent perceptions of challenging infant behaviors may help health professionals identify high risk infants in need of intervention and mothers in need of additional support. Mothers of 73 infants between the ages of 3.5 weeks and 6 months filled out questionnaires. Infant stomach issues were positively correlated with bonding issues, maternal anxiety and maternal depression. Infant crying issues were also positively correlated with bonding issues, maternal anxiety and maternal depression. Potential clinical and research applications of the instrument include early identification of caregivers in need of support and screening for further clinical assessment and care.

Keywords: infant behavior, parenting, infant risk, infant-parent bonding, parent-child bonding

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INTRODUCTION

Mothers are most often the primary caretakers for their young infants, yet little is known about how they perceive common challenging behaviors. It has been established that child characteristics and behaviors have a significant impact on parent well-being and, consequently, on how parents respond to their infants (1–3). Currently, hospital and community-based interventions target parents who are deemed to be at-risk due to specific risk factors such as parental age and rarely rely on parent perception of infant behavior to triage parents for professional help or intervention. Examining parent perceptions of challenging infant behaviors may help health professionals identify high risk infants in need of intervention and parents in need of additional support. Such efforts are needed to decrease the adverse impact of normative stressors on parent-child relationships and so that interventions can be more targeted, cost-effective, efficient and potentially more beneficial to the parent-child relationship, attachment quality and later infant outcomes.

Early infant behavior is important because it relates to infant-parent attachment and is predictive of behavior throughout life (4). Research evidence suggests that infant behaviors are related to maternal risk of postpartum depression. To this point, qualities of the infant, such as prolonged, excessive or inconsolable crying (5, 6) increase a mother's risk of postpartum depression, something

that impacts roughly 14.5 percent of new mothers within the first 14.5 months of giving birth (7) and has adverse effects on the parent-child relationship (8). Maternal mental health can also impact infant behavior. To this point, postpartum depression impacts infant development across a variety of domains including motor development and cognitive development (9).

Difficulties with infant feeding are highly correlated with crying and are often encompassed within the working definition of an infant with "colic" (10). Less frequently studied infant behaviors that are nonetheless encompassed in many parents' working definition of a "difficult" infant include how good of a sleeper and eater the infant is. Infants who have difficulty with these early self-regulatory behaviors (i.e., crying, sleeping and feeding) are at risk for adverse outcomes later in life (11), suggesting the need for further research into these behaviors. To this point, the volume and timing of infant sleep is one of the most important infant behaviors to new parents (12). However, the above outlined behaviors do not occur in isolation, and each may impact multiple areas of functioning. For example, feeding an infant at night has been shown to create sleeping problems (13–15), and sleeping problems have been associated with stomach aches in young children (16). Stomach issues are noted in research as one of the leading reasons that new parents take children to the doctor outside of routine visits (17). Taken together, these early infant behaviors (i.e., crying, eating, sleeping and stomach issues) are areas of both explicit and implicit concern for parents.

Infant crying is a normative behavior that has been found on average to occur for just over 2 hours per day for infants between 1 and 3 months and about 1 hour per day for infants between 4 and 6 months (18). Concern over infant crying emerges when the crying is excessive as it is associated with maternal depression (19) and increased risk of harm to the infant. For example, infant crying has been implicated as a behavior that could provoke infant shaking by parents (20), increasing risk for injuries such as Shaken Baby Syndrome (SBS).

It is important for clinicians to quickly gather information from parents about their areas of concern related to their infant's behavior.

Existing interventions in the newborn period might benefit from more specified targeting within the population level that is similar to the screenings that are currently implemented in the area of postpartum depression—with assessments that quickly gather information and triage parents to more support. The purpose of this study is to demonstrate that parental perceptions of infant behavior are related to parent bonding and parent well-being. Our hypothesis is that parental belief that their child is having trouble in an area such as crying, eating, sleeping and stomach issues will be correlated with worse outcomes such as impaired bonding or heightened parental depression or anxiety.

MATERIALS AND METHODS

Participants

Seventy-three mothers of infants between the age of 3.5 weeks and 6 months (characteristics of the sample outlined in **Table 1**) were included in the study. Parents filled out questionnaires on anxiety, depression, infant bonding and infant behaviors as part of a larger cross-sectional study investigating the impact of participation in infant floating classes on parent mental health, bonding and infant behavior. Infant floating classes involve placing a flotation device around an infant's neck so that the infant can float in a tub of water and kick their feet. There were no significant differences in any measures across whether parents participated in floating classes with their infants; however, whether or not parents participated in floating classes is included in all analyses to control for any effect of group status on results. The sample was originally 74 parents, but only one father participated in the study. Due to the small sample of fathers, the father was dropped from the sample.

TABLE 1 | Demographics of sample ($n = 73$).

Variables	% (SD)
Parent Sex	
Female	73
Parent Age	32.03 (4.51)
Child Sex	
Male	43
Female	31
Child age in months	3.65 (1.55)
Race	
White	54
African American	3
Asian	8
Multi-racial	6
Not reported	2
Hispanic/Non-hispanic	15/58
Relationship Status	
Single, never married	3
Married	65
Separated	1
Relationship, living together	4
Yearly Household Income	
Less than $50,000	14
$50,000–100,000	10
Above $100,000	49
Highest Education	
High school	2
Some college, no degree	15
College degree	31
Advanced degree	25

Procedures

Participants were recruited through a local infant floating facility in Houston, TX as well as through online postings on Facebook©. Participants completed initial questions to confirm eligibility online, including being a parent of an infant between the ages of 3.5 weeks and 6 months old. Participants were prescreened and excluded from the study if they self-reported that infant had any known health issues that might interfere with the child's

TABLE 2 | Original items in BABI infant behavior scale.

Cry Items	
Cry_1_Reversed	How much does your baby cry?
Cry_2_Reversed	How often does your baby cry?
Cry_3_Reversed	How intensely does your baby cry?
Cry_4_Reversed	How easily is your infant comforted by you when he/she cries?
Eat Items	
Eat_1_Reversed	How satisfied are you with the amount your baby eats?
Eat_2_Reversed	How satisfied are you with how often your baby eats?
Eat_3_Reversed	Compared to other babies your infant's age, how much does your baby eat?
Sleep Items	
Sleep_1	How satisfied are you with your infant's sleep?
Sleep_2_Reversed	Compared to other babies your infant's age, how much does your baby sleep?
Sleep_3	Compared to other babies your infant's age, how often does your baby wake up in the middle of the night?
Sleep_4_Reversed	Compared to other babies your infant's age, how much does your baby nap?
Stomach Items	
Stomach_1	Compared to other babies your infant's age, how much reflux does your baby have?
Stomach_2	Compared to other babies your infant's age, how much gas does your baby have?
Stomach_3	Compared to other babies your infant's age, how much stomach pain does your baby have?

The eating subscale was dropped in its entirety due to issues with item normality and low inter-item correlation. Sleep_4_Reversed was removed after EFA and CFA due to low correlation with other items and lack of face validity with other items.

physical abilities. Four participants were excluded based on this prescreening. Participants were informed that they would be entered into a raffle to win three free sessions at the infant aquatic therapy facility as compensation for their participation, and informed consent was obtained through Qualtrics prior to any study activities. This study was approved by the Institutional Review Board at the University of Houston.

Measures

The Baby Actions and Behavior Index

The Baby Actions and Behavior Index (BABI) infant behavior scale measures critical domains of infant behavior: eating issues, stomach issues, crying, and sleep issues. The authors (LF and EP) created 14 questions assessing infant behavior in these domains: eating ("How satisfied are you with the amount your baby eats"), stomach issues (e.g.," Compared to other babies your infant's age, how much gas does your baby have?"), crying (e.g., "How much does your baby cry?"), and sleep issues (e.g., "Compared to other babies your infant's age, how often does your baby wake up in the middle of the night?") (see **Table 2** for full scale).

Mother-Infant Bonding Scale

Mother-Infant Bonding Scale [MIBS; (21)] is an eight-item, self-report scale assessing emotions mothers may have experienced toward their infants. This measure was designed to identify difficulties experienced by new mothers in establishing a relationship with their babies, and was intended for use in the first weeks after the child's birth through 4 months postpartum (22). Participants were asked to identify to what degree they have felt various emotions toward their infant in the past few weeks by responding on a four-point Likert scale from *very much (0)* to *not at all (3)*. Emotion prompts include "loving" [very much (0) to not at all (3)] and "resentful" [reverse scored; very much (3) and not at all (0)]; higher total scale scores indicate worse bonding. This measure has demonstrated high sensitivity in detecting bonding alterations between new mothers and their babies (23) and has evidenced moderate concurrent validity with two other measures: the Postpartum Bonding Questionnaire (24) and the Maternal Postpartum Attachment Scale (25). Reliability analyses have demonstrated a Cronbach's alpha, or internal consistency score of 0.71, evidencing acceptable reliability (21). The Cronbach's alpha for the MIBS was 0.59 in the present study.

Edinburgh Postnatal Depression Scale

Edinburgh Postnatal Depression Scale [EPDS; (26)] is a 10-item, self-report measure developed to help identify new mothers who may be at risk for postpartum depression. Research has demonstrated a potential long-term negative impact of postpartum depression on the child, including behavioral disturbances (27) and later cognitive deficits (28). This scale was created in response to research confirming that the period after childbirth is frequently characterized by some form of psychological distress for new mothers (29), and that at least 10–15% of mothers experience depression during this time (26). Participants respond to prompts about how they have felt in the past seven days on a four-point Likert scale with scores from 0 to 3 (e.g., *yes, all the time* to *no, not at all*; *yes, quite often* to *never*, etc.), and total scores range from 0 to 30. Higher scores on this scale indicate higher symptomology of depression. Item examples include "I have felt happy," "I have felt sad or miserable," and "things have been getting on top of me." Cutoff scores have previously been determined; Cox, Holden and Sagovsky identified a cutoff of 12/13 for moderate depression, which was replicated by Harris (30) (using Diagnostic and Statistical Manual of Mental Disorders-III criteria [DSM-III]) and Murray and Carothers (31) (using Research Diagnostic Criteria [RDC]). Additionally, Cox, Holden and Sagovsky recommended a cutoff score of 10 to include minor depression as well as increased sensitivity of the scale or ability to capture people with a diagnosis of depression (32). This was also confirmed by Harris (30), as well as Murray and Carothers. Previous research using a cutoff of 10 has demonstrated accurate later classification of mothers at 4 weeks later (85.4% accurately classified) and 8 weeks later (82.5% accurately classified) (33). This measure has also demonstrated satisfactory validity, split-half reliability and adequate sensitivity to changes in depression over time (26). Reliability analyses have demonstrated a Cronbach's alpha of 0.87, evidencing good reliability (26); the Cronbach's alpha in the present study was found to be 0.87.

Generalized Anxiety Disorder

Generalized Anxiety Disorder is a seven-item scale (GAD-7; 33) assessing anxiety. This measure asks participants to identify how often they have been bothered by certain problems, and participants respond on a four-point Likert scale (with scores from 0 to 3) from *not at all* to *nearly every day*. Items include "feeling nervous, anxious, or on edge" and "not being able to stop or control worrying." Scores range from 0 to 21 and higher scores on this scale indicate higher symptomology of anxiety. Scale authors suggest a cutoff point of 10 for identifying anxiety. At this cutoff, the scale has yielded a sensitivity of 89% in a primary care sample (34), and in a sample of pregnant and postpartum women, it has yielded a sensitivity of 76.0% (35). Reliability analyses evidenced a Cronbach's alpha of 0.92, demonstrating excellent reliability (34) and a Cronbach's alpha 0.91 in the present study. Additionally, this measure has been found to have found good construct as well as factorial and procedural validity (34).

Data Analysis Plan

Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to examine the validity of subscales in the BABI scale (36). This was done to ensure that the intended scales functioned as originally conceptualized before proceeding to any other analyses with the subscales. To explore our hypothesis that parental belief that their child is having trouble in an area such as crying, eating, sleeping and stomach issues will be correlated with worse outcomes such as impaired bonding or heightened parental depression or anxiety, correlations were conducted to examine the relationship between the BABI scale and important variables such as Mother-Infant Bonding, postpartum depression and anxiety. Variables were deleted listwise. Because the infants in our sample varied by almost 6 months in age, Cronbach's alphas were examined separately for all measures.

RESULTS

Exploratory and Confirmatory Factor Analyses

Prior to use of the BABI to explore our hypothesis, preliminary construct validity was established with an exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) using the Mplus statistical software [version 7.11, (37)] to ensure that subscales of the BABI measured their intended facets of infant behavior. Before conducting factor analyses, we checked the normal distribution of our items and their correlations. We found that all items were normally distributed, except for one item for eating issues, which slightly violated the normality assumption *EAT_1R*; skewness = 1.40 and Kurtosis = 1.96). In addition, the correlation between the other two items for eating issues (*EAT_2R* and *EAT_3R*) was unexpectedly small, $r = 0.16$. Due to these problems pertaining to items on eating issues, we decided to remove all three items for eating issues. There were three remaining scales: crying, sleeping and stomach issues. We also removed one item on sleeping issues (*SLEEP_4R*) due to its low correlations with other sleep items ($r = 0.13$ with *SLEEP_1* and $r = -0.04$ with *SLEEP_3*), possibly due to the fact that (*SLEEP_4R*) asks about infant napping whereas the other items (*SLEEP_1*, *SLEEP_2R*, and *SLEEP_3*) ask about general sleep behaviors. Low correlations among items led us to have a poor performance of a factor analysis (38). In the final analysis, we included 10 items: four items addressing crying issues (*CRY_1R, CRY_2R, CRY_3R,* and *CRY_4R*), three items addressing sleeping issues (*SLEEP_1, SLEEP_2R*, and *SLEEP_3*), and three items addressing stomach issues (*STOMACH_1, STOMACH_2,* and *STOMACH_3*).

TABLE 3 | Varimax-rotated factor loadings of exploratory factor analysis for the baby actions and behavior index (BABI).

	Factor 1	Factor 2	Factor 3
CRY_1R	0.89	0.07	0.10
CRY_2R	0.92	0.08	0.07
CRY_3R	0.81	0.13	−0.16
CRY_4R	0.66	−0.02	0.12
SLEEP_1	0.03	0.84	0.20
SLEEP_2R	0.18	0.86	−0.05
SLEEP_3	−0.00	0.82	0.05
STOMACH_1	0.11	0.20	0.68
STOMACH_2	−0.12	0.05	0.88
STOMACH_3	0.14	−0.06	0.90

We conducted EFA with the varimax rotation. The scree plot suggests that a three-factor model best captures the items in our scale. Additionally, the eigenvalue of the three-factor model was higher than one, whereas the eigenvalue of the four-factor model was less than one, further indicating the validity of the three-factor model. Factor loadings of the final three-factor model are presented in **Table 3**.

Due to the fact that the items were written as part of a subscale structure when the scale was originally conceptualized, we also conducted a CFA. Our CFA model result is presented in **Figure 1**. We included one correlation between residual variances for *CRY_1R* and *CRY_4R* because the modification index suggested the correlation. Furthermore, we believe that these two items are meaningfully related—infants who are harder to console when they cry will exhibit prolonged crying (i.e., cry more than other babies of the same age). The model fit was very good: $CFI = 0.970$, $RMSEA = 0.068$, and $\chi^2_{(df)} = 41.47_{(31)}$, $p = 0.099$, suggesting that our scale consists of three distinct behavioral issues found in infants. Due to this very good model fit, we did not further conduct a *post-hoc* analysis to improve our model fit.

Partial Correlations

Partial correlations between the BABI stomach issues, crying issues and sleep issues subscales and the Mother-to-Infant Bonding scale, anxiety scale, and postpartum depression scale were conducted in order to further establish construct validity (controlling for whether or not the mothers participated in floating class). Our hypothesis, that maternal belief of their child having trouble in an area such as crying, sleeping and stomach issues (*note: eating removed due to violation of the normality assumption*) will be correlated with worse outcomes such as impaired bonding or heightened parental depression or anxiety,

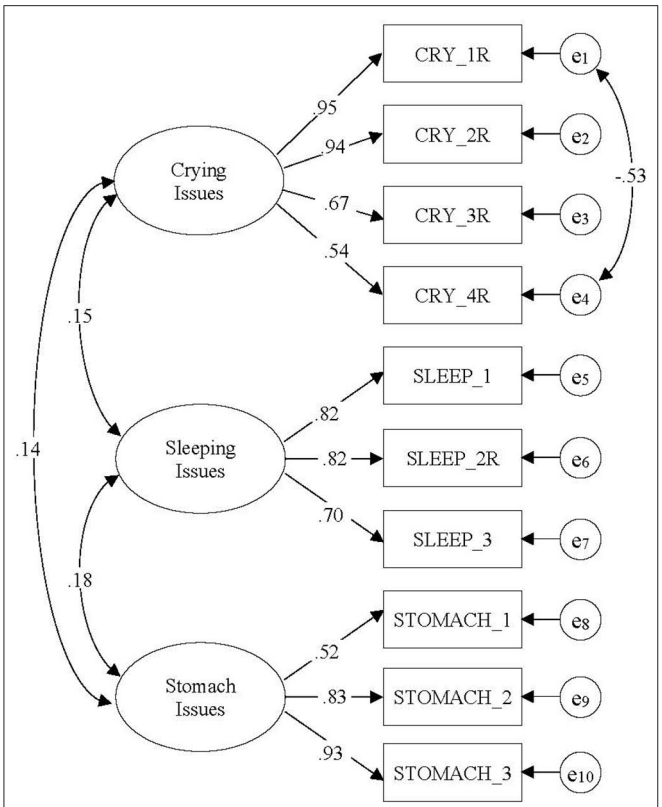

FIGURE 1 | The confirmatory factor analysis model with crying issues, sleeping issues, and stomach issues. Numbers indicate standardized factor loadings and correction coefficient. CFI = 0.970, RMSEA = 0.068, and $\chi^2_{(df)} = 41.47$ (31), $p = 0.099$.

TABLE 4 | Partial correlation coefficients among study variables.

Measure	MIBS	GAD anxiety	EPDS depression
Infant stomach issues	0.31**	0.24*	0.25*
Infant crying issues	0.34**	0.26*	0.25*
Infant sleep issues	0.15	−0.03	−0.04

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level (2-tailed). Controlling for whether the child had ever participated in floating classes. Missing variables deleted listwise. N = 69.*

was partially supported. Significant results were found for the following relationships: infant stomach issues were positively correlated with bonding issues, maternal anxiety and maternal depression; infant crying issues were also positively correlated with all three outcome variables: bonding issues, maternal anxiety and maternal depression (see **Table 4**).

Cronbach's Alphas

Cronbach's alphas for the BABI were as follows: stomach issues was $\alpha = 0.77$, crying issues was $\alpha = 0.86$ and sleep issues was $\alpha = 0.80$.

DISCUSSION

In this study, perceived stomach issues and crying were both related to mother-infant bonding issues, higher maternal anxiety, and higher postpartum depression. Correlation coefficients are a common indicator of effect size. Although the correlations are statistically significant, they have relatively small effect sizes (39).

Assessments of newborns and young infants' behaviors such as crying, sleep and stomach issues are critical for a number of reasons: they help clinicians identify infants in need of care, help researchers identify infants at greater risk, and may help to identify new mothers who require additional support with their infant. Although the latter function of infant assessments is the least frequently used in practice, it represents a valuable addition with public health benefits to current, often observational, behavioral assessments as an implicit measure of infant-centered issues. While a number of infant behavioral assessments are currently used, there are several significant shortcomings to existing measures (e.g., restricted age of infant, requirement for extensive training of administrator, cost of the assessment, absence of established behavioral norms for comparison). Assessments of parental perception of infant behavior such as the BABI can potentially be given to large amounts of parents because they take little time and training to administer and can be used for the first half-year of an infant's life, before issues with parent-child relationships become more pervasive. Allocating resources to parents based on their perceptions of problematic infant behavior has implications for clinical practice as it could potentially help clinicians provide resources more effectively to the mother-infant dyads that need them the most.

The crying issues subscale was the only subscale in the BABI that did not have a comparative assessment where parents compared the amount that their infants cry to other infants. LF and LP were attempting to gather what they believed to be the most important indicators of domain specific infant behavior based on their expertise in infant development, and they did not believe that comparing the amount infants cry to other infants was as important as other factors such as intensity, frequency and ease of comforting. Of note, this subscale has the best internal consistency of all of the subscales ($\alpha = 0.86$).

This study demonstrates the relationship between infant issues and postpartum depression, but further research is needed to tease apart the directionality of these associations. Additionally, a considerable amount of the research on infant behaviors has focused on the impact of infant crying (5, 6, 40); however, there has been very little investigation into the impact of infant stomach issues on parental psychological status and vice versa. Focusing on parent perceptions of infant behaviors could be an important area for future research for individuals interested in Public Health.

Focusing on parental perceptions of infant behavior has the potential to aid professionals such as pediatricians in triaging parent-infant dyads to closer clinical follow-up or interventional supports. Screening for postpartum depression takes place routinely at gynecological offices, primary care practices and pediatrician's offices, which serve as ideal entry points for further assessment and referral. Even though screening for

postpartum depression is common in early postpartum pediatric appointments, controversy exists around whether it is intrusive to screen parents for postpartum depression and other issues at their children's health visits (rather than focusing on their child) since pediatricians are tasked with providing healthcare for the child and not necessarily the child's parents (41). To the point of focusing on the child, infants of mothers with depression and/or anxiety display variations in some behaviors [e.g., (42, 43)]. This study demonstrates the potential to focus on parental perceptions as they are related to maternal mental health and issues in parent-infant bonding.

Many of the at-home intervention programs are best understood as secondary prevention efforts and typically target populations with previously identified risk-factors [e.g., parental age, immaturity level; (44)] rather than parent report about trouble that they are having with their child. Although these programs appear to be a promising intervention for some parents, there are several limitations including parents being reluctant to having unfamiliar visitors in their homes (45), insufficient training of the individuals administering the intervention (46), and high average cost per family ($5,962) for running the programs (47). Targeting home visitations to parents with certain beliefs about their child (e.g., their infant is difficult compared to other infants), and consequently an explicit perceived need, might be more effective than targeting entire groups of parents (e.g., young parents).

A shift of focus to parent perceptions of infant behavior could help clinicians better allocate resources to the parents who need them the most. Interventions such as the Period of PURPLE Crying exist to normalize crying (48) and to prevent SBS as it relates to infant crying. The program is delivered to new parents in the hospital, in community settings such as at prenatal or well-child care visits, and through media (20). Findings are inconclusive regarding the effectiveness of the program in reducing SBS (49, 50). This might have to do with the fact that this intervention is designed to target a large audience (e.g., caregivers, community members, health care professionals) and is not specifically tailored for parents based on child characteristics such as how much they think their infant cries. We are missing critical entry points for intervention and opportunities to meet parents in the following situations: when perceived needs are high, when these concerns interact with known risk factors for maternal mental health, and when adverse outcomes occur for their offspring.

Limitations and Future Directions

Previous studies have found infant sleep issues to be associated with maternal depression; however, the directionality of this relationship is unknown (40). That finding was not replicated in this study. Future research might consider adding sleep questions that probe perceived quality of infant sleep. Furthermore, although this study focused on risk (parent mental health and issues in parent-child bonding), a beneficial future direction will be to identify protective factors in parent-child bonding.

The cross-sectional design prevented us from looking at test-retest reliability of the BABI Scale. It also prevented us from understanding directionality in terms of infant challenging behavior and new mothers' mental health. Therefore, it is possible that maternal mental health is impacting how parents perceive their infant's behavior. Longitudinal testing will be key to determine if parent assessment of infant behavior predicts only concurrent parent psychological status or if parent assessment of infant behavior at one time point is predictive of parent psychological status at a later time point. Infant sleep issues were not related to bonding issues or mothers' reported symptoms of maternal of anxiety or depression, however, larger studies are needed to explore these issues future. Longitudinal studies should probe the directionality to better understand whether mothers of infants who exhibit stomach issues and crying are more at risk for postpartum depression or if mothers with postpartum depression are more likely to perceive their infant's behaviors to be difficult in the first place. The directionality has important implications for points of intervention. It would also be interesting to examine the impact of parent education programs on parent perception of their infant's behavior using longitudinal studies.

Additionally, the sample consists of mostly white, middle-to-upper class, educated mother-child dyads, which may limit the generalizability to other diverse social and cultural groups. Researchers should attempt to replicate study findings with larger more diverse samples, and information about the test-retest reliability of this measure over time needs to be gathered. It is possible that relationships between infant behaviors such as sleep and parent mental health and infant-parent bonding issues will be significant with larger samples. Therefore, researchers should continue to pursue these research questions with larger more diverse samples. Additionally, further analyses can be done to examine if parent perceptions of infant behavior differ across parents from different demographic backgrounds. It would also be interesting to examine trends in parent perceptions of infant behavior across first-time vs. experienced parents.

Assessing parent perceptions of challenging infant behaviors represents a potential way for health professionals to identify infants who are higher risk and in need of intervention and parents in need of additional support. It may be of particular clinical importance for researchers to establish cutoff scores in order to screen for parents who indicate higher risk for problems such as bonding issues with their infant, infant abuse or parental depression and anxiety. However, these scores can only be determined through the application of this scale with large, diverse samples of parents of newborns.

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 University of Houston IRB. The patients/participants provided their informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LF is first author and TU is responsible for statistical analysis. All authors contributed to and approve the manuscript.

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REVIEW
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How to Support Parents of Infants and Young Children in Mental Health Care: A Narrative Review

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Objective: The aim of this narrative review is to gain insight into the appropriate intervention targets when parents of infants and young children suffer from psychopathology.

Background: Psychopathology in parents is a risk factor for maladaptive parenting and is strongly related to negative cascade effects on parent-child interactions and relations in the short and long term. Children in their first years of life are especially at risk. However, in adult mental health care, this knowledge is rarely translated into practice, which is a missed opportunity for prevention.

Methods: Electronic databases were searched for reviews and meta-analysis. In addition, sources were obtained via manual search, reference mining, expert opinion, and communications from conferences. In total, 56 papers, whereof 23 reviews and 12 meta-analyses were included.

Results: Findings regarding targets of intervention were identified in different interacting domains, namely the parental, family, child, and environmental domains as well as the developing parent-child relationship. A "one size fits all" intervention is not appropriate. A flexible, tailored, resource-oriented intervention program, multi-faceted in addressing all modifiable risk factors and using different methods (individual, dyadic, group), seems to provide the best results.

Conclusion: To address the risk factors in different domains, adult and child mental health care providers should work together in close collaboration to treat the whole family including mental disorders, relational, and contextual problems. A multi-agency approach that includes social services is needed.

Keywords: parental mental disorder, infants and early childhood, intergenerational transmission of psychopathology, targets of intervention, review

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INTRODUCTION

Children of parents with a mental disorder are at increased risk for developing mental health problems during their lifetime. The degree of transmission of psychopathology from parent to child ranges from 41 to 77% for the whole diagnostic spectrum (Hosman et al., 2009).

The risk for the child appears to be greater during pregnancy and early life, because these phases are crucial for the development of the brain and building a secure attachment relationship that impacts the development of the young child (Agorastos et al., 2019; Aktar et al., 2019). Pregnancy,

childbirth, and parenting are likely to be more challenging for parents with a mental disorder, and as a consequence may aggravate the psychopathology of the parent(s) (Barker et al., 2012; Falkov, 2012; Aktar et al., 2019). The transactional model (Sameroff, 2004) illustrates how the reciprocal nature of the parent-infant relationship over time affects both parent and child. For instance, if the parent is inadequately responsive to the infant due to their psychiatric symptoms, resulting in under-, over- or highly unpredictable stimulation, the infant will experience confusion and feel unsafe during interactions with the parent, which puts them at risk for developmental delays, insecure attachment styles, challenging behavior, and for the parent, less satisfying and more stressful parenthood. Hence, early childhood is an essential time window for the prevention and treatment of unfavorable parent-child interaction cascades. Therefore, in addition to treatment of the mental disorder of the parent, it is important to pay close attention to parenthood and the evolving parent-child relationship and to act as early in the child's life as possible to repair negative parent-infant interaction patterns (Forman et al., 2007). However, it remains unclear what should be the targets and means of both parent and child in mental health care to reduce the risk of psychopathology during infancy and early childhood.

The high degree of intergenerational transmission does not take place via a direct or simple pathway. Reupert et al. (2015) provide an overview of a number of different, mostly overlapping conceptual models that provide insight into the factors and mechanisms of transmission. The integrative model of Goodman and Gotlib (1999) for transmission of risk to children of depressed mothers is based on empirical data and clarifies the interrelated and interacting risk factors. Falkov (2012) developed the family model to promote transformation in mental health services to focus on the family rather than concentrating solely on the individual, with the aim to prevent the intergenerational transmission of psychopathology. Hosman et al. (2009) present a developmental model of intergenerational transmission of psychopathology with risk and protective factors within four different domains (parent, child, family, and environment) many of which are related to parental mental disorders. This model, as presented in **Figure 1**, is comprehensive in providing insight into which factors and mechanisms could be involved in the process of transmission.

However, there is not yet an all-encompassing framework that predicts and clarifies the developmental pathway by which parental mental disorder affects children, for this process is influenced by the presence and accumulation of interacting risk and protective factors (Maybery et al., 2015; Reupert and Maybery, 2016).

The objectives of this paper are, first, to identify important and effective intervention targets when parenting of infants and young children is included in the treatment of parents with psychopathology, in order to break through the cycle of intergenerational transmission of psychopathology, and second, to determine which among all the mentioned targets should have higher priority in order to achieve the goal of reducing the risk of transmission of psychopathology. In line with the purpose of this paper, we take a developmental-transactional perspective (Sameroff, 2004; Sroufe et al., 2009), which means that psychopathology develops through an interaction between person and environment and evolves over time. Although most research focuses on parents with a specific classification according to the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5; American Psychiatric Association [APA], 2013), in clinical practice there is wide variety in the phenomenology of mental disorders (Allsopp et al., 2019). Therefore, we will not focus on a specific classification to avoid the false impression that one is dealing with a homogeneous group that can be treated in a uniform way. We chose a narrative review because we wanted to include a wide range of data from a diverse body of literature, and many sources do not lend themselves to a quantitative pooling of results. The focus for this review will be on parents with serious psychopathology, predominantly of a chronic and complex type, that would be encountered in mental health care settings.

In this narrative review, we will present findings about intervention targets in mental health care to break the cycle of transmission of mental disorders and adverse outcomes. This covers intervention targets within different interacting domains, namely the parental, family, child, and environmental domains as well as the developing parent-child relationship.

MATERIALS AND METHODS

Electronic databases (PsycINFO and Web of Science) were searched for reviews in the period 2009–2021 using the following search terms: intergenerational transmission of psychopathology, OR parents with a mental illness, OR parental psychiatric disorder, AND/OR risk and protective factors, AND infants, OR infancy, AND interventions, AND reviews, AND Children of Parents with a Mental Illness (COPMI), AND Children of Mentally Ill Parents at Risk Evaluation (COMPARE). Because of the broad topic of this literature review and the variety of scientific fields that are involved (e.g., parental psychiatry, developmental psychopathology, infant mental health, attachment, resilience science, trauma and toxic stress, genetics and epigenetics, neuroscience and neuroendocrinology), we first searched for reviews and 916 hits of research papers and reviews were found. After reading the title of all, 117 were selected as relevant to the topic and after reading the abstract 33 for close reading, whereof six papers were included in the review. The inclusion criteria were: (1) risk and protective factors for child's psychopathology and adverse outcome related to parental mental disorders; (2) the period of infancy or early childhood; (3) young child, and family resilience; (4) interventions; (5) review; (6) meta analytic study; (7) English language; (8) peer reviewed. Exclusion criteria were: (1) child's cognitive development or school achievement related to parental mental disorder; (2) risk factors to specific child mental health disorders, such as ADHD, autism spectrum disorders, not specific related to parental mental disorders; (3) interventions preventing parental mental disorder not related to child outcomes; (4) interventions whereof the period of early

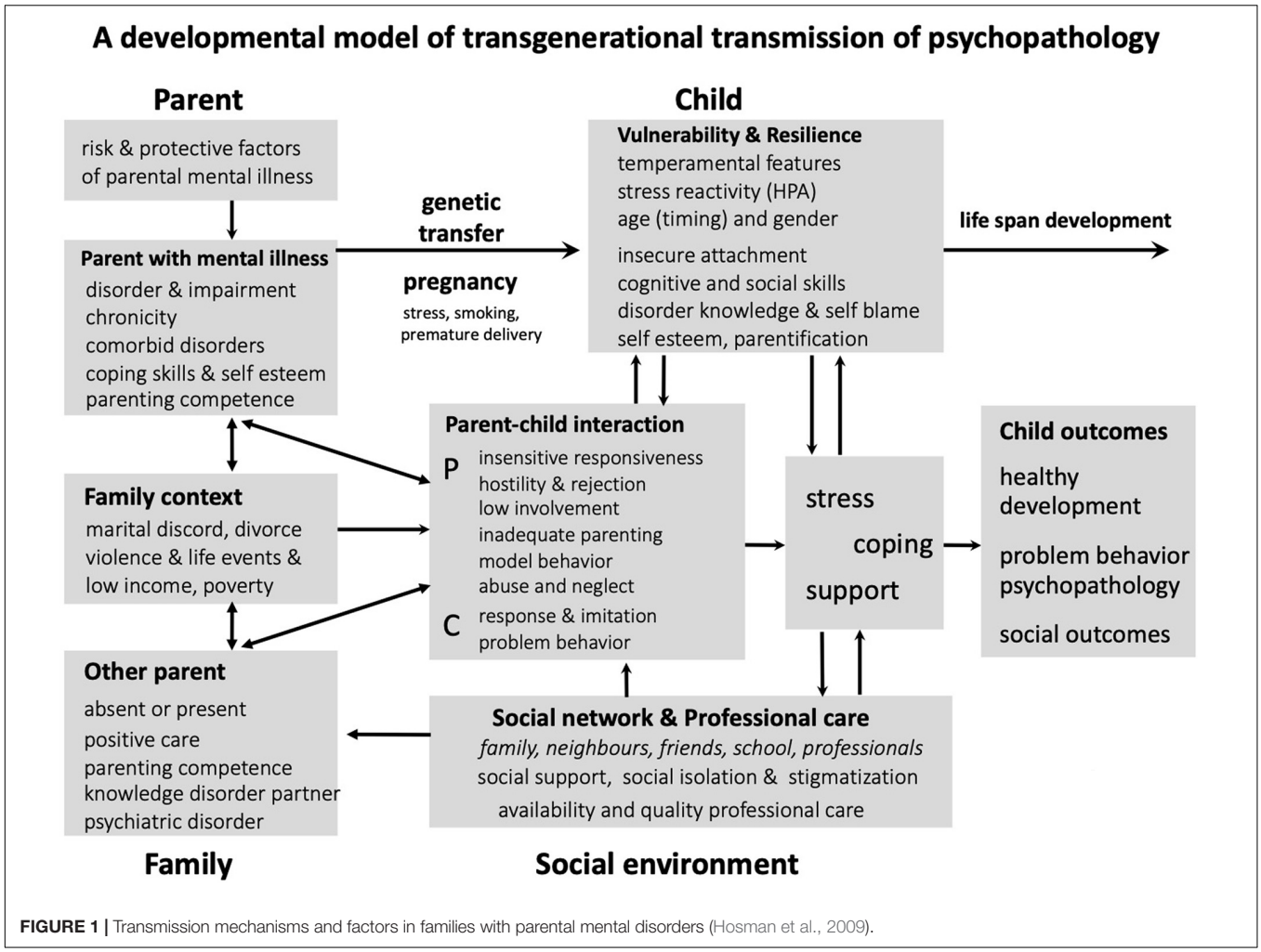

FIGURE 1 | Transmission mechanisms and factors in families with parental mental disorders (Hosman et al., 2009).

childhood was not a substantial part; (5) interventions related to physical health of the young child (medical, nutrition). However, crucial risk and protective factors in relation to intervention targets to prevent the transmission of psychopathology during infancy and early childhood according to the model of Hosman et al. (2009) were missing (e.g., attachment, resilience, adverse child experiences). We conducted additional hand searching and reference mining, alongside obtaining information from other sources such as communications at conferences and correspondence with experts. This resulted in 17 new reviews, so a total of 23 reviews were included. In addition, 12 meta-analytic studies were included. We could not find any reviews or meta-analyses on the particular impact and intervention targets in the presence of cumulative risk factors, poly victimization, and how to promote resilience during infancy and early childhood. On these particular topics we searched for papers in the same manner as described above, using the same inclusion and exclusion criteria and 21 papers about intervention targets have been added. In summary, this review on appropriate intervention targets when parents of young children suffer with psychopathology is based on 56 publications.

RESULTS

Because no reviews have been found about different intervention targets related to risk and protective factors for parents with psychopathology and their young children in mental health care, the focus in this section is to present an overview of the risk and protective factors that are specific to the phase of early childhood. In particular, the modifiable factors for the different domains (parental, parent-child relationship, family, child, and environmental) are subsequently reviewed in relation to intervention targets. We finally end by summarizing risk factors, and the targets of intervention which aim to modify the risk factors into protective factors.

Risk and Protective Factors

Interaction mechanisms among risk and protective factors in the four different domains, as presented in **Figure 1**, highly impact child's development and mental health outcome. Therefore, all risk factors suggest directions in treatment of parents and their young child to prevent the risk of intergenerational transmission of psychopathology (Christiansen et al., 2019). Risk factors related to the parental, family, child, and environmental

TABLE 1 | Risk factors during pregnancy and early childhood in different domains related to parental mental disorder.

Parental domain	Family domain	Child domain	Environmental domain
Genetic transmission[1]	Early parenthood[16,17]	Difficult temperament[4,6,2,3]	Low socio- economic status[16,31,32]
Maternal anxiety and stress in pregnancy[2,3]	Single parenthood[16,17]	Mental health disorders[23]	Poverty[4,18,17,33]
Severity, chronicity or early onset of the disorder[4,5,6]	Child abuse (physical, emotional, sexual)[4,18,19,20]	Genetic vulnerability to environmental influences[24]	Housing problems[18,32]
Comorbidity (e.g., substance abuse)[4,6]	Child neglect (physical, emotional)[18,19,20]	Effects of early life stress and trauma/ACEs[25,26]	Social isolation[18,32]
Unresolved (childhood) trauma[7,8,9]	Unpredictable or lack of daily routines[11,21]	Insecure and disorganized attachment[4,6,10,27,28,29,30]	Belonging to a minority group[34], perceived discrimination[32]
Absence of treatment[6,10]	Mental disorder/addiction other parent/family member[22,6,19]		Low quality of neighborhood[18,32]
Problematic parenting[4,11,12,13,14]	Interparental conflict/violence[4,16,18,19,12,20]		Absence or low quality of emotional and practical support network[16,32]
Frightened, frightening disrupted parental behavior[8]	Absent of both biological parents[19]		Absence or low quality of adult and child professional care[6]
Impaired and distorted parental mentalization[15]	Criminal trouble/imprisoning family member[3,12,18]		No possibilities for alternative care[18]
	Low level of education[16,17]		

[1]Kendler and Prescott, 2007; [2]Korja et al., 2017; [3]Van den Bergh et al., 2017; [4]Beardslee et al., 2011; [5]Carter et al., 2001; [6]Hosman et al., 2009; [7]Christie et al., 2019; [8]Madigan et al., 2006; [9]Suardi et al., 2017; [10]Aktar et al., 2019; [11]Falkov, 2012; [12]Hughes and Cossar, 2016; [13]Hugill et al., 2017; [14]Laulik et al., 2013; [15]Sharp and Fonagy, 2008; [16]Barker et al., 2012; [17]Evans et al., 2013; [18]Brockington et al., 2011; [19]Felitti et al., 1998; [20]Kessler et al., 2010; [21]Stepp et al., 2012; [22]Bijl et al., 2002; [23]Slade, 2009; [24]Bakermans-Kranenburg and van IJzendoorn, 2007; [25]Agorastos et al., 2019; [26]Chu and Lieberman, 2010; [27]Fearon et al., 2010; [28]Granqvist et al., 2017; [29]Sroufe et al., 2009; [30]Van IJzendoorn et al., 1999; [31]Stein et al., 2014; [32]Silva et al., 2016; [33]Lund and Cois, 2018; [34]Cyr et al., 2010.

domains, with references to the literature, are presented in **Table 1**.

Protective factors which can play a protective role in the transfer of psychopathology in the different domains are presented in **Table 2**.

An epidemiologic study by Kessler et al. (2010) showed that childhood adversities often co-occur. Several studies indicate a dose-dependent response relation of childhood adversities to mental health outcomes, which means that the number of traumas and adversities is a significant predictor of mental health disorders (Barker et al., 2012; Evans et al., 2013). A longitudinal study (Barker et al., 2012) investigated the impact of the exposure of infants from birth to 2 years old to several risk factors and the impact of maternal depression on child psychopathology at 7 years. They found evidence that a substantial proportion (37–41%) of the association between risk factors and maternal depression was explained by increased risk factor exposure. Beside exposure to maternal depression, each additional risk factor increases the odds at least 20% for child psychopathology.

Targets of Intervention in Different Domains

The following section will describe intervention targets in the domain of the parent, the family, the child, and the environment, and the early parent-child relationship as a crucial transmission mechanism, all of which are considered to be important in limiting the risk of transmission of psychopathology from parent to child.

Parental Domain

Genetic transmission and epigenetic regulation

The risk of *transmission of specific genes* from parent to child which increases the probability of psychopathology in the child (Kendler and Prescott, 2007), is not a modifiable factor. This significant risk justifies categorization as a high-risk group that needs preventive interventions. Epigenetic changes in transcription of genes have been shown in interaction with the environment, especially in early development and following adverse experiences. *Maternal anxiety and stress during pregnancy* are major risk factors for later negative child difficulties (Van den Bergh et al., 2017). Exposure to early life stress and childhood trauma, possibly arising from parental psychopathology, further enhance the risk of epigenetic programming which over time may lead to stress-related disorders (Agorastos et al., 2019). The quality of the parental environment is an important factor that can be modified and therefore it is a crucial target of intervention.

Parenting in relation to psychopathology

Much is known about how parenting can be affected by a mental disorder. Most studies address concerns related to depression in mothers and its influence on their caregiving such as unresponsiveness, intrusiveness, hostility, or high expressed emotions (Beardslee et al., 2011). There is also evidence of problematic parenting by parents with a personality disorder, for instance switches between hostile control and withdrawn behaviors as well switches between intrusiveness and coldness (Stepp et al., 2012; Laulik et al., 2013). An association has been found between PTSD and impaired parenting and less than optimal parent-child relationships (Christie et al., 2019). A systematic review of the relationship between *maternal*

TABLE 2 | General protective factors in early childhood in different domains, which may have a buffering effect on families where a parent has a mental disorder.

Parental domain	Family domain	Child domain	Environmental domain
Physical health[1]	Presence of a well-functioning other (step-) parent[7,8]	Physical health[1]	Stable and adequate income[1,6,15]
Self- and parental efficacy[1,2,3]	Warm, cohesive family interaction[1]	Easy temperament[1,10,7]	Adequate housing[1]
Good emotion and stress regulation[1,4]	Marital stability, support and satisfaction[1,3,4,6,9]	Insusceptible for environmental influences[11]	Safe neighborhood[1,15,16]
Effective coping skills[1,2,4]	Small family (<4 children)[1]	Secure attachment[1,2,4,12,13,14]	Social support (emotional/practical) [1,6,7,16,17]
Internal locus of control[1]	Moderate or high level of education[1,6]		Involvement in the community[1,6,15]
Positive belief systems[1,2,3]	Supportive and stimulating parent-child interaction[1,2,4]		Access to good quality childcare and school[1,4,6]
Appropriate parental mentalization[5]/secure attachment[6]			Access to good quality (mental) health care[1,6,7,16]

[1]Benzies and Mychasiuk, 2009; [2]Doty et al., 2017; [3]Korja et al., 2017; [4]Masten, 2018; [5]Slade et al., 2005; [6]Tharner et al., 2012; [7]Hosman et al., 2009; [8]Stein et al., 2014; [9]McEwen, 2003; [10]Beardslee et al., 2011; [11]Bakermans-Kranenburg and van IJzendoorn, 2007; [12]Seifer, 2003; [13]McGoron et al., 2012; [14]Schechter and Willheim, 2009; [15]Silva et al., 2016; [16]Brockington et al., 2011; [17]Falkov, 2012.

childhood trauma (emotionally abusive or neglectful experiences) and parenting found tentative support for a range of adverse parenting outcomes, including increased parenting stress and a higher risk of maltreatment, lower empathy, and greater psychological control (Hughes and Cossar, 2016). Hugill et al. (2017) found support for an indirect pathway from childhood sexual abuse of parents through parental depression to parenting stress. Notwithstanding the above mentioned risks, parenting can also be a positive resource for parents with mental disorders, as it may be a source of structure and stability and act as a motivator to manage their symptoms in a better way (Schrank et al., 2015).

Problematic parenting behavior and distorted parental mentalization

Parenting can be a key moderating or mediating factor in transmission of mental disorders from parent to child and therefore should be an important target of intervention (Brockington et al., 2011; Stein et al., 2014). Specific *problematic parental behavior* related to mental health problems includes overinvolvement (intrusiveness and/or overprotection), underinvolvement and neglect (unresponsiveness to physical and emotional needs), negative involvement (hostility and irritability), inconsistent involvement (inconsistency in providing daily structure and predictability), inadequate discipline and control (harsh discipline and criticism), role reversal (parent seeks comfort from child), developmentally inappropriate expectations, and lack of modeling (Falkov, 2012).

Parental mentalization or parental reflective functioning (PRF) refers to the parent's capacity to understand their own as well as their child's internal states. It allows them to regulate and comfort their child in an appropriate way and for that reason plays a vital role in the development of attachment and the child's self-regulation and capacity to mentalize (Slade et al., 2005). *Distorted parental mentalization* is associated with disorganized attachment and development of psychopathology in their children (Sharp and Fonagy, 2008). Low reflective function (RF) has been found among adults with different types of mental disorders (Katznelson, 2014).

The nature of the parental mental disorder

The chance that the child will develop a disorder is not strongly dependent on the specific disorder of the parent (Bijl et al., 2002). *Severity, chronicity, and degree of comorbidity of parental psychopathology* has been shown to contribute more to parental behavior than specific disorders (Carter et al., 2001) and to the likelihood of transmission (Beardslee et al., 2011). In this context, a*bsence of treatment* is an obvious risk (Hosman et al., 2009; Beardslee et al., 2011). *Early onset* (before age 30) of a disorder is an additional risk, because of the higher likelihood of adverse social, educational and work circumstances found in young mothers (Hosman et al., 2009).

Allsopp et al. (2019) demonstrate that most DSM-5 classifications are associated with adversities or trauma in childhood. Acknowledging the possible role of trauma or adversity in the unfolding of psychopathology, interventions should also address past traumatic experiences. This is crucial because the presence of *unresolved childhood trauma* in parents is known to be an important threat to their parenting, for example, in *frightened, frightening, and disrupted behavior,* and the early parent-child relationship (Madigan et al., 2006; Suardi et al., 2017). Indeed, parents' post-traumatic stress symptoms may impair self-regulation and the parent's ability to regulate the young child, who depends greatly on interactive co-regulation with the caregiver (Chu and Lieberman, 2010; Suardi et al., 2017). The child's behavior or distress itself can provoke and revive the post-traumatic stress symptoms caused by unresolved trauma experienced by the parent. In this process, parent and child may be caught in an unintended repeating traumatic interaction circle. Therefore, screening and treatment for unresolved parental childhood trauma will benefit the parent, the child, and their relationship (Chu and Lieberman, 2010; Suardi et al., 2017).

Although treatment of parents' mental disorders and trauma can play a role in the prevention of mental disorders in their children, interventions targeting the parent-infant relationship have been shown to produce larger overall effects in improvement of this dyad than individual interventions targeting mothers only

(Kersten-Alvarez et al., 2011; Tsivos et al., 2015; Thanhäuser et al., 2017; Aktar et al., 2019). Evidence suggests that explicit attention has to be paid to the parent-child relationship in order to improve the emergence of undesirable patterns, such as a lack of parents' responsiveness to the child (Carter et al., 2001; Nylen et al., 2006; Forman et al., 2007; Schechter and Willheim, 2009; Barlow et al., 2010; Barker et al., 2012; Barnes and Theule, 2019).

Summary

Parental mental disorders may be a serious threat to the quality of parenting. Parenting is a key moderating and mediating factor in the process of transmission of mental disorders. The capacity of the parent to understand their child's emotion and behavior and to help their child's regulation in appropriate ways depend on parental mentalization. Parental behavior and parental mentalization as highly influential factors are strongly related and therefore important targets for intervention.

The severity, chronicity, comorbidity, and early onset of parental mental disorder and unresolved parental childhood trauma increase the likelihood of intergenerational transmission of psychopathology. Treatment of the disorder and unresolved childhood trauma of the parent(s) should be accompanied by explicit attention to the developing parent-child relationship in order to prevent the emergence or continuation of undesirable parent-child interaction patterns.

The Early Parent-Child Relationship

The parent-child relationship is generally the most proximal and influential relational system for the child. Preliminary support in clinical samples suggest a link between higher levels of *insecure attachment* in infants and parental behavior related to mental disorders, but further research is needed (Aktar et al., 2019; Barnes and Theule, 2019). Seifer (2003) argued that fostering resilience of very young children of a parent with a mental disorder on the individual level is complicated, as they have not developed the functions and skills needed to develop resilience such as verbal skills and high-level cognitive functioning. Furthermore, they function in limited social contexts and miss independent access to various social communities that are assumed to be a protective factor for older youth. The focus of the resilience process needs to be the parent-child system (e.g., attachment) as an interim outcome because if there are unresolved disturbances in this relationship it will increase the risk of adverse child outcomes (Seifer, 2003). A positive change in that relationship will have positive spillover effects over time on other domains with long-term benefits to the parent (parental efficacy, positive emotions) and child (cognitive, emotional, and social functioning) (Doty et al., 2017).

Enhancing secure attachment as a protective factor

Secure attachment can be seen as an interim outcome and a buffering protective factor against the development of psychopathology (Seifer, 2003; Schechter and Willheim, 2009; McGoron et al., 2012). Parental sensitivity to children's cues is associated with and currently seen as an important—but not the only—predictor of secure attachment (Bakermans-Kranenburg et al., 2003), and for that reason is a key target in many attachment-based interventions. Parental sensitivity refers to the ability to accurately perceive and interpret the infant's signals and communications and respond appropriately. However, a recent meta-analysis (Zeegers et al., 2017) of parental mentalization and sensitivity as predictors of infant-parent attachment highlights a direct effect of parental mentalization on infant-parent attachment independent of parental sensitivity, as well as an indirect impact on attachment via its effect on sensitivity. Therefore, parental mentalization as well as parental sensitivity are important targets for interventions to enhance secure attachment. This implies helping parents to think about behavior as an expression of the intentions and internal mental states of their child. It also necessitates changing the parental representation of the child, with the result that the parent is able to see the child as having an inner life separate from their own (Slade et al., 2005).

Reducing the risk of insecure and disorganized attachment

Insecure and especially disorganized attachment in young children has been associated with later mental health outcomes such as problematic stress management, externalizing and dissociative behavior, and borderline personality disorder (Van IJzendoorn et al., 1999; Sroufe et al., 2009; Fearon et al., 2010). Disorganized attachment is the opposite of organized attachment, and entails the child becoming stuck in an unresolvable conflict between being afraid of the parent and at the same time needing comfort from the parent. This conflict, described as "fright without solution," is observable in a breakdown of attachment strategies in a stressful situation in the presence of the parent. For instance, it may involve contradictory behavior such as seeking proximity to and turning away from the parent, and stereotyped behavior such as extended rocking. On a biobehavioral level there is a measurable increased level of cortisol (Spangler and Grossmann, 1993).

There are different pathways to disorganized attachment, and one is directly related to parental psychopathology. An association has been found between subtly frightened, frightening, and disrupted maternal behavior and disorganized attachment in infancy (Madigan et al., 2006). Due to unresolved parental trauma and loss, parents themselves may become sources of chronic stress for their infants because of an ongoing state of fear, dissociative behavior, limited availability and responsiveness, and restrictive and overprotective behavior (Chu and Lieberman, 2010; Suardi et al., 2017).

Given the association between disorganized attachment and later mental health outcomes, preventive interventions targeting attachment relationships in infancy are needed. A recent meta-analysis (Facompré et al., 2018) demonstrates that interventions targeting disorganized attachment have been generally effective. The interventions in the studies focused on enhancing parental sensitivity to the infant's cues, on modifying the parental representations of the child in relation of the caregiver's own attachment history, and on the effect of practical support and education on child development. The findings show no significant differences among the intervention foci. Another meta-analysis of interventions that aim to decrease or to prevent disorganized attachment in early childhood shows a reduction in

disorganized attachment, with the majority of the interventions focusing on maternal sensitivity (Wright et al., 2017). On the other hand, Benoit et al. (2001) argue that interventions should target disorganizing interactions between caregivers and their children. Instead of blaming parents for their children's disorganized attachment, Granqvist et al. (2017) emphasize that caregivers need help to learn to follow the child's lead, avoid alarming behavior and provide nurturance, make sense of traumatic experiences, break social isolation, and learn strategies to remain with the child in the moment rather than become lost in memories.

Summary

The way parents interact with their infants is essential for building a secure attachment relationship during the first year of life, and is associated with healthy social and emotional development outcomes. Secure attachment can be seen as an intermediate outcome and a buffering protective factor against the development of psychopathology. Given the association between disorganized attachment and later mental health outcomes, preventive and curative interventions targeting attachment relationships in infancy and early childhood is a desirable response. Intervention should target enhancing parental mentalization and sensitivity, reducing disorganizing interactions between caregivers and their children, promoting practical support, and education about child development.

Family Domain

The parent and the parent-infant relationship usually function in the broader context of family life. Family factors, such as the functioning of the other (co-)parent, quality of the partner relationship, and family functioning are strong predictors of mental health outcomes. *Low level of education, early parenthood, and single parenthood* are not modifiable risk factors (Barker et al., 2012; Evans et al., 2013), although attention can be paid to diminish the social consequences for instance by social work interventions.

The other (co-)parent

Children whose *parents both have one or more mental disorders* have an increased risk of developing a disorder themselves (66%) compared to children whose one parent has a mental disorder (51%), and almost twice as high compared to children with parents without a mental disorder (35%) (Bijl et al., 2002). Healthy functioning of the other parent is mentioned as an important protective factor because it might have a buffering effect on the impact of the parent with a mental disorder on the child, and for this reason the (co-)parent should be routinely involved in the assessment phase of treatment (Stein et al., 2014). Improved child outcomes have been found when fathers are involved in family focused interventions (Harold and Sellers, 2018).

Quality of the partner relationship

This is mentioned as an important protective or risk factor because of its direct impact on the parental mental disorder and indirect impact on the child's outcome. Social support through a loving and caring relationship with a partner appears to have an ameliorative effect on psychopathology caused by early life adversity (McEwen, 2003).

Interparental conflicts predict children's problematic functioning even after controlling for other family and ecological characteristics (Cummings and Davies, 2002). A recent study found that the association between fetal exposure to parental mood disorder and children's internalizing problems at 24 months is mediated by poor postnatal quality of the couple's relationship (Hughes et al., 2019). This study recommends clinical interventions to improve couple relations during pregnancy to benefit the child's later outcomes. Korja et al. (2017) mentioned marital support and satisfaction as moderators that may attenuate the negative impact of prenatal exposure to maternal stress, depression, and anxiety.

Given the high prevalence of *interparental violence* against women with perinatal mental disorders (depression, anxiety, and PTSD), mental health services should identify and respond to interparental violence against women they treat (Howard et al., 2013). In the presence of interparental conflicts, interventions that target these conflicts at the level of the interparental relationship may benefit the child's psychopathological outcomes in the long term significantly more than interventions that target the parent-child relationship (Harold and Sellers, 2018). Therefore, the interparental relationship should get priority.

Quality of family functioning

Benzies and Mychasiuk (2009) mentioned warm interaction and family cohesion as one of the most significant protective factors for families with a parent who has a mental disorder. It provides family members a safe haven for development and is known as a buffering factor which protect children from the negative consequences related to low-income. Fostering protective factors in the family is a strength-based intervention which promote family resilience to cope with adverse events.

Unpredictable or lack of daily routines is a risk factor (Falkov, 2012), often associated with the presence of a borderline personality disorder at the parent, which should be prioritized over attachment issues (Stepp et al., 2012). Kessler et al. (2010) analyzed data from 21 countries and found that childhood adversities associated with maladaptive family functioning such as parental mental disorder, *interparental violence*, *criminal behavior*, *neglect*, and *physical and sexual abuse* of the child were the strongest predictors of mental disorders over the course of the child's lifetime. Child maltreatment is associated with disorganized attachment and adverse outcomes (Cyr et al., 2010). The prevalence of child maltreatment is elevated in the presence of a parental mental disorder, even more so when both parents are affected (Chang et al., 2018). In a review regarding the impact of traumatic stress from birth to age 5, Chu and Lieberman (2010) argued that the prevalence of trauma in early childhood is highly underestimated and seldom investigated by researchers. Childhood trauma and stress has been estimated to account for 45% of the variance of psychopathology beginning in childhood and 26–32% in adulthood (Tyrka et al., 2013). Finkelhor et al. (2007) highlight the role of poly-victimization, a phenomenon neglected by researchers and practitioners. If a child was exposed

to one kind of trauma or adverse experience it is more likely that they will have been exposed to additional traumas. For this reason, they argued that professionals need to assess for a broader range of traumas and early interventions. The impact of traumatic stress depends on the quality of the parent-child relationship, because for the infant the attachment relationship is an important resource for regulating emotions and stress (Chu and Lieberman, 2010; Shonkoff et al., 2012). The child's traumatic experiences should be treated in the context of the caregiver-child relationship (Chu and Lieberman, 2010).

A parent with psychopathology is one of the risk factors in the Adverse Child Experiences (ACE) Study (Felitti et al., 1998), a huge epidemiological study in the United States which has been replicated several times. It shows how adverse childhood experiences or traumas from infancy to 18 years of age can lead to medical disease and psychopathology. The effects of ACE start in early childhood and can be long-lasting (Felitti et al., 1998). The 10 empirically selected ACE categories, mostly related to family functioning, are *abuse (emotional, physical, sexual*), *neglect (physical, emotional*), and household dysfunction *(parental violence, household member was addicted, imprisoned, mentally ill or in psychiatric hospital, not raised by both biological parents)* (Liming and Grube, 2018). An individual ACE score is calculated by counting the number of categories experienced in childhood. The ACE Study found that the impact of the different ACE categories is more or less the same, and with an ACE of four or more, the risk of adverse outcomes is significantly increased. Young children age 0–6 with three or more ACEs were significantly more likely to exhibit behavioral problems (e.g., aggression, attention problems), mental health problems (e.g., anxiety), and overall problems compared with children with no ACEs (Liming and Grube, 2018).

Summary

Family factors can act as strong protective or risk factors for intergenerational transmission. Assessment of family factors is necessary and should include the role and mental health of the other parent, the quality of the couple relationship and family functioning, especially the presence of ACEs and trauma. Maladaptive family functioning is a strong risk factor. Interparental violence or marital conflict should get a higher priority for intervention than the parent-child relationship. Warm and supportive interactions between family members is a strong protective factor. To reduce the impact of ACEs and early childhood trauma, treatment should be in the context of the current attachment relationship.

Child Domain

Child vulnerabilities

Infant characteristics may function as a protective as well as a risk factor. Vulnerabilities may be independent of the parent's psychopathology as well as result of exposure to risk factors related to parent's psychopathology or an interaction of both. However, children's vulnerabilities pose a risk for the developing parent-child relationship, for they challenge parenting and the mentalizing capacity of the parent (Sharp and Fonagy, 2008).

Differences in reactivity, activity and self-regulation are seen as features of temperament whereby a difficult temperament refers to negative affect or irritability, withdrawal in response to novelty, high intensity of emotions and irregularity of biological processes such as feeding and sleeping (Korja et al., 2017). An infant or young child with a difficult temperament demands much more effort from the caregiver in the interpersonal regulation compared to a child with an easy temperament. Therefore a *difficult infant temperament* is a frequently identified risk factor (Korja et al., 2017; Van den Bergh et al., 2017), and conversely an easy temperament is a protective factor in the presence of risk (Benzies and Mychasiuk, 2009; Beardslee et al., 2011).

In accordance with the fetal programming model, there is robust evidence that early negative environmental factors, such as maternal anxiety, depression or stress in pregnancy (Korja et al., 2017; Van den Bergh et al., 2017) constitute a major risk factor for negative outcomes for the child later in life due to the plasticity of biological systems of the fetus in adaptation to the environment. Korja et al. (2017) suggest that there is evidence of an association between higher prenatal stress and anxiety and elevated negative reactivity or poorer self-regulation, both features of a child's temperament. Exposure to prenatal stress, possibly resulting in difficult childhood temperament, can increase the risk of later psychopathology, partly due to the impact of non-optimal parenting provoked by the child's difficult temperament. Van den Bergh et al. (2017) found that maternal stress during pregnancy was related to increased risk for behavioral problems and a wide range of mental health problems in the offspring. Prenatal exposure to maternal anxiety or depression is associated with many aspects of brain functioning in offspring such as impulsivity and attention.

To prevent unborn children from suffering the negative effects of maternal stress during pregnancy, Van den Bergh et al. (2017) recommended that pregnant women should be protected from undue hardship and stress and advised to avoid preventable stressors. Korja et al. (2017) suggest maternal caregiving sensitivity, maternal self-efficacy, and marital support and satisfaction (see also Tharner et al., 2012) are moderators that may attenuate the negative impact of fetal programming. Based on these findings, they advise preventive approaches and active treatment to help mothers who are experiencing prenatal stress or anxiety and prevent their offspring from having long-term difficulties in self-regulation. To mitigate the risk of early transmission of psychopathology Aktar et al. (2019) suggest intensive treatment of prenatal and postnatal depression alongside with interventions targeting the mother-infant interactions.

Children with *mental health disorders* themselves according to the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood (DC:0-5^{TM}) (Zero to Three, 2016), challenge the pleasure of and confidence in parenthood. For example, those on the autistic spectrum, who are born with fundamental problems in understanding social information and developing relationships with others, may be a challenge for their parents due to the

lack of reciprocity. Parents of these children are in need of help connecting with their child (Slade, 2009).

As mentioned before *early life stress and trauma* leave their traces on child's development (Agorastos et al., 2019) and may also contribute to an *insecure and disorganized attachment style,* which need treatment as discussed in the section on the early parent-child relationship (Granqvist et al., 2017).

Susceptibility to environmental influences

Bakermans-Kranenburg and van IJzendoorn (2007) highlight the role of *genetic factors in creating differences in susceptibility* to positive or negative environmental influences. If there is a high susceptibility to environmental influences, risk factors such as maltreatment or neglect will have a highly negative impact on child development, whereas a supportive environment will be of great benefit and contribute to the development of resilience. If there is a low susceptibility to environmental influences, there is less impact of negative child rearing experiences on children's development, but there is also little benefit from treatment. These individual differences underline the importance of an individual assessment, while the presence of risk factors and exposure to traumatic experiences will not automatically lead to a disorder or adverse child outcomes.

Summary

Children's vulnerabilities as a difficult temperament, mental health disorders, the impact of trauma, insecure and disorganized attachment, challenge the mentalizing capacity of the parent, and therefore represents a risk factor for the development of the parent-child relationship. Exposure to prenatal stress, anxiety, or depression, and as a possible consequence the development of a difficult temperament and behavioral problems in the child, can increase the risk of later psychopathology. Preventive approaches, such as stress reduction during pregnancy, psycho-education, and active treatment of the parent-child relationship will help parents when their offspring have long-term difficulties in self-regulation. Parental sensitivity, self-efficacy, and marital support and satisfaction are moderators that may attenuate the negative impact of fetal programming. In the presence of a mental disorder or disorganized attachment style in the child, parents need specific help in learning how to stay connected, during which they also self-regulate in a healthy manner.

Environmental Domain

The parent-child relationship develops within a larger ecological context with complex interactions between proximal factors (e.g., parenting) and distal factors (e.g., poverty) (Little et al., 2004). Research with a focus on social and economic determinants of mental health found evidence for a association between worse mental health and *poverty* (Silva et al., 2016; Lund and Cois, 2018), *low socio-economic status*, *low quality of neighborhood*, *housing problems*, *perceived discrimination*, *social isolation*, and *lack of social support* (Silva et al., 2016).

Barker et al. (2012) have found evidence for additional or independent impact of environmental risk factors (e.g., *low socio-economic status*, *low emotional, and practical support network*) along with parental mental disorders on children's adverse outcomes. A meta-analysis by Cyr et al. (2010), shows an impact on child insecure and disorganized attachment by cumulative socio-economic risks of which low income, and *belonging to a minority group* is mentioned beside other risk factors. To explain this relationship between the accumulation of environmental risk factors and disorganized attachment, it is hypothesized that parents are so occupied with their personal and daily concerns, for example about money, housing, employment, that they withdraw from interacting with their child and are lacking in being predictably and safely available to them. Families with cumulative risk factors are at risk for chaotic living and child-rearing conditions, and neglect (Cyr et al., 2010).

A review of the effects of perinatal mental disorders on the fetus and the child (Stein et al., 2014) shows that children of parents with a mental disorder in low-income families are more affected by a parent's mental disorder than children in more affluent families, and therefore interventions could be most important in such adverse circumstances.

Children of depressed mothers are exposed to significantly more risk factors than children of mothers without depression, with on average 2.3 risk factors for the former versus 1 risk factor for the latter (Barker et al., 2012). These risk factors include beside others, *low socio-economic status*, and *an inadequate emotional and practical support network*. Brockington et al. (2011) mentioned, as an example of the latter, families *without possibilities for alternative care* and Hosman et al. (2009) mentioned the *absence or low quality of adult and child professional care*.

All above mentioned authors argued, that social and economic risk factors should be targeted to improve (parental) mental health and reduce the number of risk factors to which children are exposed, especially risk factors that are responsive to intervention. In addition, the focus should be on enhancing protective factors such as social support, alternative care, and resources (Brockington et al., 2011; Falkov, 2012; Tharner et al., 2012).

Summary

Adverse socio-economic conditions and the presence of a (parental) mental disorder often occur simultaneously and reinforce each other. Children exposed to both are more affected than children exposed only to the latter. Consequently, besides treating the parental mental disorder, socio-economic risk factors should be targeted. Social support, for instance by the extended family, and possibilities for alternative care are important protective factors to take in account.

Summary of Intervention Targets

An overview of above mentioned risk factors, intervention targets, and the intended results which will act as a protective factor in the domain of concern is presented in **Table 3**.

Given the multiple interacting risk and protective factors and the large variety of family contexts, there is no universal approach for prevention and treatment. Little et al. (2004) argued that there are several points at which it is possible to intervene in the causal chain, and make a distinction between the role of proximal and distal processes in developmental deficiency,

TABLE 3 | Risk factors and targets of intervention in different domains to prevent for intergenerational transmission of psychopathology and adverse outcome.

Domains	Parental disorder	Partner relationship and family life	Parent-infant relationship	Child	Environment
Risk factors	Early onset Severity Comorbidity Addiction Unresolved (childhood) trauma Absence of treatment	Early and single parenthood Absence of both parents Conflict or low quality in partner relationship Psychopathology (addiction) of other parent Child abuse or neglect Unpredictable or lack of daily routines Imprisoning/criminal trouble family member Low level of education	Problematic parenting and parent-child relationship Disorganizing interactions between parent and infant	Difficult temperament Mental health disorders Early life stress Trauma/ACEs Significant risk with ≥3 ACEs Insecure and disorganized attachment	Low socio-economic status Poverty/debts Housing problems Social isolation No supportive network Belonging to minority group Low quality of neighborhood Absence or low quality of support network, and professional care No possibilities for alternative care
Targets of Interventions	Treat the mental disorder Treat (childhood) trauma Treat addiction problems	Involve partner Address interparental violence and child abuse or neglect Enhance marital support and satisfaction Treat mental health problems of other parent Promote consistency in daily structure	Involve other parent Diminish problematic and disorganizing parental behavior Enhance parental mentalization and sensitivity Educate parent about child development Enhance parental efficacy	Treat infant problems, trauma and early life stress in the context of the parent-child relationship	Enhance social support (extended family, friendships) and if necessary, make provision for alternative care Reduce the impact of environmental risks (e.g., housing, financial, poverty, criminality, stress)
Results/protective factors	Better mental health	Warm and supportive marital and family life	Secure attachment	Optimal development	Increased capacity to carry out parental tasks Supportive network

whereby the first operates nearby (e.g., poor parenting) and the latter far from the developmental deficiency (e.g., poverty). Children's exposure to cumulative risks almost always has a greater impact on development than exposure to a single risk, and interventions targeting the full range of risks are more likely to be effective (Evans et al., 2013). There is also a suggestion of more benefit for children's development when there is an accumulation of resources in the presence of risks (Evans et al., 2013). Therefore, intervention targets can differ and should be based on assessment of the individual profile of vulnerabilities and strengths to meet the needs of parent(s) and children in their contexts (Stein and Harold, 2015). A flexible, tailored for each individual family, resource-oriented intervention program, multi-faceted in addressing all modifiable risk factors and using different methods (individual, dyadic, group) seems to provide the best results (Nylen et al., 2006; Kersten-Alvarez et al., 2011; Evans et al., 2013; Schrank et al., 2015; Stein and Harold, 2015; Van Santvoort et al., 2015; Masten, 2018).

DISCUSSION

The aim of this article was to identify modifiable targets for intervention in the treatment of parents with serious mental disorders and their young children, and which targets should be prioritized to reduce the risk of transmission of psychopathology. The epidemiology of the intergenerational transmission of mental disorders provides grounds for concern about children of parents with a mental disorder, especially in infancy and early childhood, due to vulnerable periods in brain development and also a period of high sensitivity to stress (Agorastos et al., 2019). On an individual level, the probability is increased by cumulating risk factors and the absence of protective factors.

This paper provides a comprehensive review of intervention targets related to risk and protective factors that can help prevent the transmission of psychopathology from parents with young children in mental health care. An important conclusion of this review is that the literature shows that intervention targets are identified in different interacting domains, namely the parental, family, child, and environmental domains, as well as the developing parent-child relationship. A second conclusion is that given the multiple interacting risk and protective factors and the great variety of phenomenology of mental disorders and family and environmental contexts, there is no general approach for prevention and treatment to prevent parents and their young children from suffering intergenerational transmission of mental disorders (Schrank et al., 2015; Van Santvoort et al., 2015). Therefore, intervention targets can differ and should be determined by and based on individualized assessment of the risk profile to meet the needs of the parent(s), the child, and their relationships in their context (Nylen et al., 2006; Van Santvoort et al., 2015). A flexible, tailored, and resource-oriented program for treatment with different intervention methods (individual, dyadic, group) will promise the best results (Nylen et al., 2006; Schrank et al., 2015; Reupert and Maybery, 2016; Masten, 2018).

Unfortunately, this paper will not provide an answer to the question of which targets should be prioritized in treatment to reduce the risk of transmission of psychopathology. No research

has been conducted that has analyzed which treatment targets have which impact in preventing intergenerational transmission or in reducing the risk factors associated with it (Christiansen et al., 2019). Despite this, some hypothesis can be made regarding urgency and aspects in treatment. In high risk samples where risk factors co-occur cascading models can guide the process of decision-making about which intervention target in which domain will have the greatest effect and therefore deserves priority. Cascading effects occur on processes that strengthen resilience as well as on processes that negatively reinforce each other resulting in a worsened situation.

Doty et al. (2017) present a cascading resilience model in which parenting interventions were postulated as an leverage point in promoting positive spillover effects in the domain of the parent (parenting efficacy, positive emotions, emotion regulation), the child (development, biological stress), the family (relationships, stress regulation), and functioning in the community (sociability, trust, social networks).

Harold and Sellers (2018) present in their review a cascade model in which interparental conflict is a feature of family stress which negatively affect children. They state that the target on interparental relationship is a direct source of influence on the parent-child relationship. Interparental support will have a moderating effect on the parental symptoms (see also McEwen, 2003), a positive effect on the quality of parenting and co-parenting (see also Korja et al., 2017; Hughes et al., 2019), security in the family, and will via this pathway improve child's long-term mental health outcome. Therefore they argued that in the presence of interparental conflict, this should get a higher priority for intervention than interventions targeting the parent-child relationship. Considering the statements above, it will be obvious that the (co-)parent should be routinely involved during the assessment procedure (Stein et al., 2014).

Stepp et al. (2012) argued that mothers with a borderline personality disorder first need psychoeducation about childhood development and expectations, and skill training to promote consistency in warmth and parenting strategies, before they can benefit from attachment-based parent-child treatment.

This underscores the second conclusion that individualized assessment of the risk profile of the family should be made by professionals, before simply intervening on one domain, in order to decide which intervention targets will proceed the best spillover effects on other domains.

An important and often overlooked risk factor in mental health care is parents' unresolved childhood trauma, which could play a significant role in causing their psychiatric symptoms (Allsopp et al., 2019). This is an important threat to parenting, because post-traumatic stress implies problematic self-regulation, which threatens the interpersonal regulation of the infant (Suardi et al., 2017). Hence, screening for unresolved childhood trauma during the assessment procedure and consideration of the impact on parenting and the parent-child relationship should be undertaken.

However, although treatment of the mental disorder and trauma of the parent is important, it will not automatically change undesirable patterns in the parent-infant relationship (Forman et al., 2007; Thanhäuser et al., 2017). Disruption to the parent-child relationship will affect both child and parent, with consequences for the future. In line with the transactional model (Sameroff, 2004), the child is at risk of behavioral and emotional problems, and in that case, parenting is more challenging and less satisfying. This poses a risk of worsening the parent's symptoms, which could in turn further increase the child's problems. Therefore, in mental health care practice, assessment of parenting and the parent-infant relationship should be an essential part of the overall assessment in the interest of both parent and child (Brockington et al., 2011; Falkov, 2012). As a consequence of their own problems, a parent may be biased regarding their own parenting behavior and their child's behavior. Mothers with severe and pervasive mental disorders such as a personality disorder tend to view their struggles and behavior as ego syntonic, and Laulik et al. (2013) recommends for this reason that wherever possible, mental health care of these parents should include assessment of the attachment style of parent and child. Hence, assessment of the parent-infant relationship should be done through observation.

In addition to screening for parental trauma, the same should be done for the young child. It is important to assess the infant for traumatic experiences and exposure to parental stress from conception and treat them in the context of the attachment relationship (Chu and Lieberman, 2010).

Children are more affected by their parent's mental disorder if their family is low in socio-economic status (Stein et al., 2014). Accumulation of environmental risk factors puts children at serious risk of developing a disorganized attachment style (Cyr et al., 2010), which is associated with later psychopathology (Sroufe et al., 2009). These risk factors make it challenging for parents to be consistently available and to regulate infants' distress in a predictable and safe manner. Parents' absorption in managing their daily troubles may result in chaotic living and child rearing conditions, and child neglect. Thus, contextual risk factors are important targets for intervention to diminish parental stress. In addition, it is important to enhance social support and search for possibilities for alternative care.

Limitations

We have restricted our literature search mainly to reviews, which may have limited our identification of significant articles and potentially excluded other findings. Our choice to search for reviews was motivated by the broad field of science involved in our research question, with the possible risk that specific topics have been excluded simply because no review article about them has appeared. We have tried to address this risk by adding papers and meta-analytic studies and longitudinal research on missing issues. Another limitation is that the bulk of research focused on mothers. The influence of the psychopathology of fathers, as well as the possible buffering influence of a healthy father in case of a maternal mental disorder, has been less investigated. Furthermore, research into the transmission of parental psychopathology to offspring has mostly focused on a single mental disorder, and therefore does not offer guidance for practice in which comorbidity is present. The impact and interaction of other risk factors in transmission besides the parental mental disorder has seldom been investigated.

Despite these limitations, this review hopefully puts forward an useful overview of the present state of knowledge, identifying modifiable targets that are most helpful to parents in mental health care, enabling them to improve their parenting and develop a secure relationship with their young child, for the benefit of both. In addition, it will hopefully help professionals in adult and infant mental health care to help parents to break the cycle of intergenerational transmission of psychopathology.

Implications for Clinical Practice

As shown in this review, risk factors in the transmission of psychopathology in different domains are highly interrelated and interactive, with negative cascade effects on both parents and children. Children of parents with a mental disorder are more likely to be exposed to more family and environmental risk factors than children whose parents do not have a mental disorder. Intervention targets and ports of entry for treatment are not simple to determine. A "one size fits all" intervention is not appropriate for parents with serious mental disorders and their young children. Thus, professionals need to carefully consider which intervention targets will be most likely to benefit each individual family. Specifically, which domains, which timing and combination of treatments, whether to focus on proximal or distal processes or on protective factors that moderate the influence of risk factors, the intensity of the intervention, and which professional(s) will be working with the family all need to be considered.

In practice, "no single service can fulfill the needs of both parent and child" (Falkov, 2012, p. 8), neither adult mental health care nor infant mental health care, so it is essential for these mental health care professionals to work together in close collaboration. However, adult mental health care and even child mental health care are both appropriate places to reach and help parents and their young children by assessing and treating the whole family including mental disorders, relational, and contextual problems. To address problems in the broader context of the family and society, a multi-agency approach including social services is needed.

AUTHOR CONTRIBUTIONS

All authors contributed to the design and method, and read and commented on the manuscript text of this review article. HS read all the included manuscripts of the review and put the manuscript into writing. All authors approved the final version of the manuscript.

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Acute Maternal Stress Disrupts Infant Regulation of the Autonomic Nervous System and Behavior: A CASP Study

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Exposure to maternal stress is assumed to influence infant health and development across the lifespan. The autonomic nervous system (ANS) is especially sensitive to the effects of the early caregiving environment and linked to predictors of later mental health. Understanding how exposure to maternal stress adversely affects the developing ANS could inform prevention. However, there is no agreed upon definition of maternal stress making its study difficult. Here we use the Caretaker Acute Stress Paradigm (CASP) to study the effects of maternal stress in an experimentally controlled laboratory setting. The CASP has 5 episodes, a natural play, followed by a caretaker stressor (or control) condition, another play, a classic still face episode, followed by another play. A total of 104 4-months-old infants and their mothers were randomly assigned to either the caretaker-stress or caretaker-control condition. Changes in behavior, heart rate (HR), and respiratory sinus arrhythmia (RSA) before and after the introduction of the stressor (or control condition) were recorded and compared. Infants in the maternal stress condition showed significantly more behavioral distress [$X^2 = (1, N = 104) = 4.662$, $p = 0.031$]. Moreover, infants whose mothers were in the stress condition showed an significant increase in heart rate after the caretaker condition [$F_{(1, 102)} = 9.81, p = 0.002$]. Finally we observed a trend to faster RSA recovery in infants of the control condition [$F_{(1, 75)} = 3.539$, $p = 0.064$]. Results indicate that exposure to acute maternal stress affects infant regulation of the autonomic nervous system and behavior.

Keywords: maternal stress, infant regulation, autonomic nervous system, infant stress reactivity, caretaker acute stress paradigm, still face paradigm

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INTRODUCTION

Early exposure to maternal stress influences health and development across the lifespan (1–6). Research in humans and animals suggests that exposure to maternal stress has long-term consequences on the offspring's stress reactivity (7), with a subsequently increased vulnerability for psychological disorders later in life (8–10). The autonomic nervous system (ANS) is especially sensitive to responding to the effects of the early caregiving environment (11–13) and crucial in the prediction of mental health (14, 15). However, research so far has paid little attention to the underlying mechanisms linking maternal stress to a dysregulation of the child's ANS.

Development of Infant Regulatory Capacity

The early caregiver-infant interaction is a primary developmental context during the first year of life (16–18). While the infant's self-regulation capacity is not yet mature, the caregiver's sensitive and reliable co-regulation is crucial for the infant to cope with everyday stress. The caretaker-infant dyad usually cycles between matching with active co-regulation and dysregulated mismatching states (18, 19). These regulatory mismatches are not inherently harmful. Through reliable and repeated reparations of mismatched interactions, the infant learns that unwanted affective states and unbalanced interactions can be transformed into successful exchanges between both partners, leading to a better adaption to stress and probably future resilience (20, 21). However, if dysregulation becomes chronic and attempts to repair the interaction repeatedly fail, stress can become toxic for the child (22).

Models such as the Mutual Regulation Model (23) assume that maternal stress interferes with maternal caregiving capacity and leads to inconsistencies in the dyadic co-regulation (4, 20, 21, 24–26), which is hypothesized to be a crucial factor in the development of a child's stress response (23). Until self-regulatory capacities become more robust over the first year of life, the caregiver is a critical source of external regulation and has a key role in co-regulating the infant's emotion (16, 27). The maturation of self-regulation extends throughout childhood and the caregiver continues to serve a crucial co-regulatory function through the fourth to fifth year of life (28). Within the interaction, the caregiver's consistent and sensitive response helps the child organize its behavioral and physiological response to stress.

Regular and predictable regulatory scaffolding by the caretaker helps the infant learn how to regulate more effectively. Exposure to stress is hypothesized to lead to a depletion of resources (29, 30), resources that would otherwise be used for growth for the child or in the parent to co-regulate the dyadic interaction. When the exposure to stress becomes chronic, the diminishment of resources may result in long-lasting effects on the quality of the dyadic interaction and infant development (16, 17). Calming Cycle Theory [CCT (22)] further differentiates psychological co-regulation and physiological visceral-autonomic co-regulation. According to CCT, early shaping of visceral-autonomic co-regulation begins before birth through Pavlovian conditioning. The theory moves past attachment theory and connects how the emotional relationship between mother and infant is in part responsible for the development of the quality of the child's autonomic and behavioral regulation (31).

What unifies these theories is that all concur that a child's earliest experiences shape the development of self-regulatory capacities with long-lasting effects, for good or ill, on later mental health (17, 30, 32, 33). To date most research has focused on behavioral-affective regulation of infants in the presence of maternal stress. Recent studies on underlying biological mechanisms look at the infant's hormonal stress response, how sensitive caregiving buffers an increase of stress hormones and protects the developing brain from the potentially toxic, harmful effects (16, 16, 30, 34, 35). Even though the autonomic nervous system plays a critical role in reactivity to and regulation of stress and is sensitive to the infant's early experiences, little research, in particular experimental research has investigated its development in the context of maternal stress (36, 37).

Role of the Autonomic Nervous System

The autonomic nervous system controls central and peripheral biophysiological responses to the environment. It goes through a period of rapid development from the last trimester of pregnancy well-into infancy, making it susceptible to environmental influences (38). The ANS has two systems that are engaged in ongoing regulation of cardiac function; the parasympathetic nervous system (PNS), which controls the body's physiological homeostasis at rest. The sympathetic nervous system (SNS) is more involved in activating the "fight or flight" response during a perceived threat. Activity of neurotransmitters that innervate the vagus nerve, the tenth cranial nerve connecting visceral organs through sensory fibers with the brain, is assumed to play a significant role in creating physiological resting state homeostasis as part of the PNS (39, 40). The PNS is involved in decreasing heartrate after stress exposure and plays a critical role in returning the body to its resting state. Therefore, vagus nerve activity is assumed to indicate PNS's neural regulation by decreasing arousal and returning the body to homeostasis after a confrontation with a stressor. Due to its role in the resting state recovery of the PNS, vagal tone has been linked to self-regulatory processes. However, vagus nerve activity itself is difficult to investigate directly and respiratory sinus arrhythmia (RSA), a measure of changes in HR linked to respiration, has emerged as a proxy (41). Heart rate accelerates with inhaling and decelerates with exhaling (42). RSA is assumed to increase with PNS activation and decrease with PNS withdrawal allowing HR to increase (37). Heart rate is controlled by both PNS and SNS, but can increase without observable changes in RSA, accordingly, RSA is commonly used as a measure of PNS activity (43). Additionally, the SNS has a slower frequency and is therefore hard to measure, especially in moving infants. Thus, the majority of research on infants ANS reactivity in the presence of a stressor focuses on average heart rate (HR), heart rate variability (HRV), and respiratory sinus arrhythmia (RSA).

The Still-Face (SF) paradigm has been widely used to study infant stress reactivity [for reviews, see (44, 45)]. A recent meta-analysis identified 33 peer-reviewed studies that investigate its impact on changes in measures related to the autonomic nervous system (37). While many of the reports differ in exact measurements or calculations, a majority describes very similar results. For instance, infant heart rate is often observed to increase from the natural play episode to the SF episode (46–49). Results are more equivocal for recovery of heart rate after the SF episode; some studies found no change in infant heart rate from SF stressor to the reunion (46, 49, 50), while others report a significant decrease in infant heart rate (47, 51). Gunning et al. (52) divided infants by the characteristic of neonatal irritability. They found that non-irritable infants showed a recovery of heart rate during the reunion after the SF while irritable infants did not.

Several studies also looked at the relation of maternal stress on infant stress reactivity. Enlow et al. (46) found that maternal trauma was linked to a less pronounced recovery of heart rate

after the SF stressor. Stress during the prenatal period was associated with greater changes in infant RSA during the SF episode (38). Two studies investigating the effect of maternal anxiety found a reduced infant RSA during baseline (13, 53), and one study found higher infant RSA after the SF stressor for infants of mothers with elevated anxiety levels (54).

The Current Study

However, most of these studies have two methodological flaws; they stress the infant, not the mother, and they vary widely in their definition of maternal stress. The term maternal stress has been used as an umbrella spanning various forms of adverse life conditions mothers may face, such as poverty, low SES, low social support, as well as mental health problems such as depression or anxiety (55–57). While all of these conditions may cause "stress," there are large variations in how they may affect the caretaker's experience, physiology and everyday life. Moreover, it is difficult to differentiate which of them are closer to real toxic stress or daily challenges that many people face (55). Experimental studies that control for covariates usually stress the infant (e.g., still face experiment or cold pressure stress), studies that evaluate caretaker stress are often retrospective studies using correlational measures, making causal conclusions difficult (16, 58).

Aim of the present study is to evaluate the impact of standardized maternal stress in a controlled laboratory environment on infant behavioral and autonomic regulatory capacity. The Caretaker Acute Stress Paradigm (CASP) (59) allows studying the immediate effects of maternal stress, induced by infant cry vocalizations and distress images of infants on infant self-regulation, a clear and comparable definition of the construct ("maternal stress"). The cries of the caretaker condition were chosen as a stressor as infant cries have relevance to parenting, adding to the ecological validity of the paradigm. Previous research further indicates that infant cries produce a reliable stress response (60–62) and more distressing cries have been shown to recruit regions of the brain associated with arousal and attention (63, 64).

We hypothesized that infants of mothers in the caretaker-stress condition of the CASP would show decreased behavioral regulation and increased reactivity of the autonomic nervous system to the modeled caretaker-stress, compared to the infants of a caretaker-control group. Changes in behavior, heart rate (HR), and respiratory sinus arrhythmia (RSA) were recorded. Infant average HR and RSA before and after introducing a caretaker stressor or non-stressor control condition were compared to investigate how an acute experimental caretaker stressor may affect the infant's ability to self-regulate.

METHODS

Participants

Participants were recruited at the maternity ward of a large Harvard Medical School-affiliated hospital. A hospital employee reviewed maternal and infant medical records for study inclusion and exclusion criteria (e.g., serious medical and/or mental maternal health issues). A recruiter visited the rooms of healthy full-term infants and their mothers to either talk with the mother about the study or to leave written material with contact information if the mother was unavailable. All potential participants were contacted 3 weeks before the infants were 4-months old.

A total of 104 4-months-old infants (+/−1 week) and their mothers participated and were randomly assigned to either the caretaker-stress or caretaker-control condition of the CASP before their arrival to the laboratory. The majority of mothers were white 54.7% (black: 26.4%, did not wish to answer: 9.4%). All infants were delivered full-term (37 weeks or greater) and were clinically healthy at birth as determined by pediatric examination, with no chronic medical conditions or time in the neonatal intensive care unit. Infants also were clinically healthy at the time of testing. Mothers were between 20- and 42 years of age at the time of birth, with no serious chronic health conditions and at least a high school education.

Experimental Procedure

Participants came to the laboratory when the infant was 16-weeks old (+/−1 week). Informed consent was given, all questions were answered, and mothers signed the consent form. To collect cardiac data, seven electrodes (MindWare Technologies Ldt.) were placed on mother and infant. Infants were lying on a changing table in the waiting room, with one research assistant placing the electrodes on the infant. At the same time, a second research assistant placed the electrodes on the mother. Next, mother and infant were brought to the observation room where the infant was seated in a highchair while the mother sat on a chair facing the infant, close enough to touch and interact with the infant. The electrode wires from mother and infant were connected to MindWare, and the research assistant made sure the wires were tucked away so that the infant would not be able to reach them. Two wall-mounted video cameras were used to record mother and infant. Research assistants were able to monitor the study room and physiology from an adjacent control room. Physiology and video were initialized simultaneously through E-Prime® software to ensure exact timing on both measures. The mother was given an earpiece connected to a walky-talky so that a research assistant could provide instructions about the procedure without entering the room.

The Caretaker Acute Stress Paradigm

The Caretaker Acute Stress Paradigm (CASP) was developed to observe the influence of maternal stress on maternal and infant reactivity within an experimental setting (59). The CASP has a standard 30-second physiology baseline and five episodes, each 2-min long. Mothers are seated in a standard chair, infants placed in a highchair facing the mother, close enough that the mother can touch and interact with her child. Following a resting baseline during which the mother sits quietly while the infant watches a video, the dyad engages in a face-to-face natural play (episode E1). The acute caretaker experimental episode (E2) follows in which the caretaker is exposed to an auditory and matching visual and auditory stressor or non-stress control condition. After a brief recorded introductory narrative that the infants were undergoing a medical procedure, caretakers in the experimental

condition hear infant cries over headphones while watching matching images of crying infants on a screen in front of them. In the control condition, mothers hear infant vocalizations (e.g., cooing, gurgling) over the earphones while watching matched images on a screen and a recorded narrative that the infants were playing with an adult.

To ensure mothers focus on the experimental condition, and the infants would not be aware of the mothers' reaction, a screen was set up between her and her infant. All infants stayed in their highchair, were turned away, and a research assistant entertained them with bubbles and finger puppets for the 2-min of the stimulus episode. Thus, infants had the exact same experience regardless of maternal experimental condition.

Next, mother and infant were reunited for another face-to-face play episode (E3), followed by a classic still-face episode (E4) where the mother is asked to stop the interaction, sit back, and maintain a neutral "poker-face" (still-face). The final episode is another face-to-face play (E5; see **Figure 1** for the entire paradigm). The CASP paradigm ended after E5 or was terminated early if an infant showed significant distress (e.g., crying) for more than 30 consecutive seconds. All infants who made it to episode E3 for at least 30 s were included in the study.

MEASURES

Maternal Depressive Symptoms

Maternal stress is often linked to maternal psychopathology, especially maternal depressive symptoms. To assess a possible impact of maternal depressive symptoms on the experimental manipulation, mothers were asked to complete the CESD-R (Center for Epidemiologic Studies Depression Scale-Revised) (65).

Infant Stress Reactivity: Drop Out

The procedure was terminated if an infant showed distress for 30 consecutive seconds either in E3 (play episode after the caretaker stress), E4 (the still-face episode), or E5 (the reunion play episode after the still-face) and were labeled drop-outs. Drop-out episode (E3, E4, or E5) was recorded in the study notes and reviewed for accuracy (30 s distress) on the recorded video. The drop-out episode was then used as a measure of infant stress reactivity, to evaluate whether there was a difference in paradigm termination between the caretaker stress and control condition.

Infant Stress Reactivity: Behavioral Distress

First sign of distress (e.g., the first negative vocalization or cry) was coded by two raters until an agreement was reached to compare if the caretaker-manipulation impacted the infants affect regulation, independent of the duration of that first sign of stress.

Infant Heart Rate

Continuous cardiac data sampled at 1,000 Hz was collected on from mothers and their infants. Software from MindWare Technologies LTD was used for data cleaning and to generate the mean heart rate (HR) for mothers and their infants for each of the 2-min episodes of the CASP paradigm or the matched play-sessions of the control group.

Statistical Analysis

All statistical analyses were carried out with IBM SPSS Statistics for Mac, version 23.

RESULTS

Maternal Depressive Symptoms by Group

The average CESD score was 8.29 ($SD = 5.654$, range: 1–23) for the control group and 10.51 ($SD = 8.895$, range: 0–34) for the experimental group. General linear modeling showed that there was no significant difference in CESD score between groups ($p = 0.141$). In addition, there was no statistical difference in CESD scores between mothers of infants who dropped out of the paradigm due to too much distress compared to mothers of infants who did not drop out ($p = 0.367$).

Infant Dropout After the Caretaker-Manipulation

To evaluate the impact of the caretaker-manipulation on infant stress reactivity, we evaluated the number of infants who showed enough distress to terminate the paradigm. Chi-Square analysis comparing the caretaker-stress group with the control group revealed a significant difference in drop-out rate after the caretaker-manipulation. Significantly more infants in the maternal-stress group dropped out compared to infants in the maternal control group [$X^2 = (1, N = 106) = 4.662$, $p = 0.031$; see **Figure 2A**].

First Sign of Distress During the Paradigm

The episode of first distress was correlated with dropout episode [$r_{(105)} = 0.699$, $p < 0.000$]. A Chi-Square analysis showed that infants of mothers in the stress condition showed their first sign of distress during the (usually positive) play after the caretaker manipulation, while infants of the maternal control group had a higher rate of first distress during the following SF episode [$X^2 = (1, N = 31) = 4.288$, $p = 0.038$; see **Figure 2B**].

Differences in Infant Heart Rate

Univariate general linear modeling showed that there was no difference between infant heart rate during baseline ($p = 0.209$). However, a repeated measure analysis comparing infant heart rate before and after the caretaker stress episode revealed a significant main effect of group by time [$F_{(1, 102)} = 9.81$, $p = 0.002$; **Figure 3**], with a significant increase in infant heart rate from the first play episode (E1) to the second play episode (E3), when mothers were in the stress condition.

Differences in Infant Respiratory Sinus Arrhythmia

Univariate general linear modeling showed there was no significant difference in infant RSA by group at baseline ($p = 0.386$). Infants in the control condition showed a trend for faster RSA recovery [$F_{(1, 75)} = 3.539$, $p = 0.064$, **Figure 4**] during the second play episode (E3) after the caretaker control condition

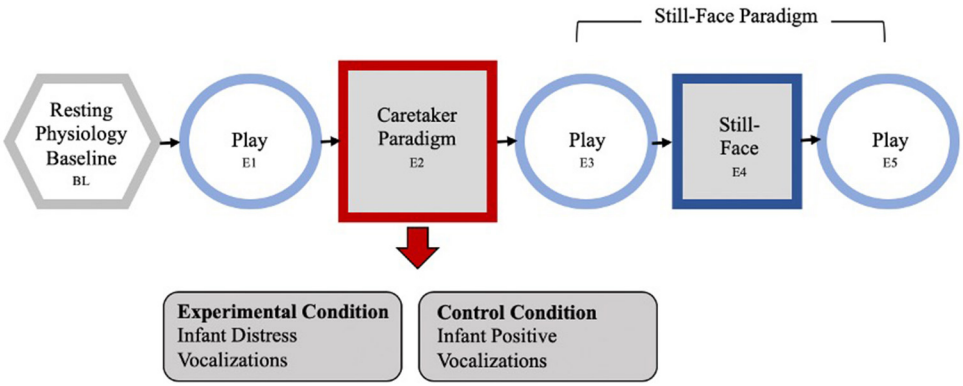

FIGURE 1 | The Caretaker Acute Stress Paradigm, containing a standard 30-s physiology baseline and 5 episodes, each 2 min long. First the dyad engages in a face-to-face natural play (episode E1). The acute caretaker experimental episode (E2) follows: the caretaker is exposed to an auditory and matching visual stressor or control condition. Caretakers in the experimental condition hear infant cries, in the control condition mothers hear infant laughter and giggles over the earphones while watching matched images on a screen. Next, mother and infant were reunited for another face-to-face play episode (E3), followed by a classic still-face episode (E4) where the mother is asked to stop the interaction, sit back, and maintain a neutral "poker-face" (still-face). The final episode is another face-to-face play (E5).

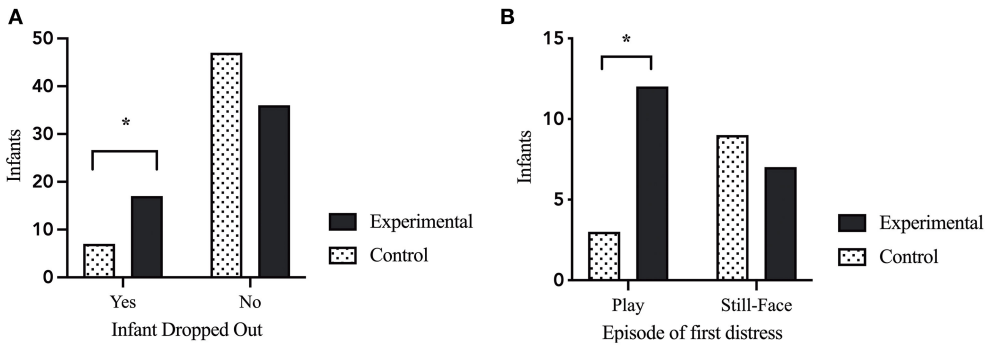

FIGURE 2 | Infant behavioral stress reactivity. **(A)** Infant drop-out of the paradigm due to exhibition of distress crying for 30-consecutive-seconds. Infants in the maternal stress condition had to terminate the procedure significant more often than infants in the control condition [$X^2 = (1, N = 106) = 4.662$, $p = 0.031$]. **(B)** Episode of first distress in the infants during the CASP paradigm. Infants in the maternal stress condition showed first distress significantly more often in the play episode after the caretaker-stress (or control) manipulation compared to infants of the maternal control condition [$X^2 = (1, N = 31) = 4.288$, $p = 0.038$]. $p < 0.05$*.

(E2) compared to infants whose mothers participated in the experimental condition (E2).

Impact of Baseline Heart Rate on Infant Stress Reactivity

A regression analysis was performed to evaluate whether infant baseline heart rate may have contributed to the infants first sign of distress or drop out of the paradigm. Neither maternal nor infant baseline heart rate had a significant association with dropout episode (infant HR_{BL}: $p = 0.893$; maternal HR_{BL}: $p = 0.124$) or first episode to show distress (infant HR_{BL}: $p = 0.459$; maternal HR_{BL}: $p = 0.346$).

DISCUSSION

The present study explored the impact of maternal stress in a laboratory setting on subsequent infant regulation. The newly developed CASP paradigm (59) experimentally manipulates maternal stress in order to observe the immediate effects of maternal stress on the infant and dyad. Our results indicate that exposure to acute caretaker stress affects the infant and the dyad.

On a behavioral level, infants in the maternal stress condition compared to the infants in the control condition showed distress earlier in the paradigm, their distress was more intense, and more of them required early termination of the paradigm. First, infants in the caretaker-stress condition, showed first signs of distress on average more often during the play episode right after the caretaker-intervention, compared to infants whose mothers were in the control condition, who showed more often stress during the typical infant stressor (still face paradigm). The results indicate that maternal stress affects the infant not only during a dyadic challenge, but it has a disruptive effect even on the natural play after the caretaker-stress condition, which is typically expected to be a positive face-to-face play interaction with the mother. Second, infants in the caretaker-stress condition were more likely to require a termination of the experimental procedure as they showed more than 30-s of consecutive distress.

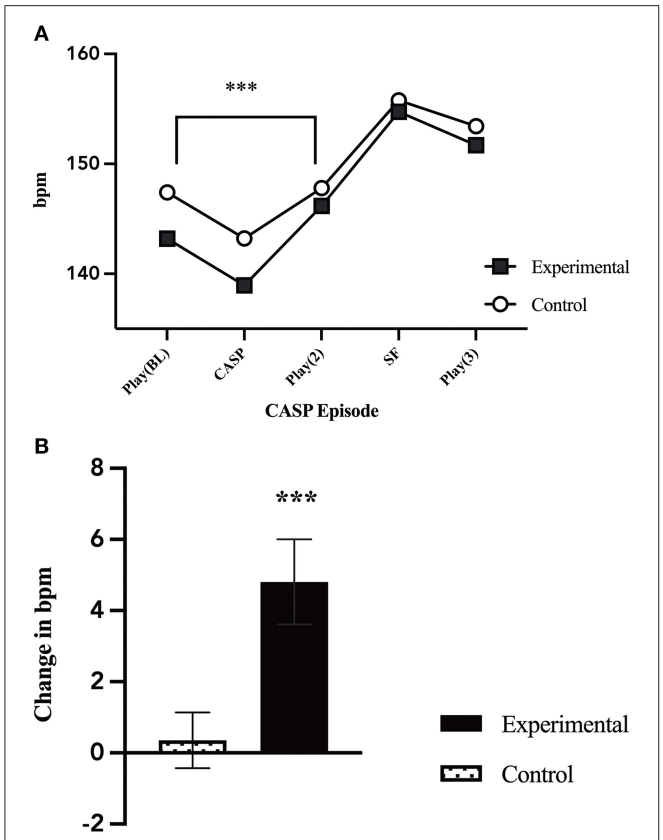

FIGURE 3 | Changes in infant heart rate. **(A)** Infant average heart rate throughout the five CASP episodes by group. There was a significant increase in heart rate from play 1 (E1) to the second play (E3) for infant's who's mothers were in the caretaker-stress condition [$F_{(1,\ 102)} = 9.81$, $p = 0.002$]. **(B)** Comparison of the change in infant average heart rate during play 1 (E1), before caretaker manipulation, and play 2 (E3), after the caretaker manipulation, by group (caretaker-stress or caretaker control condition) [$F_{(1,\ 102)} = 9.81$, $p = 0.002$]. $p < 0.01^{***}$.

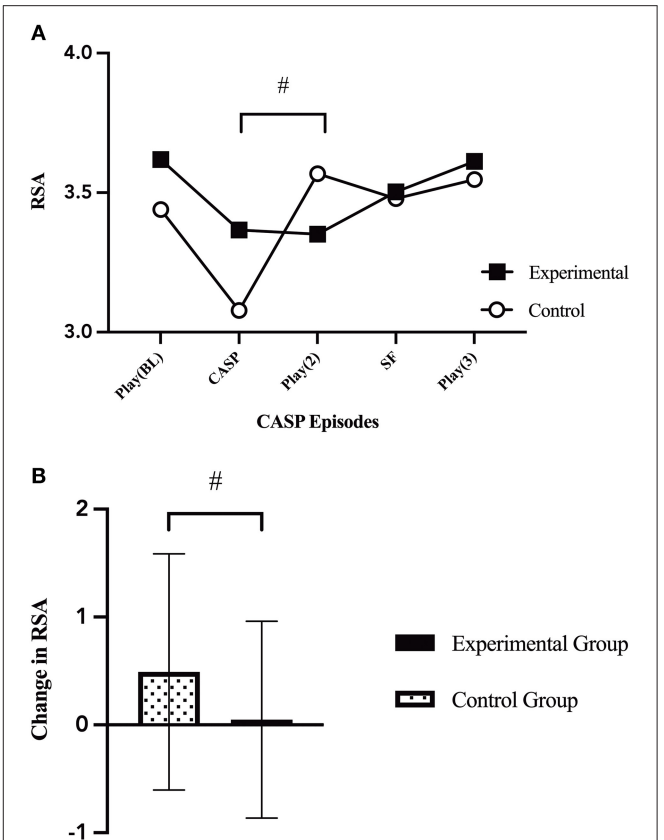

FIGURE 4 | Changes in infant RSA. **(A)** Infant average RSA throughout the five CASP episodes by group [$F_{(1,\ 70)} = 1.26$, $p = 0.294$]. There was a marginal trend between grous in the change in infant RSA from the caretaker manipulation episode (E2) to the second play episode (E3) [$F_{(1,\ 75)} = 3.539$, $p = 0.064$]. **(B)** Change in infant average RSA from the caretaker manipulation (E2) to the second play episode (E3) [$F_{(1,\ 75)} = 3.539$, $p = 0.064$], by group (caretaker-stress or caretaker-control condition). $p < 0.065^{\#}$.

It could be speculated that maternal stress depleted the dyadic resources to co-regulate over the full length of the paradigm. Interesting is also, that less infants of the caretaker-stress condition drop-out during the infant stress paradigm (still face). This could be explained with infants sensible to stress reaching their tolerable limit in the caretaker-stress condition earlier, not making it to the infant-stress episode. These experimental findings support the correlational findings by Pesonen et al. (66) that continued maternal stress over the pre- to postnatal period is associated with higher infant reactivity and by Feldman et al. (67) that infants of mothers with symptoms of depression showed less mature regulatory behaviors and more negative affect.

As regards physiology the infants in the experimental condition showed a significant increase in heart rate after the caretaker stress that was not observed in infants of mothers in the control condition. As the procedure was the same for all infants, the difference indicates that the acute stress in the experimental condition experienced by the caretaker was picked up, reacted to by the infant which may have interfered with the infants' self-regulation, as well as with the dyadic co-regulation. A similar trend was found for infant RSA, a measure of regulation rather than arousal. We observed that the infant RSA in both groups decreased, an indication of dysregulation during the caretaker stress (or control) condition, probably due to the brief separation from the mother. However, infants whose mothers were in the control condition had a faster RSA recovery as soon as the caretaker episode was over when they were reunited with their mothers. The majority of infants from the caretaker stress condition, contrariwise, did not show an RSA recovery after the infants were reunited with their mothers. The RSA recovery finding supports the original hypothesis of this study that caretaker stress leads to a disruption of regulatory resources, which then interferes with the dyad's ability to regulate stress (29, 30). Previous studies on maternal stress, namely maternal psychopathology, have found similar results, indicating a higher mean heart rate and weaker RSA recovery in exposed infants (38, 68).

Overall, the results indicate that even a brief and acute maternal stressor impacts infant physiology and emotional stress regulation. The findings are in line with research observing a lower dyadic ability to regulate after prolonged exposure to

maternal stress (16, 34) and the observation that children exhibit an elevated stress response after exposure to high maternal stress (69, 70). However, most studies related to caregiver stress find that current levels and previous levels of high stress often overlap, making it difficult to distinguish whether previous or current exposure has a greater impact (70). The CASP paradigm allows us to investigate the impact of acute maternal stress on the dyadic interaction as well as the infants stress response. While acute stress may not be comparable to chronic exposure, it still allows for controlled laboratory observations with a control group to develop a better understanding how caregiver stress may affect the infants behavioral and physiological regulatory organization.

Limitations and Future Directions

Limitations of this study include not accounting more detailed for maternal background. Previous studies have shown that maternal prenatal mental health, such as own adverse childhood experiences (ACE) or lifetime traumatic stress can affect infant regulation (69, 71). Future studies with the CASP should control for these measures or actively use them to create groups to learn more about the effect of maternal ACE or traumatic experiences on dyadic regulation of acute caretaker stress. The present study included current maternal depressive symptoms (CESD), while there was no statistical difference in maternal depressive symptoms between groups, there was a numerical difference in the highest CESD score in the caretaker-stress condition compared to the caretaker-control condition (34 vs. 23). However, we also tested if there was a difference in our main behavioral variable (infant drop-out of the paradigm) and found no statistical difference in maternal depressive symptoms of infants in the caretaker-stress and caretaker-control condition who had to terminate the procedure due to the 30-s consecutive distress limit.

Similarly, the majority of participating dyads were white. Previous research shows that maternal stress and factors that cause maternal stress, such as racism or lower socioeconomic status, are still more present in populations that belong to the global majority (back, indigenous, and people of color), which could have affected the results.

While the CASP is an attempt to measure maternal stress in a controlled laboratory setting, it measures acute, not chronic stress exposure. However, it would be important to investigate how these chronic factors (maternal exposure to racism, ACE, trauma, and SES) that have been shown to influence infant behavioral and physiological regulatory capacity affect the acute stress regulation in an experimental setting. This is one of the promising possibilities the new CASP paradigm opens research up to; it is possible to control for the effects of acute maternal stress, with a clear definition and allows to compare different maternal adversities, backgrounds, and preconditions. Large studies will allow cross-over designs, where dyads complete both the caretaker-stress and caretaker-control condition. Further, large studies could compare more than two groups, extending to maternal-healthy caretaker-stress, maternal-depression caretaker-stress compared to two control groups with matched diagnosis.

Remarkably, the findings indicate that even a brief laboratory stressor can affect the dyad in such a significant way that infant behavioral and cardiovascular regulation is compromised. Future research with the caretaker acute stress paradigm (CASP) will add to our understanding on the underlying mechanisms involved in the association between maternal depletion of resources and infant regulation. It would be especially interesting to observe dyads from a high-risk sample such as infants with depressed mothers. Results on the impact of maternal depressive symptoms have been equivocal but based on the literature one could assume a greater challenge of an additional caretaker stressor. However, it would be also within the scope of current literature to assume a better adaption of the infant to a stressed caretaker (for review, see (72)) and subsequently a better adjustment of the dyad to the CASP.

Overall, the CASP offers new opportunities to study the independent effects of maternal stress on the dyad and its interplay with other risk factors. Observations within a controlled laboratory setting will allow us to gain new insight into subtle variations of caregiving under stress in a more objective way than previous studies, extending our understanding of the underlying behavioral and physiological mechanisms associated with maternal stress.

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 IRB office at the University of Massachusetts Boston. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

IM, NS, JD, and ET contributed to conception and design of the study. JD and IM organized the database. IM performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to the article and approved the submitted version.

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The Impact of Maternal Anxiety on Early Child Development During the COVID-19 Pandemic

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Background: Maternal prenatal anxiety is among important public health issues as it may affect child development. However, there are not enough studies to examine the impact of a mother's anxiety on the child's early development, especially up to 1 year.

Objective: The present prospective cohort study aimed to examine whether maternal trait anxiety, perceived social support, and COVID-19 related fear impacted speech-language, sensory-motor, and socio-emotional development in 12 months old Serbian infants during the COVID-19 pandemic.

Methods: This follow-up study included 142 pregnant women (Time 1) and their children at 12 months (Time 2). Antenatal maternal anxiety and children's development were examined. Maternal anxiety was assessed using the State-Trait Anxiety Inventory (STAI). Child speech-language, sensory-motor, and socio-emotional development were assessed using the developmental scale in the form of an online questionnaire that examined the early psychophysiological child development. Information on socioeconomic factors, child and maternal demographics, clinical factors, and perceived fear of COVID-19 viral infection were collected. Multivariable General Linear Model analysis was conducted, adjusted for demographic, clinical, and coronavirus prenatal experiences, maternal prenatal anxiety levels, perceived social support, speech-language, motor skills, and cognitive and socio-emotional development at the infants' age of 12 months.

Results: The study revealed the influence of the COVID-19 pandemic on maternal trait anxiety. The association between selected independent factors and infants' development was found in a demographically unified sample except for employment and the number of children. There was a correlation between all observed developmental functions. Univariate General Linear model statistical analysis indicated that linear models with selected independent factors and covariates could account for 30.9% (Cognition) up to 40.6% (Speech-language) of variability in developmental functions. It turned out that two-way and three-way interactions had a dominant role on models, and STAI-T Level and COVID-19 related fear were present in all interaction terms.

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Conclusion: Our findings reveal important determinants of child developmental outcomes and underline the impact of maternal anxiety on early child development. These findings lay the groundwork for the following interdisciplinary research on pregnancy and child development to facilitate and achieve positive developmental outcomes and maternal mental health.

Keywords: perinatal mental health, maternal anxiety, infant development, social support, COVID-19 pandemic, COVID-19-related fear

INTRODUCTION

The conditions under which intrauterine development happens and the influences during childbirth and the postpartum period form the child's essential psychophysiological capacity. There is accumulating evidence about the importance of the first 1,000 days of life to a child's overall development (Black et al., 2017). During prenatal and early child development brain adapts in response to a wide range of early experiences, which supports the rapid acquisition of language, cognitive skills, and socioemotional competencies (Luby, 2015; Britto et al., 2017).

The prenatal period is the sensitive period for child development, in which negative associations between prenatal exposure to maternal anxiety and outcomes are observed (Comaskey et al., 2017). In this respect, perinatal maternal health may play an important role and influence the child's early development. A woman's mental health during pregnancy and the first year after birth refers to perinatal mental health. It includes mental health difficulties that occur before or during pregnancy and mental health problems that appear for the first time and can significantly increase during the perinatal period (Rees et al., 2019). Findings in the literature point to maternal mental well-being as crucial for optimal infant health (Ryan et al., 2017).

On the other hand, maternal mental health problems are considered a significant public health issue. Depression, anxiety, and high levels of perceived stress are the most common mental health problems during pregnancy (Hamid et al., 2008; Martini et al., 2015; Ryan et al., 2017; Rees et al., 2019).

Perinatal anxiety refers to anxiety experienced during the pregnancy and/or the first 12 months after birth. It may be significantly associated with postnatal anxiety (Grant et al., 2008). According to previous epidemiological studies, the prevalence of women who experienced high anxiety during pregnancy ranges from 6.8 to 59.5% (Leach et al., 2017). Research on the dynamics of the anxiety manifestation during pregnancy is inconsistent. While some authors reported a significant increase in anxiety during the last trimester of pregnancy (Gunning et al., 2010), others pointed to stable pregnancy-specific anxiety across all three trimesters of pregnancy (Rothenberger et al., 2011). In line with this, it is crucial to notice the difference between general anxiety and pregnancy-specific anxiety. These two entities are considered strictly interrelated, although the mechanisms of interrelation are not fully documented (Huizink et al., 2014). While pregnancy anxiety refers to an emotional state that is mostly situationally or contextually conditioned, general anxiety—trait anxiety, in particular, can be maintained and last in the period after pregnancy. In that way, general anxiety may continue to affect a mother's mental health and influence mother-child interaction (Huizink et al., 2014).

The impact of pregnant woman's anxiety on early child development has been a focus of recent studies. More specifically, interest in studying the link between prenatal anxiety and early childhood development has increased in the past 20 years. Van den Bergh et al. (2005) supported a fetal programming hypothesis and pointed out that the development of the hypothalamo–pituitary–adrenal (HPA) axis, limbic system, and the prefrontal cortex may be affected by maternal prenatal stress and anxiety. It results in cortisol passing through the placenta, affecting the fetus and disturbing ongoing developmental processes. Studies examining the impact of maternal postnatal anxiety on child development have indicated possible findings within three domains: somatic, developmental, and psychological outcomes (Glasheen et al., 2010). Similarly, studies examining the same outcomes about prenatal maternal anxiety suggest that maternal anxiety during pregnancy may also have long-lasting consequences on child development and behaviour (Dunkel Schetter and Tanner, 2012; Huizink et al., 2014). Research evidence indicates that high levels of maternal anxiety symptoms are associated with a wide range of adverse cognitive, behavioural, and neurophysiological offspring outcomes (O'Connor et al., 2014), as well as with temperamental and developmental problems (Hernández-Martínez et al., 2008). Infants of mothers with high trait anxiety have a predisposition to suboptimal nervous system development and may have an increased vulnerability for developing motor problems (Kikkert et al., 2010). On the other hand, research data on the direct impact of perinatal maternal anxiety on children's emotional problems lacks cohesion and indicate that maternal prenatal anxiety has a slight adverse effect on child emotional outcomes (Rees et al., 2019).

In addition, maternal anxiety in pregnancy is also associated with perceived social support (Sharif et al., 2021). Similarly to maternal anxiety, a pregnant woman's lack of perceived support may negatively affect her mental well-being, fetus, and close family members (Aktan, 2012). Social support plays a significant role in stressful life events and includes providing emotional, informational, and practical physical support (financial and material) during the time of need and within a person's social network (Dambi et al., 2018; Sharif et al., 2021). Research on social support during pregnancy has shown that it may be a strong predictor of a healthy pregnancy (Naveed et al., 2018).

Several studies on the population of pregnant women found that social support plays a significant role in maternal well-being, while perceived lack of social support leads to mental health problems (Aktan, 2012; Denis et al., 2015; Sharif et al., 2021).

The mentioned aspects that may affect infant and child development need to be additionally considered to the coronavirus disease 2019 (COVID-19), which has grown into a global pandemic declared by the World Health Organization (WHO) on March 11, 2020 (Cucinotta and Vanelli, 2020). COVID-19 was reported for the first time in Wuhan, China, in December 2019, with increasing global transmission (Api et al., 2020). Data on the COVID-19 in the Republic of Serbia show that the first case of COVID-19 was reported on March 6, 2020, and soon after it, precisely on March 15, 2020, a state of emergency was declared in the whole country (Stašević-Karličić et al., 2020). Psychological impacts of COVID-19 on pregnancy have already been explored in recent studies (Quinlivan and Lambregtse-van den Berg, 2020; Usher et al., 2020; Yan et al., 2020; Motrico et al., 2021). An accompanying phenomenon of the COVID-19 pandemic is the fear of COVID-19 viral infection, which can intensify the level of anxiety (Andrade et al., 2020). Although the symptoms of anxiety manifested by individuals during the epidemic/pandemic may be similar to those expressed in other anxiety situations, it is noticed that there are specific forms of anxiety-related distress responses during viral outbreaks and the COVID-19 pandemic as well (Asmundson and Taylor, 2020). Some major factors which contribute to specificity of pandemic anxiety are the fear of becoming infected and dying, socially disruptive behaviors, and adaptive behaviors (Asmundson and Taylor, 2020; Bernardo et al., 2020; Wang et al., 2020). In other words, the increased risk of death (Aldridge et al., 2020), additionally unemployment and economic losses (Coibion et al., 2020), and numerous restrictions introduced by the countries' governments around the world, lead to negative health consequences (Meyerowitz-Katz et al., 2021), that include pandemic anxiety with its specifics as well (Bernardo et al., 2020). Accordingly, a fair number of studies have been published indicating an increase in anxiety symptoms in pregnant women during the COVID-19 pandemic (Ayaz et al., 2020; Corbett et al., 2020; Durankuş and Aksu, 2020; Kotabagi et al., 2020; Lebel et al., 2020; Moyer et al., 2020; Saccone et al., 2020; Wu et al., 2020; Yue et al., 2021). So far, there are studies, systematic reviews, and meta-analyses in which the prevalence of pregnant women with moderate to severe anxiety during the COVID-19 pandemic is given more precisely (Corbett et al., 2020; Hessami et al., 2020; Lebel et al., 2020; Mappa et al., 2020; Saccone et al., 2020; Fan et al., 2021; Sun et al., 2021; Tomfohr-Madsen et al., 2021). Accordingly, it ranges from: 23.4% found in Brazil (Nomura et al., 2021); the 29% was determined during the initial stage of the COVID-19 pandemic in China (Wang et al., 2020), while 25% was determined by meta-analysis (Ren et al., 2020); the 38% was found in Poland (Nowacka et al., 2021); the elevated level of the trait (38.2%) and state anxiety (77%) was found in Italy (Mappa et al., 2020). Higher prevalence in the range from 53 to 72% was found in other countries (Corbett et al., 2020; Dagklis et al., 2020; Davenport et al., 2020; Hessami et al., 2020; Lebel et al., 2020; Saccone et al., 2020; Sut and Kucukkaya, 2020). In contrast to these studies, a lower prevalence of anxiety among pregnant women (8.4% of whom had moderate anxiety and 5.2% of whom had severe anxiety) was determined in Belgium (Ceulemans et al., 2020), while COVID-19 did not increase anxiety levels in Dutch pregnant women (Zilver et al., 2021).

Generally, the analysis of the most recent systematic reviews and meta-analysis have shown that the prevalence of anxiety in pregnancy during COVID-19 ranges from 30.5 to 42%, the prevalence of depression ranges from 25 to 30%, and prevalence of both anxiety and depression was 18% (Fan et al., 2021; Sun et al., 2021; Tomfohr-Madsen et al., 2021).

Pregnant women may be affected by various aspects of COVID-19 pandemic that can cause negative implications on both maternal well-being and child development, which imposes the need for longitudinal studies of the COVID-19 birth cohort (Quinlivan and Lambregtse-van den Berg, 2020).

Given the clear need for longitudinal studies on the impact of maternal prenatal anxiety on early child development generally, and especially during the COVID-19 pandemic, the present prospective cohort study aimed to examine whether maternal trait anxiety, COVID-19 related fear and perceived social support were associated with speech-language, sensory-motor and socio-emotional development in 12 months old Serbian infants during COVID-19 pandemic. Demographic characteristics of mothers were also controlled in the analyses. Generally, it was hypothesized that maternal trait anxiety and COVID-19 related fear are prospectively and directly associated with infant development and may affect an infant speech-language, sensory-motor and socio-emotional development.

MATERIALS AND METHODS

Study Design, Setting, and Participants

The present ongoing prospective cohort study is a part of a more extensive experimental study that examines maternal anxiety during pregnancy and its associated factors in the context of the COVID-19 pandemic in Serbia. This investigation examines the impact of maternal anxiety during pregnancy on early child development. Between April 2020 and December 2020, 900 pregnant women were included in the cohort. Expectant mothers were recruited consecutively, in the order in which they came for a regular examination during pregnancy on the Clinic for gynaecology and obstetrics "Narodni Front" in Belgrade. Women in the third trimester of pregnancy were asked to voluntarily fill out an anonymous self-administered questionnaire in a pleasant atmosphere in the waiting room during a time-optimal for them. The questionnaire contained socio-demographics, pregnancy-related background, maternal mental health, perceived social support, perceived COVID-19 related fear, and personal contact information related to an e-mail address and/or mobile phone. It is emphasized that personal contact information should be written if the pregnant woman agrees to provide data on her child development later in the longitudinal research. Of the total sample, 209 women did not complete the questionnaire, 187 women partially completed, while 145 women did not meet defined inclusion and exclusion criteria. The inclusion criteria for the study were: normal singleton pregnancy

without complications of any kind; singleton pregnancies with the presence of hypertension, diabetes, or preterm delivery symptoms; spontaneous conception, delivering a phenotypically normal live birth, no pre-and perinatal risk factors. The exclusion criteria for the study were: failure to meet the inclusion criteria, infertility treatment; hospitalization; history of pre-eclampsia, eclampsia, autoimmune diseases, cancer, or any general chronic illnesses except hypertension or diabetes; psychiatric illnesses verified and/or treated before pregnancy; use of tranquilizers or sedatives, tobacco, alcoholic beverages, or any other type of psychoactive substances; non-acceptance of participation in the study. The final sample comprised 359 pregnant women in whom it was possible to examine the presence of anxiety during the COVID-19 pandemic in Serbia. All participants signed their written informed consent prior to the study, and confidentiality of the responses was assured.

The present study included a follow-up assessment of children aged 11.5 to 12.5 months whose mothers participated in a baseline assessment of maternal anxiety during the third trimester of pregnancy. Between May 2021 and September 2021, all mothers whose children aged 11.5 to 12.5 months were invited to participate in the study. Out of the sample of 359 pregnant women, 256 left personal contact information, while 221 of them met the criteria regarding the assessment of their children at the age of 1 year. In order to observe the possible influence of anxiety on early child development, we excluded mothers who had pregnancy complications. Thereby, the sample was reduced to 164 mothers who had normal singleton pregnancies without complications of any kind. Mothers were invited to complete an online questionnaire on their child's development by phone or e-mail. After collecting and analyzing the obtained data, the final analysis showed that 19 mothers did not complete, while three mothers partially completed the questionnaire related to child development. The final sample included $n =$ of 142 mothers who completed the questionnaire related to child development (**Figure 1**). By completing the questionnaire, the mothers gave their consent to participate in the study. The sample was uniform with regard to all demographic factors except employment and the number of children.

The complete study protocol had been approved by the Ethics Committee of the Clinic for Gynecology and Obstetrics "Narodni Front" (Date: 26 March, 2020, No 27/20), in Belgrade, and by the Ethics Committee of the Institute for experimental phonetics and speech pathology (Date: 2 April, 2020, No 45/20), in Belgrade, which operates under the Ethical principles in medical research involving human subjects, established by the Declaration of Helsinki 2013.

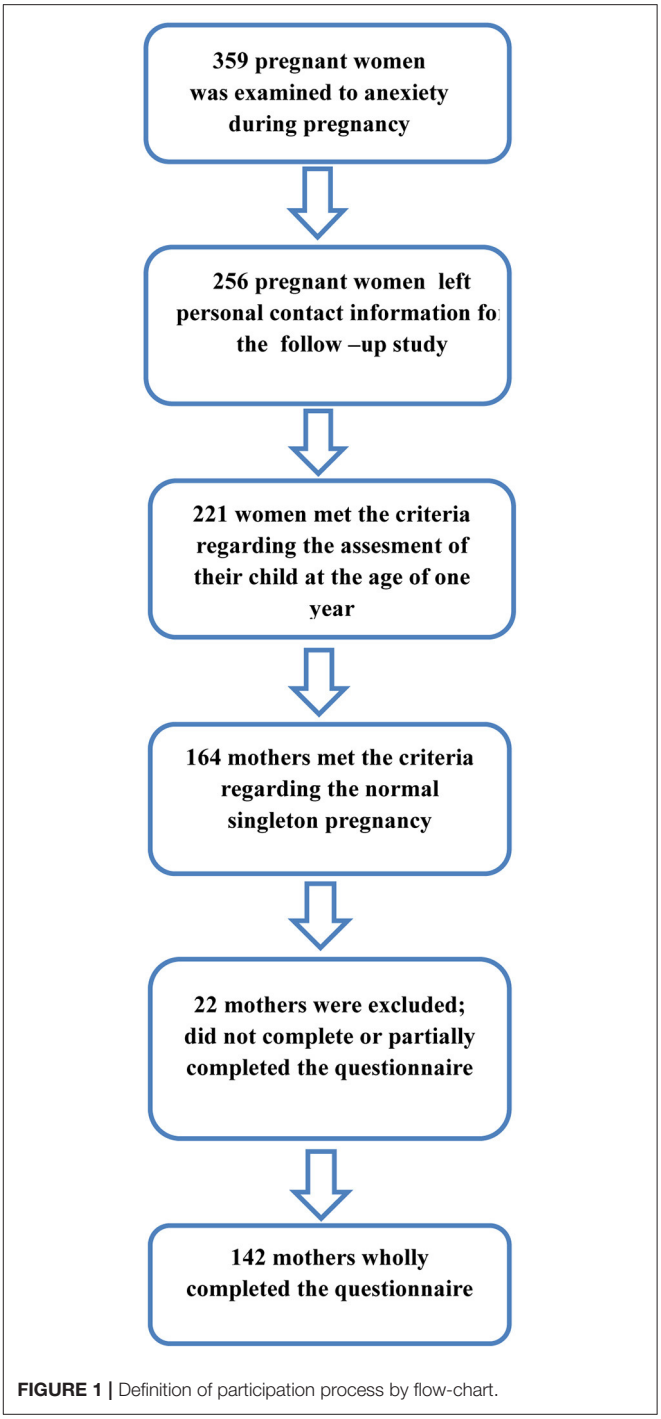

FIGURE 1 | Definition of participation process by flow-chart.

Measures

A self-administered anonymous questionnaire included questions related to socio-demographics, pregnancy-related background, maternal anxiety, perceived social support and perceived COVID-19 related fear.

Maternal trait anxiety was measured with the Spielberger State-Trait Anxiety Inventory (STAI), which is a frequently used measure for self-reported anxiety (Spielberger et al., 1983). Spielberger questionnaire form Y was used in our study (Spielberger et al., 2000). The STAI consists of two scales: state anxiety scale (STAI-S) and trait anxiety scale (STAI-T), each containing twenty items. STAI-S measures anxiety as a current state, while STAI-T measures anxiety as a personality trait, and it is considered to be more stable and more long-lasting (Easter et al., 2015). Since STAI-S is relatively transient and variable over time (Floris et al., 2017; Papadopoulou et al., 2017), it was not possible to conduct measurements by applying it in

short time intervals during the COVID-19 pandemic, which would enable obtaining a reliable mean value of the current state of anxiety during the first year of a child's life. Concerning that, we evaluated only the STAI –T, as it measures relatively stable individual differences in propensity for anxiety (Julian, 2011). Participants select responses on a four-point Likert scale, ranging from "almost never," "sometimes," "often," and "almost always." The total score ranges between 20 and 80, with higher scores indicating greater anxiety levels. Some authors use cut-off points to define two-level state and trait anxiety (low and medium/high) (Özpelit et al., 2015; Mappa et al., 2020, 2021). We used three-level cut-off points for reasons described in the literature (Tomašević-Todorovic et al., 2012; Candelori et al., 2015). Accordingly, STAI-T scores were classified as "no or low anxiety" (20–30), "moderate anxiety" (31–44), and "high anxiety" (45–80).

Maternal perecption of social support was assessed with The Multidimensional Scale of Perceived Social Support (MSPSS) (Zimet et al., 1988), the Serbian version of the scale (Pejičić et al., 2018). MSPSS consists of twelve items divided into three subscales that measure the perception of social support from three sources: family, friends and significant others. Responses are rating on a seven-point Likert scale, ranging from 1 ("very strongly disagree") to 7 ("very strongly agree"). The maximum score is 84 and indicates the highest degree of perceived social support. In the study, the total MSPSS score was used in the calculation and interpretation of the results.

COVID-19-related fear was assessed using a single item question "Do you feel a fear of COVID-19 viral infection?" Participants select one of three responses: 1–"I do not feel a fear of COVID-19 viral infection"; 2–"Sometimes, not all the time I feel a fear of COVID-19 viral infection"; and 3-"I do feel a fear of COVID-19 viral infection."

Language, sensory-motor and socio-emotional development in 12 months old infants were assessed by The Scale for Evaluation of Psychophysiological Abilities of Children (Subota, 2003; Rakonjac et al., 2016; Vujović et al., 2019; Bogavac et al., 2021). The Scale for Evaluation of Psychophysiological Abilities of Children (SEPAC) is created according to developmental norms of the child from birth to 7 years. It comprises subtests specific for different months up to the first year of life and different years of age to the seventh year of life. Each subtest consists of three subscales: Speech-language scale, Sensory-motor scale and Socio-emotional scale. The speech-language scale consists of questions through which receptive speech, expressive speech and non-verbal communication are assessed. The sensory-motor scale consists of questions through which motor skills and cognition are assessed. Finally, the socio-emotional scale consists of questions through which a child's experience and self-regulation (child's social behaviour, emotional behaviour, regulation of attention, and thoughts) are assessed. The child's achievements within each scale are assessed with three possible answers: answer "+" indicates that your baby is performing the specified activity; answer "+/–" indicates that your baby sometimes or insufficiently performs an assessed activity, and answer "–" indicates that your baby is not yet performing an assessed activity. For the scoring of the test, answers marked with "+"are scored with 2 points, answers "+/–" with 1 point, and answers marked with "–" are scored with 0 points. In our study, we used a subtest that assesses the psychophysiological abilities up to 12 months of age. It consists of 43 simple, straightforward questions related to the assessment of the following abilities and skills: receptive and expressive speech (13), sensory-motor skills (9), cognition (12), and socio-emotional skills (9). The maximal number of points on subtests is 26, 18, 24, and 18, respectively.

Statistical Analyses

Only women who completed the two questionnaires were included in the analyses. Descriptive statistics were used to determine central tendencies and distributions of variables. To determine the existence of relationships between variables, we conducted a bivariate correlation analysis. To investigate the effects of individual factors on the variables of interest and interactions between factors, we conducted Univariate General Linear Model Analysis. To perform hypothesis testing, a priori contrasts were applied and, depending on results *post-hoc* test. Statistical Package for the Social Sciences version 22.0 was used.

Before any statistical test, appropriate assumptions were checked. For STAI-T and MSPSS, we defined the new variables STAI-T level and MSPSS level, dividing the main variables into three groups. For STAI-T level, range limits are: if STAI-T is $\leq$30 Level is Low (1), if STAI-T is between 31 and 45 Level is Intermediate (2) and for values >45 Level is High (3). For MSPSS level range limits are: Low (1) <35; Medium (2) between 36 and 60; High (3) >61.

RESULTS

Sample Characteristics

The final sample consisted of 142 mothers with a mean age of 29.56 years (SD = 4.88). The majority of participants (n = 88, 61.97%) had Bachelor's degree or higher, while 63.38% (n = 90) of them were employed. There were 50.70% (n = 72) mothers having one child and 49.30% (n = 70) having two or more children. Almost half of the participants (n = 64, 45.07%) reported having a COVID-19-related fear, 39.44% (n = 56) reported having no COVID-19 related fear, while 15.49% (n = 22) reported that they sometimes have a COVID-19 fear. Half of the participants (50.70%, n = 72) had an intermediate level of anxiety, while 49.30% (n = 70) had a high level of anxiety measured on STAI-T. The vast majority of participants (81.69%, n = 116) had an intermediate level of anxiety, while 18.31% (n = 26) had a high level of anxiety measured on STAI-S. All participants reported a high level of perceived social support. Baseline sample characteristics are shown in **Table 1**.

The average STAI-T score was 44.59 ± 4.61. As previously mentioned (**Table 1**), no participants had scores corresponding to low anxiety levels. When observing the findings of social support, it is noticed that the average MSPSS score was 76.70 ± 7.14. Results related to infant's achievement included the estimation of speech-language development, sensory-motor development in which the development of motor skills and

TABLE 1 | Sample description ($N = 142$).

Sample characteristics	Mothers ($N = 142$) Mean (SD) or (%)	
Maternal age (years)	29.56	(4.88)
Years of school education		
<12 years	88	(61.97)
12 or more years	54	(38.03)
Employment status		
Employed	90	(63.38)
unemployed	52	(36.62)
Number of children		
One child	72	(50.70)
Two or more children	70	(49.30)
COVID-19-related fear		
Having a COVID-19-related fear	64	(45.07)
Having no COVID-19 related fear	56	(39.44)
Sometimes have a COVID-19 fear	22	(15.49)
STAI-T		
Low anxiety level	–	–
Intermediate anxiety level	72	(50.70)
High anxiety level	70	(49.30)
STAI-S		
Low anxiety level	–	–
Intermediate anxiety level	116	(81.69)
High anxiety level	26	(18.31)
MSPSS		
Low perceived support	–	–
Medium perceived support	–	–
High perceived support	142	(100)

TABLE 2 | Descriptive statistics on maternal anxiety, perceived social support, and infants' achievement.

Variable	Min.	Max.	Mean	SE	SD
Maternal age	19.00	39.00	29.56	0.409	4.88
STAI-T	31.00	55.00	44.59	0.387	4.614
MSPSS	62.00	84.00	76.70	0.599	7.137
Speech-language development	12.00	26.00	20.27	0.302	3.602
Motor skills	4.00	18.00	13.33	0.296	3.524
Cognition	11.00	24.00	18.99	0.304	3.619
Socio-emotional development	7.00	18.00	14.22	0.246	2.930

cognition was observed as two separate variables, and socio-emotional development. The average speech-language score was 20.27, which is 77.9% of maximal achievement score; the average motor skills score was 13.33, which is 74.06% of maximal achievement score; the average cognition score was 18.99, which is 79.12% of maximal achievement score, and the average socio-emotional score was 14.22 which is 79% of maximal achievement score (**Table 2**).

TABLE 3 | Descriptive statistics for STAI-T and MSPSS related to COVID-19 related fear.

	COVID-19 related fear	*N*	Mean	SD	SE
STAI-T	No	64	43.53	4.75	0.594
	Sometimes	56	45.46	3.95	0.528
	Yes	22	45.45	5.30	1.129
MSPSS	No	64	73.84	7.77	0.972
	Sometimes	56	79.11	5.13	0.6868
	Yes	22	78.91	6.80	1.449

One-Way Anova

Comparing mean values for STAI-T and MSPSS related to fear of getting COVID-19 (**Table 3**) shows that mean values are not equal.

One-Way ANOVA statistical test was used to check the impact of COVID-19 related fear on STAI-T and MSPSS. For STAI-T, homogeneity of variance is not violated, and *post-hoc* test with Tukey-Kramer correction for multiple comparisons (uneven sample size) was used. The MSPSS Games-Howell method was used because of its robustness when homogeneity of variance is violated, and the sample size is unequal.

There was statistically significant difference for STAI-T $F_{(2,139)} = 3.171$, $p = 0.045$. *Post-hoc* test revealed that there was no statistically significant difference between groups.

It was found that there is a statistically significant difference for MSPSS between the observed groups $F_{(2,139)} = 10{,}646$, $p < 0.001$. *Post-hoc* test showed statistically significant difference between groups 1 and 2 ($p = 0.016$), 1 and 3 ($p < 0.001$) and that there was no statistically significant difference between groups 2 and 3 ($p = 0.992$).

Mothers who reported no COVID-19 related fear have lower perceived social support (mean value 73.8) than mothers in the other two groups (**Table 3**).

Correlations

Bivariate correlation analysis revealed a statistically significant correlation between Speech-language and Motor skills, Cognition and Socio-emotional status (**Table 4**). The highest correlation is between Speech-language and Socio-emotional status [$r_{(140)} = 0.744$, $p < 0.001$]. Also, there is a low but statistically significant correlation between the child's socio-emotional status and maternal trait anxiety $r_{(140)} = 0.184$, $p = 0.028$.

The association between factors and developmental abilities (**Table 5**) ranges between weak and medium. If the mean value of eta for all developmental functions is observed to assess the association of individual factors and the child's overall development, then that association is at the level of medium association for STAI-T and weak for the other three factors.

Multifactor Analysis

It was not possible to model the relationship between children developmental abilities (Speech-language, Motor skills, Cognition and Socio-emotional status) and STAI-T, MSPSS,

TABLE 4 | Pearson correlation between variables of interest.

		Speech-language	Motor skills	Cognition	Socio-Emotional status
Speech-Language	Pearson corr.	1	0.273**	0.544**	0.744**
	Sig. (2-tailed)		0.001	0.000	0.000
Motor skills	Pearson corr.	0.273**	1	0.379**	0.276**
	Sig. (2-tailed)	0.001		0.000	0.001
Cognition	Pearson corr.	0.544**	0.379**	1	0.698**
	Sig. (2-tailed)	0.000	0.000		0.000
Socio-Emotional status	Pearson corr.	0.744**	0.276**	0.698**	1
	Sig. (2-tailed)	0.000	0.001	0.000	
Maternal age	Pearson correlation	−0.007	0.046	−0.035	−0.079
	Sig. (2–tailed)	0.938	0.590	0.682	0.353
STAI-T	Pearson correlation	0.163	−0.108	0.159	0.184*
	Sig. (2-tailed)	0.052	0.203	0.059	0.028
MSPSS	Pearson correlation	0.122	0.150	0.091	0.019
	Sig. (2-tailed)	0.149	0.075	0.283	0.825

*Significant correlations are marked in grey. *significance at the level $p < .05$. **significance at the level $p \leq .001$.*

TABLE 5 | Level of association between development abilities and factors.

Developmental function	Level of association η			
	STAI-T level	COVID fear	Number of children	Employment
Communication	0.405	0.475	0.371	0.432
Motor skills	0.449	0.277	0.331	0.449
Cognition	0.515	0.313	0.353	0.266
Socio emotional	0.254	0.378	0.415	0.363
Mean value	0.40575	0.36075	0.3675	0.3775

COVID-19 related fear, employment, maternal age and number of children that mother has, with multivariate GLM because Box's Test revealed that Equality of Covariance Matrices across groups is violated. Box's M = 359.32, $F_{(100,5,441.018)} = 2.833$, $p < 0.001$. Levene's Test of Equality of Error Variances revealed that the assumption of equality is not violated, so we conducted separate univariate GLM tests where dependent variables were Speech-language, Motor skills, Cognition and Socio-emotional status with factors: employment, number of children, COVID-19 related fear, and STAI-T level. Mother age and MSPSS were included in the model as covariates.

To determine if there was statistically significant difference between mean values of groups within interaction terms, new grouping variables were composed for each interaction term (**Appendix A**). One–way ANOVA for dependent variables was conducted. Only interaction terms of dependent variables with Observed Power >0.8 were considered.

Results of Speech-Language Achievement

Univariate GLM analysis for dependent variable SPEECH-LANGUAGE achievement revealed that full linear model (**Appendix B**) could explain 40.6% of variability $F_{(21,120)} = 3.902$, $p < 0.001$, $\eta p^2 = 0.406$ and Observed Power = 1. Maternal age and Employment as a main effects have statistically significant impact on the model. Impact of the Employment can't be analyzed separately because of its interaction with COVID-19 related fear and STAI-T level. The biggest contribution to model has interaction term Number of children * COVID-19 related fear * STAI-T level (Partial eta squared = 0.182).

One-way ANOVA revealed that there was no statistically significant difference between groups of interaction terms Employment * COVID-19 related fear [$F_{(5,136)} = 2.034$, $p = 0.078$] and Employment * STAI-T level [$F_{(3,138)} = 2.199$, $p = 0.091$] but for interaction term Number of children * COVID-19 related fear * STAI-T level, there is statistically significant difference between groups $F_{(11,130)} = 2.839$, $p = 0.002$. *Post-hoc* test with Tukey-Kramer correction was used. It turns out that group of children whose mothers have one child, sometimes fearing getting COVID-19 infection and intermediate level of STAI-T (group 2) have the highest level of speech-language achievement (mean value = 22.67). There is statistically significant difference between this group and group 4 (p2–4 = 0.006). On the other hand, children groups 3, 4, and 12 have minimal speech-language achievements (17.50, 17.56, 17.50, respectively), but there were no statistically significant differences between group mean values except mentioned between groups 2 and 4. Explanation of membership to the variable group is given in Table c in **Appendix A**.

In **Figure 2**, the plot of estimated marginal means of dependent variable Speech-language for statistically significant interactions is presented as an example of interaction terms in all four univariate GLM models.

Results of Motor Skills Achievement

Univariate GLM analysis for dependent variable MOTOR skills achievement revealed that the full linear model (**Appendix B**) could explain 34.7% of variability $F_{(21,120)} = 3.031$, $p < 0.001$, $\eta p^2 = 0.347$ and Observed Power = 0.999. One-way ANOVA for interaction term Employed * COVID-19 related fear * STAI-T level revealed statistically significant difference between groups $F_{(11,130)} = 2.206$, $p = 0.018$. It turns out that children from group 6 had the highest (mean value = 16.00), and children group 11 had the lowest level (mean value 11.42) of Motor skills achievement. *Post-hoc* test with Tukey-Kramer correction revealed that there was no statistically significant difference between particular groups. Explanation of membership to the variable group is given in Table d in **Appendix A**.

Univariate GLM analysis for dependent variable COGNITION achievement revealed that full linear model (**Appendix B**) could explain 30.9% of variability $F_{(21,120)} = 2.555$, $p = 0.001$, $\eta p^2 = 0.309$ and Observed Power = 0.997.

One-way ANOVA revealed a statistically significant difference between groups of interaction term Employed * COVID-19 related fear [$F_{(5,136)} = 2.825$, $p = 0.017$]. *Post-hoc* test with Tukey-Kramer correction was used. It turns out that group 5 has the highest level of cognitive achievement (mean value = 21.5). There is statistically significant difference between this group and groups 3 and 4 (p5–3 = 0.016, p5–4 = 0.021). On the other hand, children group 3 has minimal Cognitive achievement (mean value = 17.44), but there was no statistically significant difference between group mean values except mentioned between groups 3 and 5. Explanation of membership to the variable group is given in Table a in **Appendix A**.

For interaction term Number of children * COVID-19 related fear * STAI-T level, we obtained statistically significant difference between groups $F_{(11,130)} = 2.266$, $p = 0.015$. It turns out that children group 10 had the highest (mean value = 20.625), and children group 12 had the lowest level (mean value 15.25) of Cognition achievement. *Post-hoc* test with Tukey-Kramer correction revealed that there is statistically significant difference between groups 10 and 4. Children group 4 had a mean value of cognition achievement of 16.190. This finding is a bit specific, but in that group were 16 samples while in group 12 were only 4. Explanation of membership to the variable group is given in Table c in **Appendix A**.

Results of Socio-Emotional Achievement

Univariate GLM analysis for dependent variable SOCIO-EMOTIONAL achievement revealed that the full linear model (**Appendix B**) could explain 39.1% of variability $F_{(21,120)} = 3.673$, $p < 0.001$, $\eta p^2 = 0.391$ and Observed Power = 0.999.

One-way ANOVA revealed a statistically significant difference between groups of interaction term Employed * STAI-T level [$F_{(3,138)} = 3.309$, $p = 0.022$]. *Post-hoc* test with Tukey-Kramer correction was used. It turns out that group 4 has the highest level of Socio-emotional achievement (mean value = 15.54). There is statistically significant difference between this group and group 1 (p4–1 = 0.011). On the other hand, children group 1 has minimal Socio-emotional achievement (mean value = 13.40), but there was no statistically significant difference between group mean values except mentioned between groups 1 and 4. Explanation of membership to the variable group is given in Table b in **Appendix A**.

For interaction term Number of children * COVID-19 related fear * STAI-T level, there was no statistically significant difference between groups $F_{(11,130)} = 1.811$, $p = 0.058$. It turns out that children group 2 had the highest (mean value = 16.0), and children group 3 had the lowest level (mean value 12.33) of Socio-emotional achievement. Explanation of membership to the variable group is given in Table c in **Appendix A**.

DISCUSSION

The present prospective cohort study examined whether maternal trait anxiety was associated with speech-language, sensory-motor and socio-emotional development in 12 months old Serbian infants during COVID-19 pandemic. Prenatal maternal anxiety may represent a relevant risk factor that interferes in various ways with child development. There is already quite a bit of evidence on the consequences that prenatal maternal anxiety may produce on the psychophysiological child development (Dunkel Schetter and Tanner, 2012; Huizink et al., 2014; O'Connor et al., 2014; Rees et al., 2019), while the interest in this topic has increased significantly in the past 20 years. The impact of maternal prenatal anxiety on child development needs to be additionally considered to the COVID-19 pandemic, which impacts on pregnancy and maternal mental health have also been studied in the past 2 years (Quinlivan and Lambregtse-van den Berg, 2020; Usher et al., 2020; Yan et al., 2020; Motrico et al., 2021). On the other hand, there are scarce data about longitudinal trajectories of maternal prenatal anxiety on early child development during the COVID-19 pandemic (Barišić, 2020; Quinlivan and Lambregtse-van den Berg, 2020; Araújo et al., 2021).

The present study sought to explore whether maternal prenatal anxiety impacts psychophysiological development in 12 months old Serbian infants during the COVID-19 pandemic. Specifically, the aim was to investigate the prospective impact of maternal prenatal anxiety on infant speech-language, sensory-motor and socio-emotional development at the age of 12 months, controlling maternal age, employment status, the number of children that mother has, COVID-19-related fear, STAI-T, and MSPPS.

Our main findings were as follows: Pregnant women from the sample, who were examined during the third trimester of pregnancy, had intermediate and high levels of trait anxiety, while none had low levels of anxiety. Also, all pregnant women reported a high level of perceived social support. Almost half of the pregnant women reported a COVID-19-related fear, while a group of pregnant women whose number is slightly less than half

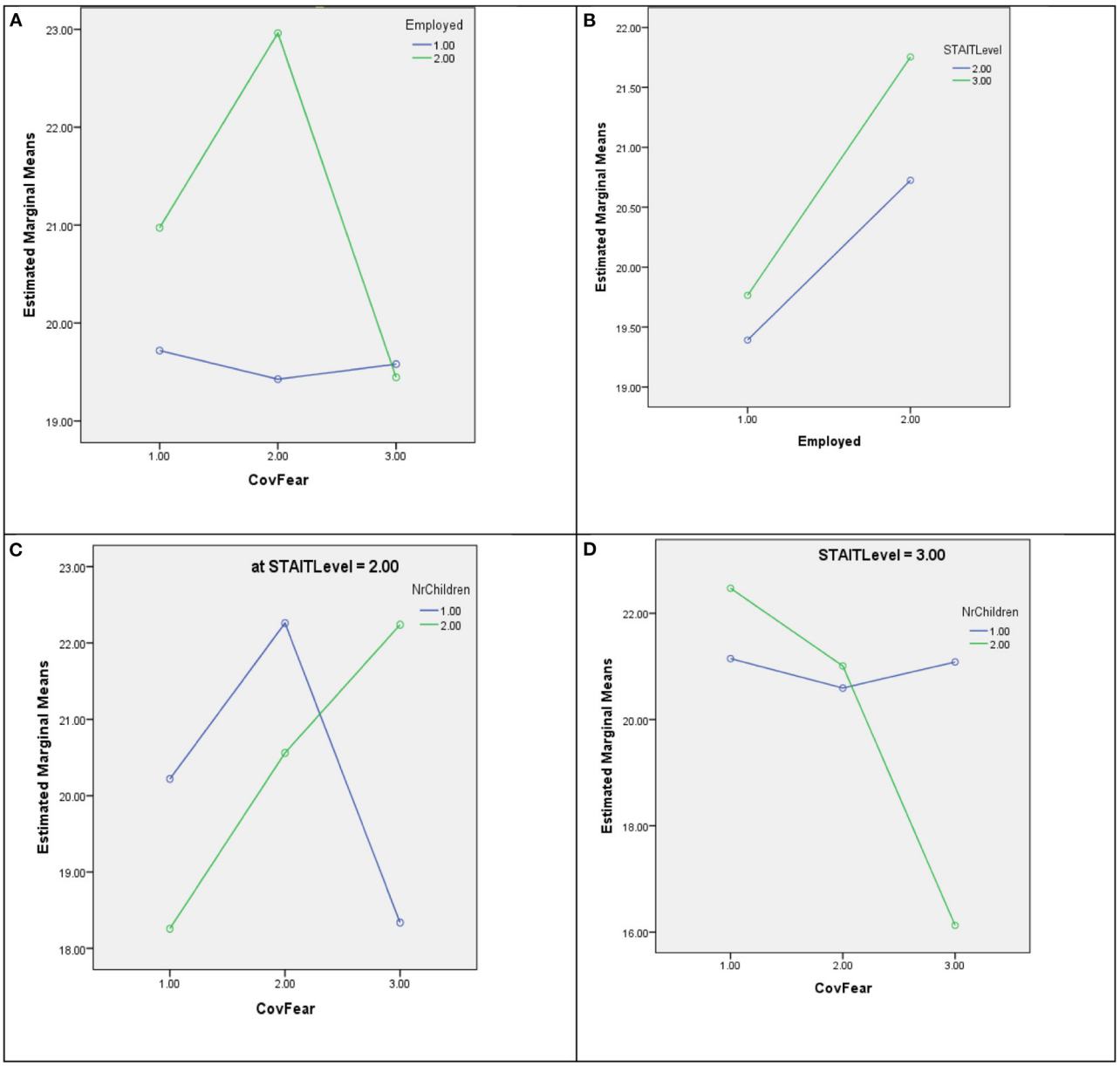

FIGURE 2 | Plot of estimated marginal means of dependent variable speech-language for interactions **(A)** Employed * COVID-19 related fear, **(B)** Employed * STAI-T level, **(C)** Number of children * COVID-19 related fear * STAI-T level where STAI-T level = 2, and **(D)** Number of children * COVID-19 related fear * STAI-T level where STAI-T level = 3. Covariates appearing in the model are evaluated at the following values: Maternal age = 29.5634, MSPSS = 76.7042.

reported that they have no COVID-19 related fear. Only a small percentage of pregnant women reported that they sometimes had COVID-19-related fear. Moreover, pregnant women who reported having a COVID-19 related fear had higher trait anxiety levels. The average developmental achievements in infants aged 12 months were as follows: the highest level of achievement was present in the assessment of cognition, followed by average achievement in socio-emotional development, then in speech and language development, and finally in motor skills. The experimental factors have an impact on infants' development.

Maternal Trait Anxiety During Pregnancy in the Context of COVID-19 Pandemic

The study found intermediate and high levels of maternal anxiety among 142 pregnant women from Serbia. The same findings were observed both on STAI-S and STAI-T scale. It was noticed that none of the study participants had a low level of maternal anxiety during pregnancy. In further analysis of the results, we observed the values of STAI-T, which measure relatively stable individual differences in propensity for anxiety (Julian, 2011), while the STAI-S values are relatively transient

and variable over time (Floris et al., 2017; Papadopoulou et al., 2017). Similarly to findings from the literature relating to the COVID-19 pandemic and mental health consequences (Shigemura et al., 2020; Xiang et al., 2020), and especially the consequences on maternal mental health (Corbett et al., 2020; Mappa et al., 2020; Saccone et al., 2020; Yan et al., 2020), our findings also indicated that the COVID-19 pandemic has a profound impact on maternal prenatal anxiety, and maternal mental health in general. Various factors during the COVID-19 pandemic have been identified that lead to mental health consequences (Berthelot et al., 2020; Liu et al., 2021). However, the exact prevalence of anxiety among pregnant women during the COVID-19 pandemic is currently unknown, although recent research from different countries suggests elevated symptoms of anxiety in this population of women (Liu et al., 2021; Tomfohr-Madsen et al., 2021). Considering the above data on elevated anxiety symptoms in pregnancy during the COVID-19 pandemic, we could partly explain only the participation of pregnant women with intermediate and high levels of anxiety and the absence of pregnant women with low levels of anxiety in our study. On the other hand, all pregnant women were examined in the third trimester of pregnancy, which emerged as the most vulnerable to the manifestation of high anxiety levels compared to the previous two trimesters (Gunning et al., 2010).

The Role of Perceived Social Support

The present study revealed that all pregnant women reported increased social support during the COVID-19 pandemic, which is in line with recent studies (Zhang and Ma, 2020; Hashim et al., 2021). This could be explained by the burdensome circumstances that resulted from the COVID-19 pandemic, since social support acts as a protective factor against the adverse mental health difficulties resulting from epidemics and natural disasters (King et al., 2012), and has been identified as an essential protection against stressful life events (Dambi et al., 2018).

Though certain studies indicate that there is a significant inverse relationship between social support and state and trait anxiety in pregnancy (Aktan, 2012), even during the COVID-19 pandemic (Lebel et al., 2020; Khoury et al., 2021), we did not notice such a relationship in our study, but the opposite one. This might be explained by the hypothesis that explains how the impact of social support on health increases during stressful circumstances (Flannery and Wieman, 1989). On the other hand, although there is large evidence that social support predicts depression and vice versa, there is little evidence to explain the directionality of perceived social support and anxiety (Dour et al., 2014). Especially, there are no precise indicators on the impact on individuals' social aspect and the mental health of pregnant women during the COVID-19 epidemic (Api et al., 2020). Findings from our study showing a high level of perceived social support in pregnant women, despite their high level of anxiety during the COVID-19 pandemic, could be further explained by the role that social support has as an essential coping resource, as well as a mechanism for the maintenance of psychological well-being under conditions of psychological burdens (Bruwer et al., 2008). Also, it is important to consider the fact that there is a strong family bonding in Serbian culture, especially during women's pregnancy when family and friends give strong support to women in every sense.

The Role of COVID-19 Related Fear

Although resent research indicated that the COVID-19 pandemic might cause a significant long-lasting increase in fear (Skoda et al., 2020), in our study, less than half of pregnant women reported having a fear of getting a coronavirus infection (COVID-19-related fear). Our results should be interpreted in line with findings that point to decreasing of COVID-19 fear within 6 weeks from the pandemic outbreak (Hetkamp et al., 2020), but also with evidence indicating that individuals may respond differently to the emotional distress caused by traumatic events such as this pandemic (Killgore et al., 2021).

Pregnant women who reported that they have no COVID-19 related fear had lower STAI-T anxiety levels. One-way ANOVA showed a statistical significance of the difference in average STAI-T values to the presence of COVID-19 related fear. However, *post-hoc* analysis subsequently showed that there was no statistical significance between the groups. However, such findings indicating a connection between fear and trait anxiety are in line with the literature that confirmed this relationship (Paredes et al., 2021).

Developmental Achievements of Infants Aged 12 Months

Child development is a complex maturational and interactive process that includes a gradual progression of perceptual, motor, cognitive, language, socio-emotional and self-regulatory abilities (Sameroff, 2009). There is increasing evidence of the importance of the first 1,000 days of life on later human development (Black et al., 2017; Agarwal et al., 2020). In that light, we also observed the first 12 months of the child's development, the age of the examined children in our study.

Harmonization of developmental abilities is a precondition for orderly child development (Sameroff, 2009). Observing the developmental abilities of infants aged 12 months in our study, we noticed that the highest level of correlation exists between socio-emotional development and speech-language development; then between socio-emotional development and cognition; then between cognition and motor skills, and finally between speech-language and motor skills. Some authors pointed to the connection between the mentioned abilities, which is not simple and direct, but rather complex and multiple (Piek et al., 2008; Wang et al., 2014; Bedford et al., 2016). The links between achievements in cognitive, social communication, and language development were noted, considering the assumed correlation and interdependence of the mentioned abilities (Iverson, 2010; Libertus and Violi, 2016). The highest association between socio-emotional development and speech-language development found in this study may be explained by the close connection between emotion and action, within which communication has a central aspect of action (Saarni et al., 2006). The quality of the maternal-infant relationship has a significant influence on infant development (Johnson, 2013). On the other hand, some authors pointed that a mother's emotional connection with her child has an essential role in predicting social–emotional outcomes and less

cognitive, language, and motor development outcomes in infant development (Le Bas et al., 2021). We assumed that maternal-infant bonding, as one of the predictors of child development (Johnson, 2013), has a significant role even more during the COVID-19 pandemic, and thus reflects infants' socio-emotional development, and speech-language consequently.

The relationship between motor skills and language, cognitive, social, and perceptual development has been intensively studied in recent years (Leonard and Hill, 2014; Leonard et al., 2015; Libertus and Violi, 2016; Libertus and Hauf, 2017; Collett et al., 2019). Interactions between cognition, language, and speech motor skills at an early developmental stage are also shown (Nip et al., 2011). However, the weakest correlation between speech-language and motor skills found in this study may be interpreted with similar findings (Alcock and Krawczyk, 2010), although it is not yet fully understood how the development of motor skills affects the development of speech-language (Libertus and Violi, 2016).

The Potential Impact of Maternal Trait Anxiety on the Early Infants' Development During COVID-19 Pandemic

Bearing in mind that in our study, all mothers during pregnancy had an intermediate or high level of trait anxiety, it was important to examine the impact of anxiety on the early infants' development. The impact of pregnant woman's anxiety on early child development has been well-documented (O'Connor et al., 2002, 2014; Dunkel Schetter and Tanner, 2012; Huzinik, 2014). Also, an essential issue under consideration is the impact of the COVID-19 pandemic upon pregnancy, childhood and adult outcomes (Quinlivan and Lambregtse-van den Berg, 2020). The results of our study pointed to a weak positive correlation between maternal trait anxiety and the child's socio-emotional status, which is in line with the literature (Rees et al., 2019).

In addition, literature data have shown that other factors may also affect the child's development, such as the maternal age, employment, and the number of children the mother has (Brooks-Gunn et al., 2002; Bernal, 2008; Chittleborough et al., 2011; Tearne, 2015; Duncan et al., 2018; Falster et al., 2018). With this in mind, we decided to examine the influence of these factors depending on the levels of trait anxiety, COVID-19 related fear, and perceived social support.

Table 5 shows the association between the independent factors STAI_T level, COVID-19 related fear, Number of children and Employment (nominal type) and the dependent variables Speech and language, Motor skills, Cognition and Socio-emotional achievement (scale type). It is evident that association depends on factor variable combination. For example, STAI-T level has the highest association with Cognition ($\eta = 0.515$) and the lowest with Socio-emotional achievement ($\eta = 0.0.254$), while Employment has the highest association with Motor skills ($\eta = 0.449$) and the lowest with Cognition ($\eta = 0.0.266$) It is important to notice that all independent factors are associated with child's development. Results indicate that part of the variability of developmental abilities can be explained by factors. It implies that the factors have an impact on child development.

Univariate analysis showed that between 30.9 and 40.6% variability of dependent variables Speech-language, Motor skills, Cognition and Socio-emotional achievement could be explained by factors Employed, Number of children, COVID-19 related fear and STAI-T level and covariates Maternal age and MSPSS. It can be concluded from **Table 5** that interaction terms have a dominant impact on models. In all models statistically significant impact of COVID-19 related fear and STAI-T level interaction is present. However, this two-way interaction also occurs as an element of a statistically significant three-way interaction. In the case of all dependent variables, they occur in interaction with number of children. Only in Motor skills Observed Power is <0.8 (0.741). In the case of Motor skills, three-way interaction with Observed Power >0.8 (0.927) occurs between COVID-19 related fear, STAI-T level, and Employed. The interaction of factors and their influence can be easily observed from the example given in **Figure 2**.

If we look at the three-way interaction term Number of children * COVID-19 related fear * STAI-T level found in all four linear models, we notice that the influence of individual factors on achievements within the developmental functions is different. That is, for each of the four development functions, the maximum and minimum achievements are influenced by different combinations of interacting factors values. For example, while children of mothers who have one child are sometimes afraid of COVID-19 and have an intermediate level of STAI-T have the most developed speech and language, children of mothers who have two or more children have no fear of COVID-19 and have a high level of STAI-T show the best cognitive abilities. The obtained results indicate a complex interdependence of the observed factors and their influence on the development of the observed functions in the first 12 months of a child's life. We can say that the mother-child relationship in this period is subject to the influence of various factors, reflecting on the child's development and having complex implications on individual functions.

The conducted research did not answer the question of the individual influence of the analysed factors on the child's development, but it confirmed our hypothesis that the mother's anxiety affects the child's development. COVID-19 related fear has also been shown to have an effect. In that sense, considering that there are no consolidated studies on the possible impacts of COVID-19 on pregnant women's health and their children's development, especially over the long term, maternal anxiety during this period is a problem that needs to be more widely addressed.

CONCLUSION

The study showes that the COVID-19 pandemic affects the level of trait anxiety manifestation in pregnant women and the level of perceived social support. Selected factors as follows: maternal age, the level of maternal anxiety, and the maternal COVID-19 related fear influence the infants' development. This study confirmes our hypothesis that maternal anxiety and fear of COVID-19 have an influence on infant's development. Due to the interaction

between the factors, their individual influence could not be precisely determined. Further focused research should provide an answer to this question.

Generally, this study aims to improve the understanding of the impact of the COVID-19 pandemic on infants' development, which can help to guide appropriate strategies to prevent dysfunctions in the children's development on the one hand, and on the other to promote a stimulating environment for children.

Strengths and Limitations

To the best of our knowledge, there are no studies that monitor the early infant's development under the influence of the mother's mental health during the COVID-19 pandemic. Since this study was conducted during a COVID-19 pandemic, we assume that it resulted without having a group of mothers with a low level of trait anxiety. In that sense, it was not possible to make a more precise conclusion about the influence of maternal anxiety on the infants' development during the COVID-19 pandemic. On the other hand, it is not possible to accurately state the impact of each observed factor on the early infants' development. It is also important to note that the comorbidity of depression/anxiety is very high, and its impact on child's development during the COVID-19 pandemic was not estimated in our study. Also, only the mothers were included in the study, which indicates that without including fathers/partners, the impact of child development could not be determined accurately. The findings from this study suggest that future research is warranted to investigate the longitudinal impacts of maternal and parental mental health on child development during the COVID-19 pandemic, taking into account additional measurement points and modifiable risk factors. The need for systematic monitoring of children at the earliest age was pointed out, and providing the necessary support to pregnant women and fathers/partners during the COVID-19 pandemic.

AUTHOR'S NOTE

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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 Miško Subotić, m.subotic@add-for-life.com.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Clinic for Gynecology and Obstetrics Narodni Front (Date: 26 March, 2020, No 27/20), in Belgrade and by the Ethics Committee of the Institute for experimental phonetics and speech pathology (Date: 2 April, 2020, No 45/20), in Belgrade, Serbia. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

LJ and MSu: conceptualization and visualization. LJ and MSo: methodology. MSu: formal, statistical analysis, and supervision. LJ, IB, and AD: investigation. AD and IB: data curation. LJ: supervision of the (ongoing) data collection and writing—original draft preparation. MSo, OG, and MK: writing—review and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.792053/full#supplementary-material

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Maternal History of Adverse Experiences and Posttraumatic Stress Disorder Symptoms Impact Toddlers' Early Socioemotional Wellbeing: The Benefits of Infant Mental Health-Home Visiting

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Background: The present study examined the efficacy of the Michigan Model of Infant Mental Health-Home Visiting (IMH-HV) infant mental health treatment to promote the socioemotional wellbeing of infants and young children. Science illuminates the role of parental "co-regulation" of infant emotion as a pathway to young children's capacity for self-regulation. The synchrony of parent–infant interaction begins to shape the infant's own nascent regulatory capacities. Parents with a history of childhood adversity, such as maltreatment or witnessing family violence, and who struggle with symptoms of post-traumatic stress may have greater challenges in co-regulating their infant, thus increasing the risk of their children exhibiting social and emotional problems such as anxiety, aggression, and depression. Early intervention that targets the infant–parent relationship may help buffer the effect of parental risk on child outcomes.

Methods: Participants were 58 mother–infant/toddler dyads enrolled in a longitudinal randomized control trial testing the efficacy of the relationship-based IMH-HV treatment model. Families were eligible based on child age (<24 months at enrollment) and endorsement of at least two of four socio-demographic factors commonly endorsed in community mental health settings: elevated depression symptoms, three or more Adverse Childhood Experiences (ACEs) parenting stress, and/or child behavior or development concerns. This study included dyads whose children were born at the time of study enrollment and completed 12-month post-baseline follow-up visits. Parents reported on their own history of ACEs and current posttraumatic stress disorder (PTSD) symptoms, as well as their toddler's socioemotional development (e.g., empathy, prosocial skills, aggression, anxiety, prolonged tantrums).

Results: Maternal ACEs predicted more toddler emotional problems through their effect on maternal PTSD symptoms. Parents who received IMH-HV treatment reported more positive toddler socioemotional wellbeing at follow-up relative to the control condition. The most positive socioemotional outcomes were for toddlers of mothers with low to moderate PTSD symptoms who received IMH-HV treatment.

Conclusion: Results indicate the efficacy of IMH-HV services in promoting more optimal child socioemotional wellbeing even when mothers reported mild to moderate PTSD symptoms. Results also highlight the need to assess parental trauma when infants and young children present with socioemotional difficulties.

Keywords: infant mental health, parent-infant psychotherapy, maternal PTSD, Infant Mental Health-Home Visiting, infant socioemotional development, maternal childhood adversity, toddler socioemotional development

INTRODUCTION

Science illuminates the role of parental "co-regulation" of infant emotion as a pathway to young children's capacity for socioemotional wellbeing, including the ability to express and manage emotions, and manage attention and impulses that facilitate social relationships (Geva and Feldman, 2008). Parents with a history of childhood adversity, such as maltreatment or witnessing family violence, may have greater challenges in co-regulating their infant, thus increasing the risk of their children exhibiting social and emotional problems such as anxiety, aggression, and depression (Ahlfs-Dunn and Huth-Bocks, 2014; Steele et al., 2016). In this paper, we summarize the relationship between maternal psychological wellbeing and infant socioemotional development. Specifically, we examine the influence of maternal early adversity and current symptoms of posttraumatic stress on infant socioemotional wellbeing. Finally, we explore the efficacy of Infant Mental Health-Home Visiting (IMH-HV) (Tableman and Ludtke, 2020) in promoting the socioemotional wellbeing of infants whose mother has a history of early adversity and current symptoms of posttraumatic stress disorder (PTSD).

Infant Socioemotional Development

Emotion regulation is an important aspect of infant socioemotional wellbeing. It acts to reduce negative emotions and, importantly, also serves in "amplification, an intensification of positive emotion, a condition necessary for more complex self-organization" (Schore, 2001b, p. 21). The neuroscience of the development of early childhood emotion regulation largely focuses on parent–child interactions and the parent–infant attachment system. Exchanges between parent and child in the form of emotional or affective communication, sharing emotion, and the caregiver's "empathic understanding" of the child's emotional state are important pathways in the process of emotion regulation (Schore, 2001a; Trevarthen, 2001; Manian and Bornstein, 2009). Ultimately, the synchrony children experience in infancy primes them for emotion regulation, social interactions, and affiliative partnerships later in life (Kinreich et al., 2017). The newborn infant is biologically equipped to engage in "bio-behavioral synchrony" (Feldman, 2012) that also contributes to the development of the attachment relationship with their parent(s). Their biosocial development is supported through daily interactive exchanges, as they learn the language (Oller et al., 2001; Kuhl et al., 2006) and emotion display "rules" (Matsumoto and Hwang, 2013) of the culture in which they are growing.

In studies examining behavioral challenges in children, several indicators of parenting are associated with social competence and resilience, as well as early emotional/behavioral disorders. For example, a secure mother–infant attachment not only promotes resiliency, but also protects against such behavioral issues (Letourneau, 1997; Edwards et al., 2006; Cyr et al., 2010; Riva Crugnola et al., 2014). Higher parental cognitive empathy and reflective functioning, both of which measure the capacity to perceive and understand the emotional states of others, are connected to emotion regulation and social competence in children (Wong et al., 2017; Borelli et al., 2020). Furthermore, higher frequency of shared pleasure moments in early childhood between mother and child have been shown to lower the likelihood of emotional/behavioral problems in children and moderate the possible negative effects of parental psychopathology on the development of children's emotion regulation abilities (Mäntymaa et al., 2015).

Parents who are grossly insensitive to their infant's affective communication overwhelm their infant's capacity to develop organized and effective emotion regulation strategies (Lyons-Ruth et al., 1999). Underdeveloped emotion regulation systems often lead to dysregulated emotions and frequently manifest as child internalizing and externalizing behaviors, including excessive or prolonged tantrums, physical aggression, and/or emotional withdrawal and anxiety (Lyons-Ruth, 1996; Calkins et al., 2007; Chambers and Allen, 2007; Beauchaine and Thayer, 2015; Ostlund et al., 2019).

Maternal Stress and Trauma

An informed approach to understanding the dynamics and developmental implications of early parent–child interactions must also attend to parental wellbeing and psychopathology. The mental health of any primary caregiver can significantly affect early relationships and child development; however, we focus on maternal mental health given the replicated associations between maternal wellbeing and myriad gestational, birth, and caregiving

outcomes (Grote et al., 2010; Kingston et al., 2012; Monk et al., 2012; Van den Bergh et al., 2020). A history of adverse experiences in childhood, traumatic stress, and PTSD can impact adult emotion regulation and sensitive and responsive parenting, and in turn impact young children's social–emotional development.

Adverse Childhood Experiences

Adverse Childhood Experiences (ACEs) generally refer to events prior to the age of 18 that may have been distressing or traumatizing for an individual, including psychological, physical, or sexual abuse, physical and emotional neglect, or witnessing interpersonal violence, among other events (Felitti et al., 1998). The original ACEs study (Felitti et al., 1998) demonstrated the significant connection between cumulative exposure to abuse, neglect, or household dysfunction during childhood and multiple adverse health outcomes in adulthood, including increased risk of depression, an array of physical health issues, and early mortality (Chapman et al., 2004; Felitti et al., 2019). In the perinatal period, higher ACE scores are associated with negative pregnancy and birth outcomes, including high-risk pregnancy behaviors (e.g., alcohol and cigarette use), preterm birth, and low birth weight (Chung et al., 2009; Hudziak, 2018; Racine et al., 2018). Pregnancy and the postpartum period are commonly associated with the initial onset or exacerbation of mental health concerns (Munk-Olsen et al., 2016) and women with a history of childhood adversity are disproportionately at risk for clinically significant symptoms of perinatal depression, anxiety, and PTSD (McDonnell and Valentino, 2016; Narayan et al., 2016, 2018; Oh et al., 2016; Meltzer-Brody et al., 2018; Racine et al., 2018; Atzl et al., 2019; Osofsky et al., 2021). In the current study, we therefore expand upon the existing literature to address intergenerational relationships between experiences of adversity in a mother's own childhood, current maternal PTSD symptoms, and socioemotional and behavioral outcomes for her young child.

Maternal Traumatic Stress

Childhood adversity can also lead to cumulative, chronic stress when the event is on-going in duration or uncontrollable in nature, and children do not have a stable or emotionally available caregiver who can support and protect them or help them make sense of the situation(s) (Lieberman and Van Horn, 2009; Slade, 2014). Mothers who faced more adversity in their own childhoods are more likely to use corporal punishment and to display hostile, intrusive, or frightening parenting behaviors (Jacobvitz et al., 2006; Chung et al., 2009). Condon et al. (2019) suggest that mothers who experienced high levels of adversity and stress early in life may have limited lived experiences to draw from in order to offer their children solace from stressful experiences or teach effective coping skills in the presence of current stressors. Intrusive, withdrawing or hostile parenting styles can have direct effects on the infant and young child, as well as contribute to challenges within the mother–child relationship (Lyons-Ruth, 1996). Maternal ACEs in the form of childhood maltreatment are directly correlated with higher levels of maladaptive socioemotional symptoms in infants (McDonnell and Valentino, 2016). There is evidence that maternal childhood trauma leads to disturbed caregiving behavior which in turn interferes with infants developing a secure attachment (Lyons-Ruth and Block, 1996). Furthermore, a mother's history of ACEs predicts higher behavioral problems and blood pressure levels – a tangible biomarker of stress – in children (Condon et al., 2019). Nevertheless, the impact of maternal childhood adversity and toxic stress on parenting behaviors and child outcomes is probabilistic rather than deterministic. When controlling for concurrent perinatal mental health symptoms, effects of maternal childhood adversity on parenting and child outcomes do not always confer risk (Martinez-Torteya et al., 2014; Muzik et al., 2017; Morelen et al., 2018). However, in toddlers and older children, maternal childhood abuse and adversity more consistently predict risk for emotional and behavioral problems (e.g., Collishaw et al., 2007; Min et al., 2013; Myhre et al., 2014; van de Ven et al., 2020). Thus, a mother's own childhood adversity and caregiving history may directly impact her child's development of emotion regulation, often manifesting as behavioral and emotional regulation challenges. This is even more true in the context of maternal post-traumatic stress disorder. For example, maternal PTSD symptoms predict infant emotional reactivity and regulation deficits (Bosquet Enlow et al., 2011), insecure and disorganized attachment (van Ee et al., 2016), dysregulation in preschoolers (Pat-Horenczyk et al., 2015), and internalizing and externalizing problems in children (Schechter et al., 2011; Glaus et al., 2021).

There are multiple psychosocial routes through which maternal PTSD may affect young children. Prenatal PTSD symptoms can affect child development through prenatal exposure to mothers' disordered stress-response systems and altered epigenetic programming (Glover et al., 2010); however, dysregulated prenatal stress responses are not limited to current stressors and childhood adversity may play a significant role. Bublitz et al. (2014) found that maternal history of severe childhood sexual abuse was associated with increased cortisol awakening response – a biomarker of PTSD – for pregnant women between 25 and 35 weeks' gestation. In the postpartum period, effects of maternal PTSD on child development may be conferred through disruptions to sensitive and responsive caregiving. Higher severity of PTSD symptoms increase risk for maternal negative representations of the parent–child relationship (Schechter et al., 2005; van Ee et al., 2016). Mothers with PTSD may be emotionally unavailable; experience higher levels of parenting stress; endorse higher levels of aggression toward their children; have increased difficulty reflecting on their child's needs; have limited empathic responses to their child's struggles; and display significant difficulties providing sensitive, nurturing care that contributes to security of attachment and healthy child development (Schechter et al., 2008, 2005; Pereira et al., 2012; Muzik et al., 2013; van Ee et al., 2016). Notable child outcomes associated with maternal PTSD and these maladaptive parenting behaviors include difficult temperament, sleep disturbances, and internalizing and externalizing problems, among other challenges (Tees et al., 2010; Hairston et al., 2011; Parfitt et al., 2013; van Ee et al., 2016; Plant et al., 2018). Maternal trauma symptoms have also been found to mediate the relationship between maternal history of childhood trauma/interpersonal violence and child

outcomes (Schechter et al., 2011; Fenerci and DePrince, 2018). However, no study to our knowledge has examined the impact of broader maternal ACEs on maternal PTSD symptoms and child behavioral outcomes, a gap the current study will address.

Both past and ongoing stress and trauma can impact parent mental health, parenting behavior, parent perception of the infant, and infant socioemotional development. Infant mental health interventions can support parents with a history of stress and trauma and in turn buffer the negative effects of stress and trauma on infant socioemotional development.

Infant Mental Health Treatment

The seminal article, "Ghosts in the Nursery" (Fraiberg et al., 1975), spawned the birth of home-based "kitchen table" therapy (Fraiberg et al., 1980) as a preventative intervention model to promote sensitive and nurturing care, reduce maltreatment, and to promote infant wellbeing (Weatherston and Tableman, 2015; Lawler et al., 2017). Fraiberg and colleagues, 1980 documented, with clinical sensitivity and acuity, the myriad of ways a parental history of unresolved childhood loss, separation, abuse, or neglect resulted in the ghosts in the nursery of the traumatized parent, invading the present parent–infant relationship. The very defenses that the parent, when she was a young child, used to ward off the anxiety of uncontained fear (Fraiberg, 1982; Slade, 2014) emerges in parenting in response to the vulnerability of their newborn or young infant. Later termed infant mental health-home visiting (IMH-HV; Tableman and Ludtke, 2020), IMH-HV offers a mix of needs-driven intervention, often combining concrete services, emotional support, developmental guidance, and infant–parent psychotherapy. Weekly, or twice weekly, depending on the needs of the family, the IMH-home visitor meets in the home of the family, with the infant present. The presence of the infant focuses attention on the developing relationship and enables both the parent and the infant to inform the IMH specialist, *via* their interactive exchanges, what is going well and what is challenging. The Michigan Model of IMH-HV is an empirically validated approach to enhancing parenting outcomes (Rosenblum et al., 2020; Julian et al., 2021; Stacks et al., 2021), but research is nascent of its' impact on the socioemotional wellbeing of the infant. In the presence of a containing, responsive therapist, the parent is helped to grieve unmourned losses, give voice to the fears that went unnoticed in their own childhood, and hear and see the needs of their infant (Malone and Dayton, 2015; Weatherston and Ribaudo, 2020). Infant mental health treatment may help to mitigate the impact of parents' painful early relationship history on the current parent–child relationship and infants' wellbeing.

Current Study

The current study has two distinct aims. The first is to examine the association between maternal ACEs, maternal symptoms of PTSD, and maternal perception of their young child's socioemotional difficulties. Our second aim is to examine whether participation in IMH-HV improves child socioemotional outcomes and mitigates the associations between maternal PTSD symptoms and child socioemotional and behavioral difficulties. With regard to aim 1, we hypothesize that mothers who report greater exposure to ACEs during their own childhood will report more symptoms of PTSD at study baseline and will report that their young children demonstrate more behavioral and emotional difficulties. Furthermore, we hypothesize that mothers' PTSD symptoms will mediate the association between maternal ACEs and elevated infant socioemotional and behavioral difficulties. With regard to aim two, we hypothesize that in the context of maternal PTSD symptoms, mothers randomized to IMH-HV treatment will report their toddlers display more positive socioemotional functioning compared to toddlers randomized to the control condition.

MATERIALS AND METHODS

Methods

Participants were 58 mother–infant/toddler dyads who completed baseline and 12-month follow up visits as part of a larger longitudinal randomized control trial (N = 73) testing the efficacy of the relationship-based IMH-HV treatment model. Families were eligible based on child age (<24 months at enrollment) and endorsement of at least two of the following: eligibility for public assistance, probable maternal depression, perceived parenting challenges, or history of maternal childhood adversity (ACE score >3). Eligible parents were >18 years of age, had legal custody of their child at enrollment, and did not endorse symptoms of substance use disorders or psychosis. Diagnoses such as depression, anxiety, attention deficit hyperactivity disorder, etc., were *not* grounds for exclusion. The study was reviewed and approved by the University of Michigan Institution Review Board. The participants provided their written informed consent to participate in this study.

This particular study included dyads whose children were born at the time of study enrollment and completed 12-month follow-up visits. Seven families were enrolled in the study during pregnancy, resulting in no child baseline data. Eight additional families were lost to follow up. Aside from child age, there were not demographic differences between those who were retained in the study and those who were not, suggesting there was no differential attrition. Given the small sample size, it was not possible to use intent-to-treat analyses. Instead, only those participants with data at the 12 month follow-up were included. Families who did not complete later follow-up visits were evenly split across the treatment and control conditions (4 from each). Additionally, some families completed later follow-up evaluation visits even after they ended participation in the intervention, which ended for some families before 12 months largely due meeting mutually agreed upon goals. Further details can be found in Riggs et al. (2021).

At the time of study enrollment, average maternal age was 32.5 years (SD = 5.41) and the average age of the child was 11.9 months (SD = 6.57). The majority of the sample identified as a racial or ethnic minority (62.1%); White mothers comprised 37.9% of the sample. Nearly 40% of the families (n = 22) reported household incomes of less than $40,000 and the average number of ACEs (Felitti et al., 1998) experienced by mothers was 3.64

(SD = 2.40) out of a possible 10, significantly above the national mean ACE score of 1 (Merrick et al., 2018). See **Table 1** for additional demographic characteristics.

Measures

Maternal Adverse Childhood Experiences

The ACEs questionnaire is a 10-point measure used to assess harmful events (i.e., abuse, neglect, or household dysfunction) that occurred prior to the age of 18. The 10 events include psychological abuse, physical abuse, sexual abuse, physical neglect, emotional neglect, parental divorce, family member mental illness, substance abuse by a family member, incarceration of a family member, and domestic violence. At baseline data collection, participants endorsed (yes) or denied (no) exposure to the 10 items. A total score was calculated by summing the endorsed items, with higher total scores indicating a greater number of adverse events. See **Table 2** for a summary of descriptive statistics for the ACE questionnaire.

Maternal Posttraumatic Stress Disorder Symptoms

The PTSD Checklist for DSM-5 (PCL-5; Weathers et al., 2013; Blevins et al., 2015) is a 20-point self-report measure that assesses symptoms consistent with PTSD diagnostic criteria. Respondents are asked to report on symptoms within the past month, for example, how much they have been bothered by "*Repeated, disturbing, and unwanted memories of the stressful experience?*" or "*Feeling distant or cut off from other people?*" The PCL-5 is scored on a 0–4 Likert scale, increasing in severity from 0 (*not at all*) to 4 (*extremely*), with total scores ranging from 0 to 80. This measure can be used as a screener for a provisional diagnosis of PTSD, wherein the suggested clinical cut-off for total scores falls between 31 and 33. In this study, a total score was calculated by summing the individual items, with higher scores reflecting greater severity of symptoms. Prior reports indicate sound psychometric properties of the PCL-5 (Blevins et al., 2015), and reliability was high in the current sample (α = 0.94). PTSD symptoms data was collected at baseline and 12 months.

TABLE 1 | Frequencies (and percentages) for social demographic characteristics (*N* = 58) at baseline assessment.

	n (%)	*M*	SD
Participant demographics			
Mother age		32.65	5.23
Child age in months		11.95	6.19
Household income range			
0–$19,999	9 (15.8)		
$20,000–$39,999	13 (22.4)		
$40,000–$59,999	13 (22.4)		
$60, 000–$79, 999	5 (8.5)		
$80,000 and above	17 (29.2)		
Race/ethnicity			
White	22 (37.9)		
Racial or ethnic minority	36 (62.1)		
Education level			
High school diploma or less	8 (13.8)		
Some college or associates degree	12 (20.7)		
College or Voc. Tech degree	22 (37.9)		
Postgraduate degree	16 (27.6)		
Marital status			
Currently married	47 (81.0)		
Not currently married	11 (19.0)		

One participant did not wish to report income data for her family.

Infant-Toddler Socioemotional Development

The Brief Infant-Toddler Social Emotional Assessment (BITSEA; Briggs-Gowan et al., 2004) is a 44-item parent-report measure for children ages 12–35 months. It is a screener used to assess social, emotional, behavioral problems, and delays in competence as well as to identify children measuring at-risk in multiple areas. Parents rate each descriptive comment about their child (e.g., "My child often gets very upset") from 0 (*not true/rarely*) to 2 (*very true/often*). In this study, the 31-item total Problem Score was utilized, with a possible range of scores from 0 to 62. Higher Problem Scores indicate greater difficulties with child internalizing, externalizing, or regulation capacities. The BITSEA can only be administered after the infant is 12 months old. Because a number of families began treatment prior to the child's first birthday, there was too much missing data at baseline to use in analyses. As such, the BITSEA is only used in study aim 1 to assess elevated social emotional difficulties at 12-months.

The Devereux Early Childhood Assessment

Because the BITSEA is only administered after the infant is 12 months old, we also included the Devereux Early Childhood Assessment-Infant (DECA-I) and the Devereux Early Childhood Assessment-Toddler (DECA-T; Powell et al., 2007) to enable a large enough sample size to accommodate the planned analyses. The DECA-I and DECA-T are standardized parent-report measures of children's emotional and behavioral adjustment. The measure generally assesses positive and protective factors demonstrated by resilient infants and toddlers. There are two subscales that are consistent across both versions of the Devereux Early Childhood Assessment (DECA); the Initiative scale, which measures behaviors used by the infant/toddler to meet their needs, and the Attachment/Relationships scale, which assesses social and emotional behavior and regulation exhibited between the infant/toddler and their caregiver. Example items on the Initiative scale include "*. . .how often did the child try to do things for herself/himself?*" and "*. . .how often did the child try to comfort others?*" Example items on the Attachment/Relationships scale include "*. . .how often did the child seek comfort from familiar adults?*" and "*. . . how often did the child express a variety of emotions (e.g., happy, sad, mad)?*"

For the infant version of the assessment (DECA-I; used for children 0–18 months of age), there are 18 items on the Initiative subscale and 15 items on the Attachment/Relationships subscale. For the toddler version of the assessment (DECA-T; used for children 18–36 months of age), there are 11 items on the Initiative scale and 18 items on the Attachment/Relationships scale. Scoring on both forms of the DECA yield standardized *T*-scores, where scores greater than 60 indicate a strength, scores less than 40 indicate an area of concern, and scores

between 40 and 60 indicate typical socioemotional development. Subscale reliability for both versions of the DECA were acceptable (Cronbach's alpha for the Initiation subscale ranged from 0.68 to 0.85; Cronbach's alpha for the Attachment/Relationships subscale ranged from 0.90 to 0.92).

Analytic Strategy

Data were analyzed using IBM SPSS for Windows, Version 26. Frequencies and percentages were calculated for all categorical variables. Means and standard deviations were calculated for the continuous variables. Before proceeding with the primary study analysis, data were screened for errors and extreme values to ensure that data met assumptions for statistical analysis and to understand factors that may affect interpretation of the findings. Variables were checked for outliers and assessed for normal distribution of differences in the scores; all assumptions for the planned analyses were met.

For our first aim, we conducted a multiple regression mediation model using PROCESS (Hayes, 2013) to explore the relationship between the mothers' baseline experience of childhood adversity, the severity of maternal PTSD symptoms, and infant/toddlers' socioemotional and behavioral outcomes at the 12 month follow up wave. We used the BITSEA Problem score as the measure of socioemotional and behavioral outcomes for this aim, given its wide use as a measure of child socioemotional functioning and excellent psychometric properties.

For our second aim, we conducted a multiple regression moderation model (Hayes, 2013) to explore the impact of treatment condition on infant/toddler socioemotional outcomes and the potential role of maternal PTSD symptoms in this effect. For this aim, we utilized the DECA subscales as our measures of child socioemotional development. This was necessary in order to control for baseline socioemotional development because the DECA can be administered to infants less than 12 months of age, while the BITSEA can only be administered once the child is older than 1 year. Given that many of the families began treatment when their child was less than 1 year, there was not enough BITSEA data available to use to examine pre/post treatment efficacy. DECA Initiation and Attachment subscales were evaluated separately.

RESULTS

Preliminary Analyses

Prior to conducting primary analyses, we examined descriptive and correlational data among our study variables of interest. See **Tables 2**, **3** for additional detail. Overall, maternal experiences of childhood adversity were relatively high compared to population estimates, and ACE scores ranged from 0 to 10 (M = 3.64; SD = 2.40). Although average scores were below the cutoff used to identify probable PTSD diagnoses (suggested cutoff of 33), there was some variability in the sample, with a number of participants endorsing PTSD symptoms scores above the clinical cutoff (n = 17; 23.30% of sample). Maternal PTSD symptom scores reported at the 12-month data collection visit were relatively lower but included a number of participants (n = 8; 12.1% of sample) whose 12-month assessment of PTSD symptoms indicated probable diagnosis of PTSD.

TABLE 2 | Descriptive statistics for key study variables.

	Baseline			12-month follow-up			
Variable	***M***	**SD**	**Range**	***M***	***M***	**Range**	**Possible range**
Maternal measures							
ACE score	3.64	2.4	0–10	–	–		0–10
PTSD score (PCL-5)	22.89	17.42	1–67	14.06	13.73	0–69	0–80
Child measures							
BITSEA Problems score	–	–	–	11.14	5.92	2–27	0–62
DECA Attachment score	50.94	8.54	33–67	51.94	9.86	33–66	
DECA Initiative score	51.72	8.63	33–72	52.35	10.04	32–72	

ACE, Adverse Childhood Experiences questionnaire; PCL-5, PTSD Checklist for DSM-5; BITSEA, Brief Infant-Toddler Social and Emotional Assessment; DECA, Devereux Early Childhood Assessment.

Over a quarter of the sample of toddlers were rated above the socioemotional problems cutoff score at both data collection time points (n = 20; 27.4% of sample), representing a subgroup of children with high levels of socioemotional problem behavior. Child protective and positive socioemotional factors were also examined using the DECA. On the Attachment subscale of the DECA, scores indicated that most children were in the "typical" range at baseline (M = 50.94; SD = 5.92) and 12-month (M = 51.94; SD = 9.86) data collection visits. Some parents rated their children as having "needs" (baseline and 12-month follow up n = 7; 9.6%) or "strengths" (baseline n = 10; 13.7%; 12-month follow up n = 17; 23.3%) on the Attachment subscale. Likewise, when evaluating the Initiative subscale of the DECA, scores indicated that most children in this study were in the "typical" range at baseline (M = 51.72; SD = 8.63) and 12-month data collection visits (M = 52.35; SD = 10.04), with some children rated as having needs (baseline n = 4; 5.5%; 12-month follow up n = 5; 6.8%) or strengths (baseline n = 9; 12.3%; 12-month follow-up n = 17; 23.3%) in this area.

Examination of bivariate correlations among study variables revealed several significant associations among key study variables. See **Table 3** for additional information.

Primary Analyses

Consistent with our first study aim, we examined the association between maternal ACEs, maternal symptoms of PTSD, and toddler socioemotional difficulties. We hypothesized that mothers who reported greater exposure to childhood adversity would report greater symptoms of PTSD (H1). As shown in **Table 3**, this hypothesis was supported. There was a moderate, positive bivariate association between maternal ACE score and baseline maternal PCL-5 score (r = 0.42, p = 0.000),

TABLE 3 | Correlations among key study variables.

Variable	ACE score	PCL-5 baseline	PCL-5 12-month	BITSEA Problems baseline	BITSEA Problems 12-months	DECA Attachment baseline	DECA Attachment 12 months	DECA Initiative baseline
Parent measures								
ACE score (baseline)	–							
PCL-5 (baseline)	0.42***	–						
PCL-5 (12-month)	0.15[c]	0.44***	–					
Child measures								
BITSEA Problems (baseline)	0.39*	0.10[e]	−0.05[f]	–				
BITSEA Problems (12-month)	0.36**	0.45***	0.22[a]	0.53***	–			
DECA Attachment (baseline)	−0.02[f]	0.05[e]	−0.01[f]	−0.56***	0.01[f]	–		
DECA Attachment (12-month)	−0.11[d]	−0.13[c]	0.06[e]	−0.43*	−0.52**	0.34**	–	
DECA Initiative (baseline)	0.08[e]	0.24[a]	0.08[e]	−0.36*	0.05[e]	0.69***	0.15[c]	–
DECA Initiative (12-month)	−0.19[b]	−0.14[c]	0.0[f]	−0.42*	−0.37**	0.35**	0.68***	0.30*

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a]p ranges from 0.051 to −0.10; [b]p ranges from 0.101 to 0.20; [c]p ranges from 0.201 to 0.30; [d]p ranges from 0.301 to 0.50; [e]p ranges from 0.501 to 0.70; [f]$p > 0.701$.
ACE, Adverse Childhood Experiences questionnaire; PCL-5, PTSD Checklist for DSM-5; BITSEA, Brief Infant-Toddler Social and Emotional Assessment; DECA, Devereux Early Childhood Assessment.

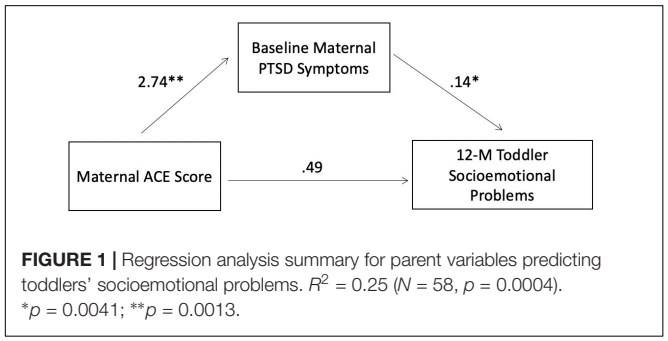

FIGURE 1 | Regression analysis summary for parent variables predicting toddlers' socioemotional problems. $R^2 = 0.25$ ($N = 58$, $p = 0.0004$). *$p = 0.0041$; **$p = 0.0013$.

wherein mothers who reported greater experiences of childhood adversity reported greater symptoms of PTSD when they entered our study. We also hypothesized that toddlers of mothers with greater experiences of childhood adversity would demonstrate more behavioral and emotional difficulties (H1). This relationship was also supported; as shown in **Table 3**, there was a moderate, positive association between maternal ACE score and BITSEA Problem score at baseline ($r = 0.39$, $p = 0.02$) and 12-months ($r = 0.36$, $p = 0.006$). This first hypothesis was also supported within the multiple regression models (see **Figure 1**).

Our second hypothesis was that PTSD symptoms would mediate the association between maternal exposure to childhood adversity and increased risk of child socioemotional and behavioral difficulties in the next generation (H2). Prior to mediation analyses, maternal ACE scores were positively associated with maternal PTSD symptoms measured at baseline and toddlers' socioemotional difficulties as measured by the BITSEA at the 12-month follow-up, such that mothers with more ACEs had greater PTSD symptoms and reported more behavioral and emotional difficulties among their toddlers. Mediational analyses in PROCESS (Hayes, 2013) revealed a significant mediation model [($F(2,55) = 9.2$, $R^2 = 0.25$, $p = 0.0004$], see **Figure 1**. After controlling for the effect of the proposed mediator – baseline maternal PTSD symptoms – the direct effect of ACEs on child emotional problems was no longer significant ($B = 0.20$, $t = 1.57$, $p = 0.123$), and there was an indirect effect of maternal ACEs on the BITSEA Problem score through maternal PTSD symptoms (β = 0.16, bootstrapped 95% CI = 0.07–0.71). Thus, having a higher number of ACEs predicted more PTSD symptoms among mothers, which in turn predicted more child problems.

Our second aim was to examine how participation in an in-home, relationally based intervention impacts child socioemotional development and whether it mitigates the association between maternal PTSD symptoms and child outcomes.

As seen in **Table 4**, the overall moderation model estimating the 12-month DECA Attachment scale was significant [$R^2 = 0.20$, $F(4,53) = 3.23$, $p = 0.02$]. Baseline ratings on the DECA Attachment subscale predicted 12-month ratings on the DECA Attachment subscale ($t = 2.82$, $p = 0.006$). There was a trend-level main effect of treatment on DECA Attachment scores ($t = 1.93$, $p = 0.06$) wherein mothers randomized to the treatment condition rated their toddlers higher on this scale while controlling for baseline levels. This implies that in the full sample, treatment was marginally effective at improving toddler socioemotional outcomes. There was also a significant interaction between treatment condition and maternal PTSD symptoms at baseline ($t = -1.76$, $p = 0.04$). Specifically, mothers randomized to receive IMH-HV treatment who had lower PTSD symptoms at the start of treatment rated their toddlers higher on the DECA Attachment scale compared to mothers with subclinical baseline PTSD symptoms who did not receive treatment. Thus, IMH-HV treatment was most associated with positive child socioemotional development when mothers entered treatment with fewer PTSD symptoms, see **Figure 2**. When mothers entered the study with higher PTSD symptoms suggestive of a probable diagnosis of PTSD, their toddlers had similar scores on the DECA Attachment subscale regardless of treatment condition.

As shown in the lower portion of **Table 4**, the overall moderation model estimating the 12-month DECA Initiative

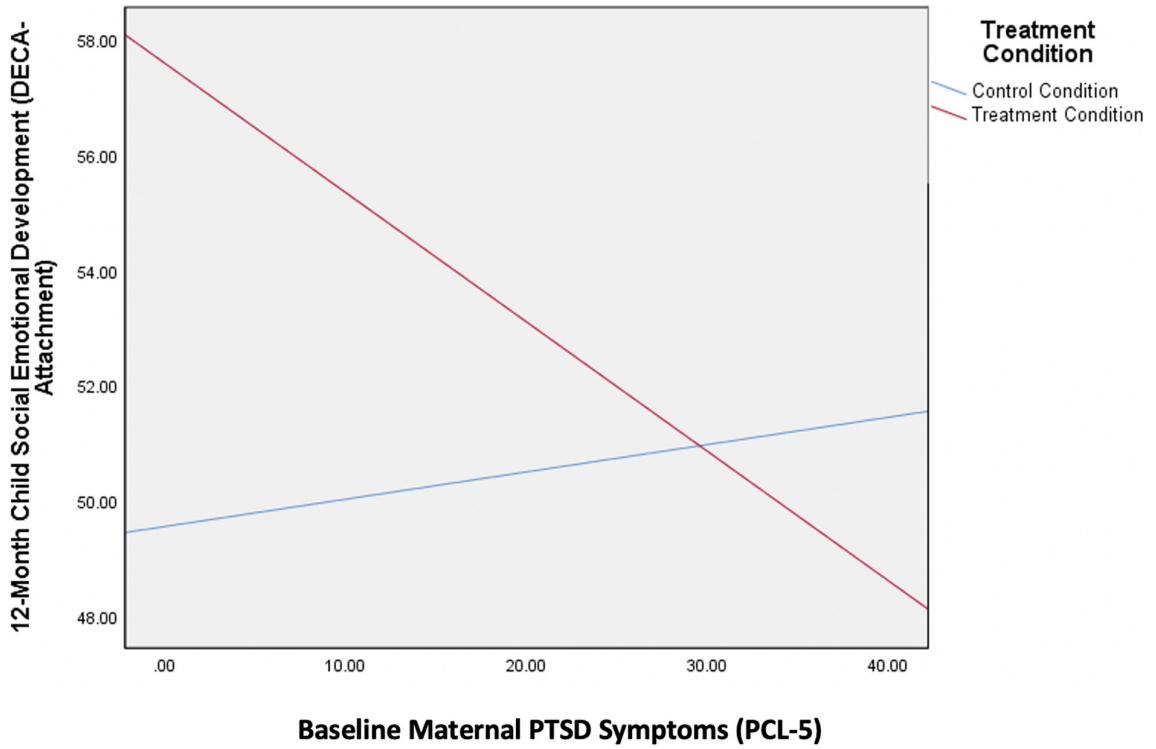

FIGURE 2 | Interaction between maternal PTSD symptom at baseline and treatment condition on child socioemotional development.

scores was also significant [R^2 = 0.18, $F(4,50)$ = 2.73, p = 0.04]. Baseline ratings on the DECA Initiative subscale predicted 12-month ratings on the DECA Initiative subscale (t = 2.72, p = 0.009). Treatment condition was not associated with 12-month rating on the DECA Initiative subscale (t = −0.13, p = 0.89). Baseline maternal PTSD symptoms were a trend-level predictor of DECA Initiative ratings when accounting for the other terms in the model.

There was no significant interaction between treatment condition and baseline PTSD symptoms in the model predicting DECA Initiative scores (t = 0.50, p = 0.62).

DISCUSSION

The current study had two aims. First, we aimed to determine if maternal PTSD symptoms mediate the relation between maternal history of adversity and child outcomes. Second, we aimed to test whether IMH-HV was efficacious in improving child outcomes, particularly in the context of maternal PTSD symptoms. Each result will be discussed below.

Maternal Adverse Childhood Experiences, Posttraumatic Stress Disorder, and Child Outcomes

Our study provides further support for the notion that childhood adversity may increase the likelihood of maternal mental health challenges and thus negative consequences for their offspring. We interpret these associations to be probabilistic, and not deterministic, given the findings that the impact of adversity is mediated by maternal PTSD symptoms, which are amenable to psychotherapeutic intervention. Current symptoms of maternal PTSD were observed to mediate the influence of maternal childhood adversity on infant socioemotional wellbeing suggesting that prenatal screening for maternal symptoms of PTSD is warranted (Erickson et al., 2019). Treating maternal PTSD symptoms sooner rather than later may reduce maternal suffering. Such amelioration affords the developing relationship between mother and infant the opportunity to unfold unhindered by extremely insensitive, misattuned maternal behaviors, such as dissociation, avoidance, or flooding, which can disrupt the sensitive caregiving and the affective communication between parent and infant (Lyons-Ruth et al., 1999).

Importantly, young children presenting with externalizing and internalizing disorders may be adapting to parental behavior in order to sustain the attachment relationship, even if costly to their psychosocial development (Sroufe, 2009; Borelli et al., 2020). Mothers who are experiencing intrusive thoughts while interacting with their infant may demonstrate behaviors that are disruptive to the infants' affective communication, such as dissociation, aversive hostility, or withdrawal (Lyons-Ruth et al., 1999). Infants of mothers who are struggling with PTSD must adapt to caregiving that is more likely to be negative, intrusive, or in other ways persistently insensitive or alarming (Lyons-Ruth, 1996; Schechter et al., 2014). As Fraiberg noted long ago, infants who are routinely unprotected from overwhelming affects and

TABLE 4 | Main and interaction effects of maternal PTSD symptoms and intervention on DECA Attachment and Initiative subscales.

Variables	*b*	SE	*t*	*p*
Model 1	**Child social emotional development – 12-month DECA Attachment**			
Constant	28.53	8.02	–	
Treatment	8.03	4.16	1.93	0.06
Maternal baseline PTSD score	0.05	0.11	0.42	0.67
Treatment by baseline PTSD symptoms (moderator)	−0.27	0.15	−1.76	0.04
Control variables				
Child socioemotional development (baseline)	0.41	0.15	2.82	0.006
Model 2	**Child social emotional development – 12-month DECA Initiative**			
Constant	33.85	8.04	–	
Treatment	−0.55	4.09	−0.13	0.89
Maternal baseline PTSD score	−0.21	0.11	−1.91	0.06
Treatment by baseline PTSD symptoms (moderator)	0.08	0.15	0.50	0.62
Control variables				
Child socioemotional development (baseline)	0.42	0.15	2.72	0.009

Model 1: R^2 = 0.20, F(4,53) = 3.23, p = 0.02.
Model 2: R^2 = 0.18, F(4,50) = 2.73, p = 0.04.
Maternal PTSD symptoms measured by the PTSD Checklist for DSM-5 (PCL-5); Child socioemotional development measured by the Devereux Early Childhood Assessment-Infant (DECA-I) and the Devereux Early Childhood Assessment-Toddler (DECA-T).

frequently left in a state of helpless despair develop psychological defenses against the aversiveness of interaction with the parent (Fraiberg, 1982; Weatherston and Ribaudo, 2020). The substrate of socioemotional health is laid in the first months of life; when the infant experiences frequent lapses in parental responsivity, or when the parent becomes the source of alarm (Hesse and Main, 2000) the infant is more likely to develop defensive strategies such as avoidance or aggression (Fraiberg, 1982) that result in an increased risk of child psychopathology (Lyons-Ruth, 1996; Plant et al., 2018). The data suggests that practitioners who are consulted due to concerns regarding young children with socioemotional problems should pay careful attention to assessing parental mental health, including assessment of subclinical levels of PTSD. Treatment of children's behavior problems in the absence of treating parental mental health may be ineffective. In addition, the association between parental psychopathology and childhood socioemotional problems lends evidence to the need for family systems and dyadic assessment (Shonkoff et al., 2012; Erickson et al., 2019). For instance, psychotherapists providing individual treatment for adults who are parents of young children can promote two generation approaches by encouraging their patients who have a history of early adversity or depression to access IMH-HV services, in addition to their continuing their own psychotherapy. However, it is noted that such an approach would require significant coordination and teamwork, ideally within a reflective consultation/supervision group with the therapists to reduce the risk splitting/fragmentation and confusion for the traumatized parent(s) (Biggart et al., 2017; Green, 2018).

Efficacy of Infant Mental Health-Home Visiting

Building upon previous reports that IMH-HV is an effective intervention that promotes maternal sensitivity, responsivity, and reflective functioning (Rosenblum et al., 2020; Julian et al., 2021; Stacks et al., 2021), the current study explored the effectiveness of IMH-HV for improving child outcomes among mothers with a history of childhood adversity and current PTSD symptoms. Results indicated positive socioemotional outcomes for children of mothers who received IMH-HV compared to the control group, with the best outcomes seen for children of mothers with low to moderate PTSD symptoms who received the intervention. Attention to early intervention and the emerging relationship (Fitzgerald et al., 2011), before early childhood adaptations become traits (Perry et al., 1995), is a hallmark of infant mental health work. Our findings suggest that dyadic intervention for mothers with low to moderate PTSD symptoms helps promote child socioemotional wellbeing. Mothers with low to moderate PTSD symptoms may respond more quickly to IMH-HV intervention than mothers with more severe symptomology. IMH-HV services are designed to provide intervention until the infant's third birthday. This study only examined child wellbeing after 12 months of service. A longer duration of treatment of both individual and dyadic psychotherapy may be warranted for mothers with more PTSD symptomology to effect improvement in children's socioemotional functioning. Some mothers may need a sustained period of intervention to stabilize their symptoms (Stacks et al., 2021). They may need time to experience "being held in the mind of another" (O'Rourke, 2011, p. 170) and understanding their own mental states (Suchman et al., 2018) before they can regulate their own emotions well enough to help their child co-regulate. For mothers with history of relational harm, the "felt sense" of being cared for that fuels mothering may be thin. The therapeutic relationship serves as a corrective emotional experience, but that takes time to develop, especially for mothers with a history of early childhood adversity (Stacks et al., 2021). In addition, once the mother begins to understand her mental states, it will still take time for the child to shift their "expectation" of interactions. The longer they have adapted to a particular attachment template, the longer it may take to develop the confidence in using the parent as a source of comfort (Stovall-McClough and Dozier, 2004; Barlow et al., 2021). It is also possible that children of mothers with severe PTSD symptoms did benefit from the intervention, but that these mothers were not reliable reporters of their infants' symptoms early on and became more insightful as treatment progressed. This reporter-bias would have masked treatment effects in this group. Further research is necessary to examine the efficacy of the model, including the duration and intensity required, to effect dyadic change in the highest risk group.

Importantly, many of the mothers faced systemic inequity and oppression, in addition to interpersonal harm, which

add to the complexity and severity of traumatic stress (Cyr et al., 2010). The challenges of developing a therapeutic alliance with traumatized individuals can be exacerbated when there are obvious differences in social identities, especially when clinicians are uncomfortable addressing racial and ethnic differences (Owen et al., 2017). Further research is necessary to examine the contribution of client and therapist match to therapeutic outcomes.

Contributions and Limitations

Our study has several strengths, including randomization and a control group, low attrition, a racially and economically diverse sample, and longitudinal data. It expands and refines attention to the mounting load of PTSD symptoms on the mother and infants' wellbeing. It provides evidence that IMH-HV is efficacious at improving child socioemotional outcomes and can be especially effective for dyads where the mother has low to moderate PTSD symptoms. However, for mothers with more PTSD symptoms, it's possible that longer durations of treatment may be more effective at reducing mother's dysregulation before the positive impact on the infant is observable.

A limitation of the study is that we relied on self-report of PTSD symptoms, rather than a clinical interview. Because avoidance is a central feature of PTSD, it may be that this led to under-reporting of PTSD symptoms. If this is true, it could impact the results of this study, especially considering that IMH-HV was found to be especially effective for mothers with low to moderate PTSD symptoms. If self-reported PTSD symptom rates were lower due to participant avoidance, it may be that the intervention is effective for those with greater PTSD symptoms than we initially thought. Similarly, we did not ask the mothers to elaborate which traumatic experience they were reflecting upon while answering the PCL-5 questions. Knowing the nature of the traumatic event(s) that contribute to dyadic disruption may offer the capacity for more refined treatment. For instance, there are likely to be qualitative differences in interactions with a baby if parent is reporting PTSD symptoms related to a recent incident of interpersonal violence as opposed to recalling physical abuse in their childhood (Schechter et al., 2014).

Another limitation of the study is the reliance on parental self-report for measures of infant wellbeing. Mothers who are coping with multiple stressors, including PTSD, may have a negative bias which contributes to perceiving the infant as difficult (Romero et al., 2021) or may present as avoidant of their infant's challenges. Future research would benefit from having both parent-reported and observer-rated measures of infant socioemotional development.

Additionally, the gold standard for treatment studies is intent-to-treat analyses, which were not possible in this trial. Thus, the attrition rate may affect the generalizability of the findings. Finally, there is some evidence of the utility of the DECA in samples of preschool children from low-income backgrounds, though the behavioral concerns subscale may not adequately assess culturally and linguistically diverse children in low-income families (Bulotsky-Shearer et al., 2013). Thus, this measure may not have captured the full range of socioemotional concerns or strengths of our population.

Future Directions

Our sample included many women who have faced systemic inequalities and oppression. Experiences with systems of care guided by dominant culture may negatively impact the epistemic trust (Fonagy and Allison, 2014) that contributes to the development of a therapeutic relationship. Infant mental health therapists, though engaged in reflective practice, may unwittingly interfere with the development of a trusting relationship by engaging in microaggressions or being culturally insensitive. Mothers whose history of relational harm intersects with societal harm, may present with co-morbid and severe traumatic life-events (e.g., life-threatening encounter with law enforcement) and thus demonstrate related mental health challenges. They may require longer, more intensive or multi-modal, and interdisciplinary interventions that are culturally responsive and humble, while also recognizing often unacknowledged sources of resiliency and support (Parker, 2021).

A majority of our sample (70%) was married. This study did not specifically address how paternal support contributes to the infant's mental health. Given the influence of the father–infant relationship on infant mental health, *via* the marital relationship and direct interaction with the infant, future studies could reveal the impact of the marital relationship on infant socioemotional wellbeing (Hall et al., 2014; Korja et al., 2016).

In conclusion, this study contributes to the body of research that suggests that maternal mental health influences the socioemotional wellbeing of young children. It provides evidence that IMH-HV is effective in supporting the socioemotional health of infants and young children of mothers, especially for those who experience low to moderate PTSD symptoms. It suggests that a longer period of intervention may be required to impact the mother's capacity to support their infant's socioemotional wellbeing when she struggles with more severe PTSD symptomology.

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 Michigan Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MM and KR obtained funding and oversaw all aspects of the clinical trial. JuR, JL, and JeR conceptualized and

designed the study for this manuscript. JJ organized the database. JuR, JL, JeR, and JJ performed the statistical analyses. JuR wrote the first draft of the manuscript. JuR, JeR, NE, and JL wrote sections of the manuscript. All authors contributed to manuscript revision, and read and approved the submitted version.

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From Early Micro-Temporal Interaction Patterns to Child Cortisol Levels: Toward the Role of Interactive Reparation and Infant Attachment in a Longitudinal Study

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Parental mental disorders increase the risk for insecure attachment in children. However, the quality of caregiver–infant interaction plays a key role in the development of infant attachment. Dyadic interaction is frequently investigated via global scales which are too rough to uncover micro-temporal mechanisms. Prior research found that the latency to reparation of uncoordinated dyadic states is associated with infant behavioral and neuroendocrine regulation. We investigated the hypothesis that this interactive mechanism is critical in predicting secure vs. insecure attachment quality in infancy. We also assessed the predictive quality of infant attachment regarding neuroendocrine reactivity later in childhood. A subsample of N = 58 dyads (n = 22 mothers with anxiety disorders, n = 36 controls) from a larger study were analyzed. At 3–8 months postpartum, maternal anxiety disorders were diagnosed via a structured clinical interview as well as dyadic interaction during the *Face-to-Face-Still-Face* (FFSF) was observed and coded on a micro-temporal scale. Infant attachment quality was assessed with the strange situation paradigm at 12–24 months of age. In an overlapping subsample of N = 39 (n = 13 mothers with anxiety disorder; n = 26 controls), we assessed child cortisol reactivity at 5 to 6 years of age. Generalized linear modeling revealed that longer latencies to interactive reparation during the reunion episode of the FFSF as well as maternal diagnosis at 3–8 months of age predict insecure attachment in children aged 12–24 months. Cox regressions demonstrated that dyads with infants who developed insecure attachment at 12–24 months of age were 48% less likely to achieve an interactive reparation at 3–8 months of age. Mixed models revealed that compared to securely attached children, children who had developed an insecure attachment at 12–24 months of age had an increased cortisol reactivity at 5 to 6 years of age during free play. The results confirm the hypothesis that the development of attachment is affected by experienced micro-temporal interactive patterns besides

diagnostic categories. They also showed that infants of mothers with postpartum anxiety disorders have a more than fivefold increased risk of developing an insecure attachment than the infants of the control group. Moreover, results imply that these patterns may influence neurohormonal regulation even in preschool aged children.

Keywords: maternal anxiety disorder, still-face, interactive reparation, infant attachment, child cortisol reactivity

INTRODUCTION

Attachment theory describes the inherent human need to establish close relationships to other humans from the perspective of the emotional needs of infants. Attachment is discussed as the evolutionary established ensuring of child survival, since the human offspring is specifically in need of long-term care and help (for an overview, see Bowlby, 1969/1982, 1973, 1980). Ainsworth developed the strange situation – an observational experiment for classifying secure, insecure-avoidant and insecure-ambivalent attachment styles (Ainsworth et al., 1978), as well as the later defined disorganized attachment (Main and Solomon, 1986). However, it is not only the relationship quality between children and their parents that is determined by the attachment style. For decades now, the scientific literature has also demonstrated the multi-facetted long-term effects of secure vs. insecure attachment for child development.

To mention a few recent results, securely attached infants manifest higher capacities in processing social information than insecurely attached infants (Biro et al., 2015). The latter exhibit a higher increase in cortisol levels than their securely attached counterparts following the strange situation (Luijk et al., 2010). Securely attached children demonstrate vagal adaption to external demands, such as social stressors, while insecurely attached children do not (Paret et al., 2015). Additionally, Bernard and Dozier (2010) detected a cortisol response following the strange situation for disorganized and not for children with a secure attachment quality. Later in life, securely attached adolescents show a higher empathetic responsiveness (Diamond et al., 2012), whereas insecurely attached children, adolescents and adults exhibit difficulties in regulating stress, more specifically, they show signs for a dysregulation of the hypothalamus–pituitary–adrenal (HPA) axis (Oskis et al., 2011; Pierrehumbert et al., 2012; Kidd et al., 2013). In their review, Beatson and Taryan (2003) concluded that secure attachment serves as a buffer in the relationship between HPA dysregulation and the development of depressive symptoms later in life. Thus, one can conclude "early attachment quality may be a lasting source of vulnerability or protection in children's development" (Carlone and Milan, 2021, p. 603).

Waters et al. (2010) explored the ties between attachment and emotion regulation. They emphasized the importance of emotion understanding in the development of these constructs. Furthermore, Kerns and Brumariu (2014) discussed insecure and disorganized attachment as risk factors for the development of affective disorders and that this association might trace back, in part, to less competent emotion regulation capacities in insecurely attached children. A hypotheses that was recently supported by Verhees et al. (2021), who found a mediation pathway between attachment insecurity, the regulation of positive, as well as negative affect and the development of depressive symptoms in a large longitudinal sample of adolescents.

Emotion regulation capacities are hypothesized to be formed by social interactions children experience in their everyday life (Beeghly and Tronick, 2011). Also, Ainsworth emphasized the importance of caregiving behavior, specifically the caregiver's sensitivity, for the development of a secure attachment. Ainsworth defined sensitivity as the caregiver's ability to perceive, correctly interpret, as well as to promptly and adequately respond to the infant's communicative signals (Ainsworth et al., 1978). Braungart-Rieker et al. (2001) found that both infant affect regulation and maternal sensitivity discriminate between secure and insecure infants and that the association between sensitivity and attachment was partially mediated by infant regulation. Besides these associations to infant attachment (e.g., Fuertes et al., 2009), parental sensitivity has been shown to be of relevance for a wide range of further developmental outcomes, such as the processing of social information (Biro et al., 2015), fear reactivity (Braungart-Rieker et al., 2010), physiological (Moore et al., 2009; Conradt and Ablow, 2010), neuroendocrine (Spangler et al., 1994; Jansen et al., 2010b) and affective regulation (Haley and Stansbury, 2003; Jonas et al., 2015; Rodrigues et al., 2021), social behavior (Kivijärvi et al., 2001; Bernier et al., 2021; Licata-Dandel et al., 2021), as well as cognitive and language development (Malmberg et al., 2016; Rodrigues et al., 2021).

However, as much as the concept of parental sensitivity was and is needed to understand infant attachment, it is both multidimensional and a somewhat rough macro characteristic. Thus, it is limited in uncovering the details of the moment-to-moment interactive mechanisms that may be important in forming a secure attachment throughout the interactive history of a child (compare to Mesman, 2010). One such mechanism may be derived from Tronick's reparation model (Tronick, 2007). In this model, Tronick describes the micro-temporal regulation of affect and distress in caregiver–infant dyads. The interactive partners are described as open and dynamic systems (Ham and Tronick, 2009; DiCorcia and Tronick, 2011), whose interactive states are interdependent, especially in young infants. As their self-regulatory capacities are limited, they rely on the regulatory input of their caregivers. It is a complimentary expanded view shared by other theoretical frameworks (see Cole et al., 2004) that suggest a developmental sequence of increasing self-regulatory capacities. In this sequence, young infants have basic regulatory skills of limited effectiveness (compare to Diener and Mangelsdorf, 1999), then interactively engage with their caregivers who represent external resources of regulation (Spangler et al., 1994), and finally

develop more competent self-regulatory strategies throughout their development. The interactive process is asymmetric (e.g., Beebe et al., 2016) as it is largely led by the caregivers (Cohn and Tronick, 1988) which is somewhat due to the limited capacities of infants. However, in this process, the role of infant interactive behavior is essential as they communicate their biobehavioral status by means of eye-contact, facial expressions, body postures, vocalizations, etc. and consequently invite the caregivers to regulatory scaffolding. The caregivers, in turn, may perceive, correctly interpret, as well as promptly and adequately respond to the infant's signals (compare "sensitivity," Ainsworth et al., 1978), and thus externally regulate the biobehavioral status of their infant. According to Tronick (1989) this process is mutually regulated.

Paradoxically, this regulatory process in itself is stressful. Due to misinterpretations of the caregiver or the limited interactive capacities of the infant, the speed of exchange, etc., uncoordinated dyadic states (so-called mismatches) repeatedly occur in small time intervals. These mismatches produce inconsistencies between the regulatory need of the infant and the regulatory input of the caregiver, which Tronick describes as micro-stressors. These stressors are overcome as soon as the caregiver is able to provide a regulatory input that corresponds to the infant's regulatory need, or the infant adjusts to the caregiver's actions – a process called interactive reparation. Thus, the reparation model describes the dyadic regulation as mutual adaptive process in which the dyad oscillates between coordinated states (matches) and mismatches on a micro-temporal scale. It is this dynamic process, which is thought to shape not only infant regulatory strategies but also a wide range of developmental domains, such as attachment (DiCorcia and Tronick, 2011). Indeed, interactive reparation was demonstrated to be associated to infant neuroendocrine (Müller et al., 2015) and psychological regulation (Provenzi et al., 2015). Furthermore, Beebe et al. (2010) revealed, that a moderate level of interactive contingency, which may be described as the occurrence of mismatches that are quickly repaired to matches, predicted infant secure attachment, whereas both low (failure to reparation) and high (few mismatches) levels of contingency predicted insecure attachment. This result fits well with the idea, that a perfectly matched interactive pattern between caregivers and children is neither possible nor desirable as it would prohibit the opportunities to internalize dyadically scaffolded regulation strategies by transforming micro-temporal stressors into non-stressful states (DiCorcia and Tronick, 2011). Nonetheless, to the best of the author's knowledge, the role of interactive reparation regarding the development of secure vs. insecure attachment has not been investigated. As Provenzi et al. (2018) state, "more research on the interconnections between macro-analytical concepts in caregiver–infant research, such as sensitivity and attachment, and micro-analytical processes is desirable" as "[. . .] future investigations on the relations between macro- and micro-analytical concepts would not only connect different methodological approaches but also enhance our understanding of the dynamics in developmental trajectories" (page 18).

Besides the associations between parental sensitivity and infant and child attachment, it is well known, that parental mental disorders may lead to unfavorable effects on child behavioral (Kingston and Tough, 2014), cognitive (Murray et al., 2003) and psychopathological (Goodman et al., 2011) development and that parental psychopathology may interfere with the development of a secure attachment style (Wan and Green, 2009). Although most studies have concentrated on maternal depression (e.g., Goodman et al., 2011) there is also some empirical and growing evidence about the associations between parental anxiety and child development (Glasheen et al., 2010; Goodman et al., 2016; Reck et al., 2018b; Polte et al., 2019). Specifically, for this current study and to the best of the authors' knowledge, there is only one study demonstrating that maternal anxiety may predict insecure attachment in children (Stevenson-Hinde et al., 2011). As it is assumed that the attachment quality and regulatory capacities are associated to and organized by interactive history, it is only natural to conclude, that the association between parental anxiety and child attachment would be mediated by interactive characteristics. Indeed, dyads in which the mother suffers from anxiety show specific problematic interactive patterns (for an overview see Kaitz and Maytal, 2005; Goodman et al., 2016). Besides reduced maternal sensitivity (Warren et al., 2003; Kertz et al., 2008; Feldman et al., 2009; Stevenson-Hinde et al., 2013), dyads with anxious mothers also show micro-temporal differences compared to non-anxious mothers, as for example less contingent maternal interactive patterns (Beebe et al., 2011), as well as changed infant patterns of positive and negative affective displays (Reck et al., 2018a).

However, compared to the effects of parental depression, the evidence regarding the effects of parental anxiety on interactive patterns is less consistent. Several studies identify specific rather than general interactive impairments in dyads with anxious mothers: Grant et al. (2009), for example, did not find an association between maternal anxiety and maternal sensitivity. A finding that is shared by the results of Murray et al. (2007) regarding mothers with social phobia. However, they specifically observed that the mothers were more anxious and were less engaging when interacting with a stranger. Moreover, they encouraged their infants less to interact with the stranger. Additionally, the infants of mothers with social phobia were less responsive to the stranger. The results of Murray et al. (2012) did not reflect general differences regarding interactive patterns between dyads with social phobic mothers and controls in a non-threat interaction task, too. Contrary, in disorder-specific challenges, some parenting difficulties were observable for the clinical group. These difficulties, however, did not seem disorder specific. Accordingly, Kertz et al. (2008) report, that anxious mothers only demonstrate less sensitivity in social tasks. Hence, it may be erroneous to assume general interactive deficits in these dyads. Results suggest the associations between maternal anxiety and child behavioral regulation along with mental development are moderated by caregiving behaviors (as shown for sensitivity in Grant et al., 2010a,b). Notably, these studies refer to prepartum anxiety and their results are discussed considering the fetal programming hypothesis (see van den Bergh et al., 2017). However, we suggest the applicability of this idea to the postpartum period as shown by Kertz et al. (2008) as well as Richter and Reck (2013) for infant regulatory problems and

aim to control for prepartum effects in our models in particular. It also seems highly unlikely that the associations between child attachment and long-term consequences are mono-causal. They are rather more likely determined by mutually moderating risk-constellations and factors. For example, the effect of insecure attachment on cortisol response seems more pronounced in infants of depressed mothers (Luijk et al., 2010). Furthermore, insecurely and disorganized attached children seem more prone to develop behavioral and cognitive deficits when exposed to parenting distress or maternal depression than securely attached children (Tharner et al., 2012; Carlone and Milan, 2021).

The aim of this study is to identify the most important predictors for (1) the development of insecure vs. secure attachment considering the effects of micro-temporal reparation processes along with parental anxiety in the postpartum period, prepartum distress and their interaction effects, and (2) child cortisol-reactivity considering the long-term effects of infant secure vs. insecure attachment, maternal anxiety in the postpartum period and the interaction between these factors. Though these analyses were exploratory in nature, according to current literature, we expected infant attachment quality to be mainly predicted by interactive measures (e.g., Stevenson-Hinde et al., 2013).

STUDY 1

Materials and Methods

Procedures

The current secondary analyses consist of two subsamples derived from a larger longitudinal sample previously described elsewhere (Reck et al., 2013, 2018a,b; Richter and Reck, 2013; Tietz et al., 2014; Müller et al., 2015, 2016; Zietlow et al., 2019). The independent ethics committee of the medical faculty, Ruprecht-Karls-University, Heidelberg, Germany approved the study protocol prior to the first assessment. After the study procedures had been fully explained to the caregivers, we obtained written informed consent to participate in the study.

The data for the first part of the study were collected from 2006 to 2010. At 3–8 months postpartum, the caregiver–infant interaction was videotaped in laboratory during a standardized interaction experiment, namely, the Face-to-Face-Still-Face paradigm (FFSF). The FFSF was designed by Tronick et al. (1978) and in its most prevalent form (Mesman et al., 2009) consists of three episodes, i.e., the play, the still-face and the reunion episode, in which each episode lasts 120 s. Throughout the procedure, the infant is secured in a booster seat. The initial play episode is a face-to-face-interaction between the caregiver and the infant. The caregivers are instructed to play with their infants as they would at home, however, without the use of toys and/or pacifiers. At the end of the play episode, the caregivers are instructed to react to an acoustic signal by turning their head aside and silently count to ten (transition). Next, they turn their head back around but look slightly above their infant's head, however, without engaging in any gestures, facial expressions, or vocalizations for the next 120 s (still-face). Finally, during the reunion episode, the caregivers are required to resume face-to-face-play with their infant for the last 120 s. After the FFSF, we carried out the German version of the Structured Clinical Interview for DSM-IV Disorders (Wittchen et al., 1997). Furthermore, questionnaires regarding sociodemographic and psychological variables were handed out to fill out at home. Around 1 year postpartum, the dyads were invited to revisit the lab for the strange situation (Ainsworth et al., 1978) for 12- to 24-month olds. The strange situation is designed to elicit exploration and attachment behavior in the child, and thus enable the observation and evaluation of attachment security. Like the FFSF, this procedure was videotaped. The strange situation is, like the FFSF, a standardized behavioral experiment that involves a sequence of eight episodes each lasting approximately 3 min, in which a caregiver and her child are repeatedly separated, reunited and a strange person is introduced. Attachment is classified based on the infant's behavior. The reunion episodes (episodes 5 and 8) are coded concerning proximity seeking, contact maintaining, proximity avoidance and resistance to contact.

Measures

Maternal Mental Disorders

Mental pathology during the postpartum period was assessed via the German version of the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I, Wittchen et al., 1997). The SCID-I was a widely used semi-structured interview for the diagnosis of selected disorders. It was the diagnostic gold standard at the time. According to the DSM-IV, anxiety disorders included generalized anxiety disorder, panic disorder with and without agoraphobia, agoraphobia without history of panic disorder, specific phobias, social phobia, obsessive-compulsive disorder, posttraumatic stress disorder, and anxiety disorder not otherwise specified.

Recollected Prepartum Distress

Prepartum distress was assessed retrospectively via a self-report instrument, namely the Prenatal Emotional Stress Index (PESI; Möhler et al., 2006). The PESI assesses emotional distress during pregnancy separately with 11 items per pregnancy trimester. The items assess anxiety, sadness, joy, distress, and tension via a visual analog scale ranging from 0% to 100%. The item values (2 items with reversed polarity) are averaged for each trimester, resulting in three PESI scores ranging from 0% to 100%. Measures for internal consistency were taken from the larger study sample ($N = 111$): We bootstrapped ($N = 1.000$ samples) 95% confidence intervals for McDonald's ω (Hayes and Coutts, 2020) which revealed a good to excellent reliability ($\omega = [0.88;0.94]$ for the first, $\omega = [0.88;0.95]$ for the second and $\omega = [0.91;0.95]$ for the third trimester). We selected the PESI score for the third trimester as independent measure. Thus, we used the measure with the least memory bias.

Dyadic Interaction

Two trained and reliable coders coded the interactive behaviors of the infants and caregivers during the FFSF using the Noldus Observer Video-Pro coding system with 1-s time intervals. They were blinded to the hypotheses of the study and maternal

diagnostic status. They used the German translation and revision of the microanalytical Infant and Caregiver Engagement Phases (ICEP-R; Reck et al., 2009). The engagement phases combine information from the face, direction of gaze and vocalizations of the infants and caregivers. For the infant, the following engagement phases can be coded: negative engagement (further divided into withdrawn and protest), object/environment engagement, social monitor, and social positive engagement. For the caregiver, the engagement phases are negative engagement (further divided into withdrawn, hostile and intrusive), non-infant focused engagement, social monitor/no vocalizations or neutral vocalizations, social monitor/positive vocalizations, and social positive engagement. 10% of the video tapes from the larger longitudinal sample (n = 9 of N = 91) were randomly selected and coded by both of the two independent study coders to assess the inter-rater reliability. The coders were unaware of which videos were used for reliability. The inter-rater reliability was determined using Cohen's κ (Cohen, 1960). The achieved values of Cohen's κ (κ = 0.82 for the infant codes; κ = 0.73 for the maternal codes) were similar to those reported in previous studies (Tronick et al., 2005; Reck et al., 2011). Positive social matching states were defined as the caregiver and infant simultaneously exhibiting the same affective-behavioral state as follows: the caregiver is in positive engagement or social monitor/positive vocalizations and the infant is in positive engagement or social monitor. We calculated the independent measures – the latency to interactive reparation – as the time interval from interaction onset to positive social match onset, that is, the initial mismatch duration of the respective FFSF episode in seconds. As the reunion episode is particularly informative regarding the regulatory quality of the interaction (Weinberg and Tronick, 1996), we selected the latency to interactive reparation during the reunion episode as independent measure.

Attachment Quality

Two trained and reliable coders annotated the videos of the strange situation paradigm. They were blinded to the hypotheses of the study and the maternal diagnostic status. Infants were classified as secure, insecure-avoidant, insecure-ambivalent or disorganized according to their behavior throughout the strange situation paradigm, and especially in the reunion episodes (see above). The disorganized category was assigned, if the attachment behavior was no longer organized or directed toward the caregiver (Simonelli and Parolin, 2017). The 25% of the video recordings from the larger longitudinal sample (n = 19 of N = 77) were randomly selected and coded by both of the two independent study coders to assess inter-rater reliability. The coders were not able to distinguish if they were coding videos for the reliability assessment or for the general study purpose. The inter-rater reliability was determined using Cohen's κ (Cohen, 1960). The achieved values of Cohen's κ (κ = 0.82) were similar to or higher than those reported in previous studies (Behrens et al., 2016; Smith et al., 2016). As we were interested in predicting secure vs. insecure attachment quality, we binary coded all secure patterns as "0 = secure" and all insecure and disorganized patterns as "1 = insecure/disorganized."

Sample

In this project, we focused on the primary caregiver, which in most cases is the mother (e.g., Harmon and Perry, 2011). Mothers were included in the clinical group, if they were diagnosed with at least one of the following anxiety disorders according to the DSM-IV (American Psychiatric Association, 2000) in the postpartum period: panic disorder with agoraphobia, agoraphobia without history of panic disorder, generalized anxiety disorder, social phobia, obsessive compulsive disorder, posttraumatic stress disorder and anxiety disorder not otherwise specified. A specific phobia was not considered as a sufficient condition due to lowered clinical relevance. However, if the specific phobia did not occur as single diagnosis but occurred as a comorbidity to other clinically significant anxiety disorders, we did not exclude the respective cases. Mothers were excluded from the clinical group if an acute or former psychosis, a current or former bipolar disorder, current substance abuse or acute suicidal tendency was diagnosed. Despite initial screening efforts to exclude mothers with any other comorbid psychological disorder, the occurrence of comorbid disorders after screening did not exclude a mother, if it was ascertained that the comorbid disorder constituted a secondary diagnosis. Healthy controls were included if they didn't have any current or antecedent axis I diagnosis according to the DSM-IV.

Initially, 122 mothers with their infants were recruited for the larger study. All mothers were of Caucasian ethnicity. n = 14 mothers were excluded due to meeting diagnostic exclusion criteria. For the first subsample, we excluded n = 50 cases as one of the main variables was missing: n = 18 interactive measures at 3–8 months and partly overlapping n = 37 attachment measures at 12–24 months. Consequently, for the first subsample the clinical group comprised n = 22 mothers with an anxiety disorder while n = 36 mothers were included in the control group.

Data Analysis

We used R (R Core Team, 2021, v. 4.1.1) in combination with RStudio® (RStudio Team, 2021, v. 1.4.1717) for Microsoft Windows 10® for all analyses. We used the following packages: "haven" (Wickham and Miller, 2021, v. 2.4.3), "tidyverse" (Wickham et al., 2019), "naniar" (Tierney et al., 2021, v. 0.6.1), "psych" (Revelle, 2021, v. 2.1.6), "MBESS" (Kelley, 2020, v. 4.8.0), "survival" (Therneau and Grambsch, 2000; Therneau, 2021;, v. 3.2.13).

To ascertain that list-wise case exclusions were valid for our analyses, we evaluated if missing values occurred at random. Thus, we tested the missing-completely-at-random (MCAR)-condition by carrying out Little's MCAR test (Little, 1988) once for each subsample. Moreover, for each subsample, we evaluated the comparability between the clinical and the control group regarding sociodemographic and birth-related variables. Depending on the measurement level, we used *OR*, *U*, and *t*-tests for this analytic step. In case of significant differences and dependent on the measurement level, we Spearman- or Pearson-correlated the potential confounder with the other study variables to ascertain if it needed to be controlled for in the main analyses.

The analyses regarding the first part of the study refer to the predictive quality of maternal diagnostic status and dyadic

interaction regarding infant secure vs. insecure attachment by controlling for effects of prepartum distress. Thus, we used a series of hierarchical generalized binomial regression models with logit-link-function and likelihood-ratio coefficient tests.

For solely descriptive reasons, we added a series of hierarchical Cox regressions on the dummy-coded and time-dependent event "first match". The time variable was the latency to interactive reparation in seconds. The initial predictors were maternal diagnostic status, dummy-coded attachment quality of their infants and prepartum distress. The coefficients were tested via *z*-statistic. These retrospective analyses used attachment quality as strata and the prior assessed interactive quality as outcome. Though these analyses do not inform about the predictive quality of attachment, they inform about the interactive quality of infants later classified as securely vs. insecurely attached. Despite the Cox regressions, the hierarchical model tests started with full-factorial models including all two-way and three-way interaction terms. The hierarchical set of Cox regressions started exclusively with main effects. Terms were excluded from the models if they failed to significantly contribute to explaining the dependent variables. The procedures ended with the model that only contained significant predictors.

Regarding the binomial and the Cox regressions, the relative risks and hazard ratios, respectively, serve as estimators of effect sizes. Empirical *p*-values are reported two-tailed. The critical α-errors of the two confirmative analyses sets (i.e., Study 1: binomial regressions; Study 2: mixed models) were Holm–Bonferroni adjusted (Holm, 1979) regarding multiple testing. This sequential procedure controls the family-wise error-rate by adjusting the critical α-level for each of the individual hypotheses. Thus, the critical α is set to 0.025 for the first and 0.05 for the second model series. The α-errors were not adjusted for the descriptive Cox regression. For the full statistical procedure see the knitted R-markdown in the **Supplementary Data Sheet 1**. Due to the sensitive nature of the current data, it is available on request only.

Results

Preliminary Analysis

For the MCAR-test we considered the following variable categories: Sociodemographic variables (e.g., maternal age), birth-related date (e.g., gestation age), questionnaire data (PESI and questionnaires not described in the current study), interaction data (ICEP-R, Reck et al., 2009) and developmental data not described in the current study (Bayles Scales of Infant and Toddler Development – III; Bayley, 2006). The MCAR-test turned out non-significant ($\chi^2 = 1.352$, $df = 1.330$, $p = 0.328$). Thus, we concluded that the list-wise case exclusions were valid for our analyses.

Sample Description

In the clinical sample ($n = 22$), $n = 14$ mothers had multiple anxiety disorders (median = 2). $n = 8$ women were diagnosed with two, $n = 4$ mothers with three and $n = 2$ women with four anxiety disorders. Overall, there were $n = 10$ mothers with a panic disorder or agoraphobia. $n = 6$ women fulfilled the criteria for a social phobia. Obsessive-compulsive disorders were diagnosed in $n = 8$ mothers, while $n = 1$ woman had a posttraumatic stress disorder. There were $n = 12$ mothers with a generalized anxiety disorder and $n = 1$ woman with an anxiety disorder not otherwise specified. $n = 6$ of the mothers were diagnosed with an additional specific phobia as a disorder comorbid to other clinically significant anxiety disorders. $n = 16$ women reported that at least one anxiety disorder had an onset already prior to pregnancy. Another $n = 3$ mothers had an onset during pregnancy and an additional $n = 3$ mothers after birth. As reported above, there were some women with comorbid disorders in our sample: $n = 1$ mother had a comorbid major depressive episode, $n = 1$ woman had a dysthymia, $n = 1$ case had a somatoform disorder and $n = 1$ mother was diagnosed with a comorbid binge eating disorder. The full sample description and tests on comparability between subgroups is reported in **Tables 1A,B**. There were no differences between the two subgroups ($p > 0.14$) on sociodemographic variables except for the number of children ($p = 0.02$): Mothers in the control group had more children (median = 2) than mothers in the clinical group (median = 1). However, as the Spearman-correlations ($\rho < 0.17$) with the study variables were non-significant ($p > 0.21$), we refrained from controlling the number of children in the models.

Descriptive Statistics of Study Variables

In our sample, $n = 37$ infants were classified as securely attached while $n = 13$ infants were insecure-avoidant, $n = 1$ infant insecure-ambivalent and $n = 7$ infants were disorganized. Thus, the insecurely attached group comprised $n = 21$ infants. In mean, it took dyads 8.9 s to achieve a match during the reunion episode ($SD = 20.0$ s) ranging between 0 and 109.2 s. $n = 9$ dyads did not achieve a match at all, thus decreasing the list-wise *n* in models with the raw latency to reparation as a predictor.

Regarding distress during pregnancy, the correlations between the first and second trimester ($r = 0.89$, $p < 0.01$, 95% CI = [0.82; 0.94]), between the second and third trimester ($r = 0.85$, $p < 0.01$, 95% CI = [0.75; 0.91]) and between the first and third trimester ($r = 0.69$, $p < 0.01$, 95% CI = [0.52; 0.81]) revealed a medium-to-high inter-scale consistency, thus supporting the choice to concentrate on only one of these measures. Our sample reached an overall PESI-mean during the third trimester of pregnancy of $M = 30.2\%$ ($SD = 24.3\%$), ranging between 0% and 85.5%. $n = 3$ women did not fill out the questionnaires. However, as the distress during pregnancy was not our primary predictor, we did not generally exclude these dyads. Notably, the list-wise *n* varies depending on the inclusion of the PESI-score in the models.

Main Analysis

The series of hierarchical generalized logistic regressions on secure vs. insecure attachment revealed a final model (AIC = 55.947) consisting only of two predictors, i.e., maternal diagnostic status and latency to interactive reparation. All other predictors (i.e., prepartum distress and all interaction terms) were stepwise eliminated as they did not significantly contribute to the model ($p > 0.025$, for details see **Table 2** comparing the first and the final model of the series as well as the **Supplementary Table 1** demonstrating the excluded models 2–5). Maternal anxiety disorders were revealed as strong predictors of insecure

TABLE 1A | Maternal and infant parametric demographics and tests on comparability of subgroups 3–8 months postpartum (Study 1).

	Overall			Control		Anxiety		Test statistics	
	Range	*M*	*SD*	*M*	*SD*	*M*	*SD*	$\|t\|$	*p*
Maternal age (years)	22.0–42.0	33.1	5.2	33.4	5.4	32.6	4.9	0.57	0.57
Gestation age (weeks)	36.3–41.9	39.4	1.3	39.5	1.3	39.3	1.3	0.52	0.60
APGAR (10 min)	8.0–10.0	9.9	0.5	9.9	0.4	9.8	0.5	0.82	0.41
Infant age at FFSF (months)	2.8–7.2	3.7	1.1	3.6	1.1	3.9	1.1	1.04	0.30
Infant age at SST (months)	13.2–22.7	19.2	1.4	18.9	1.6	19.6	1.0	1.49	0.14

t, t-value; p, empirical α-error; M, mean; SD, standard deviation; FFSF, Face-to-Face-Still-Face paradigm; SST, Strange Situation Test.

TABLE 1B | Maternal and infant non-parametric demographics and tests on comparability of subgroups 3–8 months postpartum (Study 1).

	Overall		Control		Anxiety		Test statistics	
Maternal education	*n*	%	*n*	%	*n*	%	*W*	*p*
High or low secondary qualification	14	24.1	8	22.2	6	27.3	413.0	0.77
University entrance qualification	11	19.0	7	19.4	4	18.2		
University degree	33	56.9	21	58.3	12	54.5		
Number of children	[a]		[b]		[c]			
One infant	33	56.9	16	44.4	17	77.3	529.0	0.02
Two infants	19	32.8	15	41.7	4	18.2		
Three or more infants	6	10.3	5	13.9	1	4.5		
Marital status							***OR* 95% *CI***	*p*
Married	40	72.7	26	76.5	14	66.7	0.62 [0.16;2.47]	0.54
Not married	15	27.3	8	23.5	7	33.3		
Infant sex								
Female infants	34	58.6	19	52.8	15	68.2	0.53 [0.14;1.79]	0.28
Male infants	24	41.4	17	47.2	7	31.8		

[a] *Median = 1.*
[b] *Median = 2.*
[c] *Median = 1.*
Valid %, percentage of valid values; W, statistical value of Wilcoxon test for independent samples (U test); p, empirical α-error; OR, odds ratio; 95% CI, 95% confidence interval of test statistic.

attachment: With an odds ratio of OR = 5.446 ($p = 0.010$), they increased the risk for insecure attachment by more than fivefold. However, latency to reparation seems to add to the effect of diagnostic category: With an OR = 1.042, this predictor increases the risk for insecure attachment by 4.2% for each passing second ($p = 0.022$).

For the series of descriptive hierarchical Cox regressions on the time-dependent event "match," we created a dummy-coded variable "match" whereas "1" was coded for "match achieved during FFSF-interaction" and "0" was coded for "no match achieved during FFSF-interaction". Moreover, we recoded the raw values of latency to interactive reparation in two ways: (1) We coded the measure to 1 s, if dyads already started with a match in the interaction, not to lose these specific dyads in the analyses. (2) We coded the measure to 120 s (the maximum observation period) for all dyads not achieving any match during the early interaction to integrate them as censored data in the analysis. The final model ($LR = 4.9$, $df = 1$, $p = 0.03$) only consisted of one factor: i.e., infant attachment quality (see **Figure 1**). The other two factors, i.e., maternal diagnostic status and prepartum distress were stepwise eliminated as they did not significantly contribute to the model ($p > 0.22$, for details see the **Supplementary Table 2**). With a hazard ratio of $HR = 0.52$ (95% CI = [0.28; 0.94]; $p = 0.03$), attachment quality was revealed as a strong factor, meaning that at 12–24 months insecurely attached infants were 48% less likely to having achieved a match in the interaction 3–8 months postpartum.

STUDY 2

Materials and Methods

Procedures

The data for the second part of the study 5–6 years postpartum was collected from 2010 to 2014. During a lab visit, child

TABLE 2 | First and final generalized binomial regression models on infant attachment out of hierarchical backward procedure.

Predictors	Model 1				Final model			
	OR	95% *CI OR* lower bound	95% *CI OR* upper bound	*p*	*OR*	95% *CI OR* lower bound	95% *CI OR* upper bound	*p*
Intercept	0.075	0.003	1.050	/	0.161	0.050	0.411	/
Anxiety disorder	0.378	0.000	65.418	0.021	5.446	1.437	23.166	0.010
Interactive reparation	0.817	0.425	1.150	0.029	1.042	1.005	1.110	0.022
Prepartum distress	1.034	0.888	1.186	0.039	/	/	/	/
Anxiety disorder * interactive reparation	1.637	0.895	5.031	0.204	/	/	/	/
Anxiety disorder * prepartum distress	1.019	0.873	1.216	0.442	/	/	/	/
Interactive reparation * prepartum distress	1.015	0.993	1.056	0.853	/	/	/	/
Anxiety disorder * interactive reparation * prepartum distress	0.982	0.943	1.007	0.164	/	/	/	/

Coding of attachment outcome: 0 = secure, 1 = insecure.
OR, odds ratio; CI, confidence interval; p, empirical α-error.
Model 1: AIC = 53.962, fitted probabilities numerically 0 or 1 occurred.
Final model: AIC = 55.947.

cortisol-reactivity was assessed via salivary samples taken immediately before, 20 and 40 min after a socioemotional stressor: engagement with unfamiliar peers and a clown. Two caregiver–child pairs from the same study, who did not know each other, were asked to enter an empty room with a carpet and two chairs located in each corner opposite the other. Pairs were chosen to have children of the same gender. The caregivers were asked to sit on the chairs and fill in questionnaires while the children were invited to sit in the middle of the room and play on a carpet with some gender appropriate toys located there. After a few minutes an attractive toy was placed in the middle of the carpet, and it was coded who grabbed it first. Then, a clown entered the room, told a story, and invited the children to play with him. The whole procedure lasted 20 min. The cortisol baseline was assessed on two consecutive days at home.

Measures

Salivary Cortisol

For the assessment of salivary cortisol, children sucked on a cotton ball until it was saturated. The saliva was then expressed and stored at −20°C until analysis. To account for possible effects of circadian rhythm on cortisol reactivity, we attempted to have the visits to the laboratory, as well as the baseline assessments at home always at around the same time of the day. Moreover, since cortisol reactivity is strongly associated with daytime napping or feeding, the caregivers were instructed to keep their children well rested and well fed on their usual routine in order not to confound the cortisol assessment. The baseline measures were averaged over both assessments. Sampling, storage, transport and analysis of cortisol samples took place according to standard protocols (Schwartz et al., 1998). The limit of detection of the used assay was 0.15 ng/ml. Intra-assay variances were 5.95%

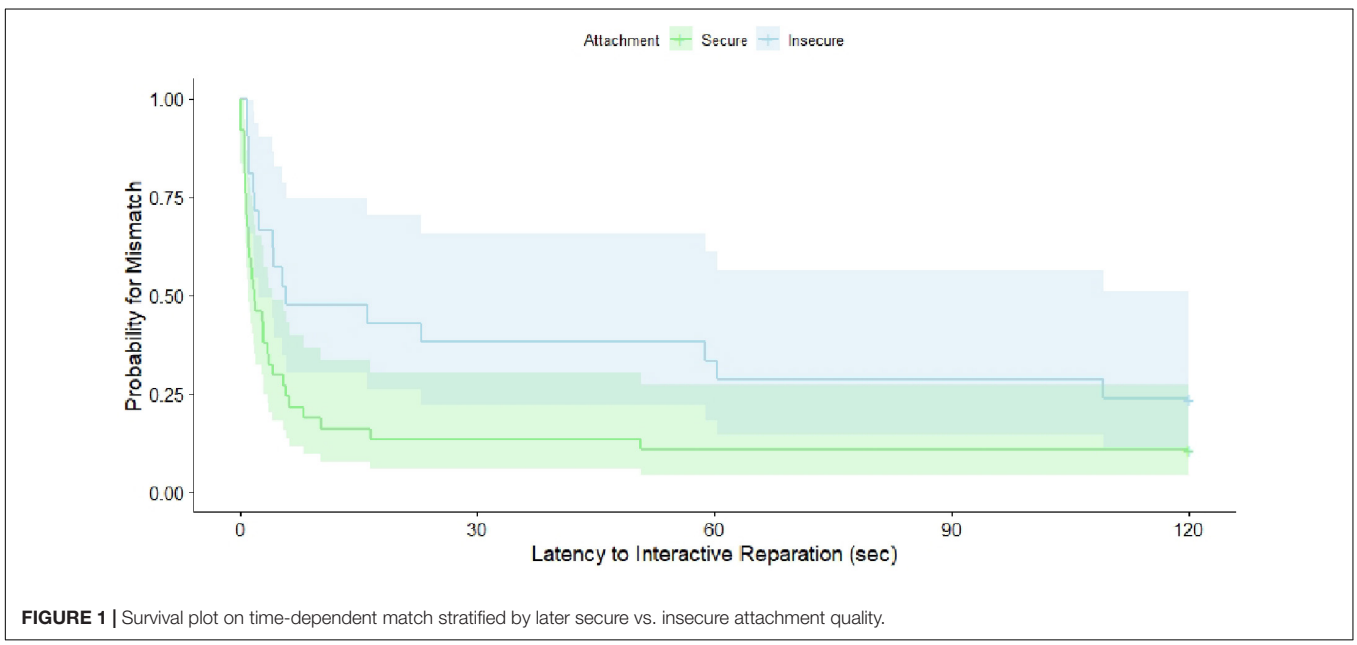

FIGURE 1 | Survival plot on time-dependent match stratified by later secure vs. insecure attachment quality.

volume for 2.6 μg/100 ml, 1.59% for 17 μg/100 ml and 4.62% for 26.6 μg/100 ml.

Sample

Besides the dyads excluded due to diagnostic criteria or missing attachment measures (n = 51), in the second subsample, we lost further n = 23 dyads missing the follow-up at 5–6 years postpartum. Additionally, n = 9 children had missing cortisol values during the stress paradigm (n = 7) or at baseline (n = 9). Thus, for the second subsample, n = 26 mothers were included in the control group, while the clinical group comprised n = 13 mothers.

Data Analysis

We used the following packages: "ggplot2" (Wickham, 2016), "survminer" (Kassambara et al., 2021, v. 0.4.9), "lme4" (Bates et al., 2015), "lmerTest" (Kuznetsova et al., 2017) and "writexl (Ooms, 2021, v. 1.4.0)."

The analyses regarding the second part of the study refer to the predictive quality of the dummy-coded attachment quality and the maternal diagnostic status during the postpartum period on child cortisol-reactivity by controlling for cortisol baseline. Thus, we used a series of hierarchical mixed models on the three nested cortisol measures during the socioemotional stressor. The main effects were tested via F-statistic. The hierarchical model tests started with full-factorial models including all two-way and three-way interaction terms. Terms were excluded from the models if they failed to significantly contribute to explaining the dependent variables. The procedures ended with the model that only contained significant predictors.

Regarding the mixed models effect sizes are reported as partial ω^2, which is a population-based estimator of explained variance. Empirical p-values are reported two-tailed. The critical α-errors of the two confirmative analyses sets (i.e., Study 1: binomial regressions; Study 2: mixed models) were Holm Bonferroni adjusted (Holm, 1979). This sequential procedure controls the family-wise error-rate by adjusting the critical α-level for each of the individual hypotheses. Thus, the critical α is set to 0.025 for the first and 0.05 for the second model series.

Results

Preliminary Analysis

For the MCAR-test, we considered the following variable categories: sociodemographic variables (e.g., maternal age), birth-related date (e.g., gestation age), questionnaire data (PESI and questionnaires not described in the current study (e.g., the Child Behavior Checklist, Arbeitsgruppe-Deutsche-Child-Behavior-Checklist, 2002), interaction data (Coding Interactive behavior, Feldman, 1998), cortisol data and developmental data not described in the current study (Kaufman Assessment Battery for Children; Melchers and Preuß, 2009). The MCAR-test turned out non-significant (χ^2 = 1.188, df = 1.132, p = 0.119). Thus, we concluded that the list-wise case exclusions were valid for our analyses.

Sample Description

In our clinical sample (n = 13), n = 8 mothers had multiple anxiety disorders (median = 2) during the postpartum period. n = 4 women were diagnosed with two, n = 3 mothers with three and n = 1 woman with four anxiety disorders. Overall, there were n = 6 mothers with a panic disorder or agoraphobia. n = 4 women fulfilled the criteria for a social phobia. Obsessive-compulsive disorders were diagnosed in n = 6 mothers, while n = 1 woman had a posttraumatic stress disorder. There were n = 6 mothers with a generalized anxiety disorder and n = 1 woman with an anxiety disorder not otherwise specified. n = 2 of the mothers were diagnosed with an additional specific phobia. n = 10 women reported that at least one anxiety disorder had an onset already prior to pregnancy. Another n = 1 mother had an onset during pregnancy and an additional n = 2 mothers after birth. As reported above, there were some women with comorbid disorders in our sample: n = 1 mother had a comorbid major depressive episode, n = 1 woman had a dysthymia and n = 1 mother was diagnosed with a comorbid binge eating disorder. For the follow-up sample, the mother with the somatoform disorder was lost. n = 7 mothers still suffered from an anxiety disorder 5–6 years postpartum. The full sample description and tests on comparability between subgroups is reported in **Tables 3A,B**. There were no differences between the two subgroups ($p > 0.09$) except for marital status ($p < 0.01$): Mothers in the control group were more frequently married than mothers in the clinical group. However, as the Spearman correlations ($r < 0.16$) with the study variables were non-significant ($p > 0.36$), we refrained from controlling marital status.

Descriptive Statistics of Study Variables

In our sample, n = 28 infants were classified as securely attached, while n = 8 infants were insecure-avoidant and n = 3 infants were disorganized. Thus, the insecurely attached group comprised n = 11 infants. The descriptive statistics for cortisol measures are demonstrated in **Table 4**. In mean, the samples were taken around 2 pm (M = 13.9) with a standard deviation of SD = 1.8 h

TABLE 3A | Maternal and infant parametric demographics and tests on comparability of subgroups 5–6 years postpartum (Study 2).

	Overall			Control		Anxiety		Test statistics	
	Range	*M*	*SD*	*M*	*SD*	*M*	*SD*	|*t*|	*p*
Maternal age (years)	27.0–48.0	39.8	5.3	40.0	5.0	39.2	5.9	0.45	0.66
Infant age at SST (months)	13.2–22.5	19.2	1.6	18.9	1.9	19.6	1.0	1.18	0.25
Child age at follow-up (years)	5.1–6.5	5.7	0.4	5.7	0.4	5.8	0.3	0.89	0.38

t, t-value; p, empirical α-error; M, mean; SD, standard deviation; SST, Strange Situation Test.

TABLE 3B | Maternal and infant non-parametric demographics and tests on comparability of subgroups 5–6 years postpartum (Study 2).

	Overall		Control		Anxiety		Test statistics	
Maternal education	***n***	**%**	***n***	**%**	***n***	**%**	***W***	***p***
High or low secondary qualification	9	23.1	6	23.1	3	23.1	187.5	0.55
University entrance qualification	8	20.5	4	15.4	4	30.8		
University degree	22	56.4	16	61.5	6	46.2		
Number of children	[a]		[b]		[c]			
One child	7	20.0	4	16.0	3	30.0	221.5	0.09
Two children	16	45.7	11	44.0	5	50.0		
Three or more children	12	34.3	10	40.0	2	20.0		
Marital status							***OR* 95% *CI***	***p***
Married	31	88.6	25	100.0	6	60.0	0.00 [0.00; 0.49]	<0.01
Not married	4	11.4	0	0.0	4	40.0		
Infant sex								
Female infants	26	66.7	15	57.7	11	84.6	0.26 [0.02;1.55]	0.15
Male infants	13	33.3	11	42.3	2	15.4		

[a]*Median = 2.*
[b]*Median = 2.*
[c]*Median = 2.*
W, statistical value of Wilcoxon test for independent samples (U test); p, empirical α-error; OR, odds ratio; 95% CI, 95% confidence interval of test statistic.

and ranging from 9 am to around 4 pm. Moreover, the baseline was taken in mean at 7:30 pm (M = 19.5) with a standard deviation of SD = 0.9 h and ranging from 5 pm to 8:45 pm. Due to the high range of sample times, we checked associations to the cortisol measures. However, all correlations ($r < 0.17$) were non-significant ($p > 0.30$). Thus, we refrained from controlling for time of day.

Main Analysis

The series of hierarchical mixed models on cortisol measures revealed a final model ($REML$ = 233.1) with three predictors: time, cortisol baseline and attachment quality. All other predictors, maternal diagnostic status during the postpartum period and all interaction terms were stepwise eliminated as they did not significantly contribute to the model ($p > 0.24$, for details see the **Supplementary Table 3**). The inferential statistics are demonstrated in **Table 5**. The descriptive statistics of the main effects of attachment quality and time are depicted in **Figures 2**, **3** as well as in **Table 6**. The cortisol levels of children with an insecure attachment quality at 12–24 months were higher during the stress paradigm at the age of 5 to 6 years compared to the ones of securely attached children. This effect explains around 4% of variance in cortisol measures ($\omega^2 = 0.04$), while time explained about 8% of variance ($\omega^2 = 0.08$). Still, most of the variance is explained by cortisol baseline with about 9% ($\omega^2 = 0.09$).

TABLE 4 | Descriptive statistics of cortisol measures in ng/ml.

	M	*SD*	*SE*	*Min*	*Max*
Measure immediately before stressor	1.45	0.91	0.15	0.47	5.40
Measure + 20 min after stressor	1.28	0.80	0.13	0.44	4.25
Measure + 40 min after stressor	1.03	0.47	0.07	0.26	2.45
Baseline 1	0.80	1.13	0.18	0.12	5.72
Baseline 2	0.58	0.40	0.06	0.17	2.16
Mean baseline	0.69	0.69	0.11	0.18	3.63

M, mean; SD, standard deviation; SE, standard error; Min, minimal value; Max, maximum value.

DISCUSSION

The present study aimed at testing the hypotheses that prepartum distress, maternal anxiety disorders in the postpartum period as well as latency to reparation predict infant secure vs. insecure attachment and possibly moderate each other's effect. To the best of the authors' knowledge, there is only one other study to date that has demonstrated associations between maternal anxiety, interactional behavior and insecure attachment in a sample of 4.5 year-olds and their mothers (N = 98, Stevenson-Hinde et al., 2013). These results showed that maternal anxiety was a significant predictor of maternal sensitivity measures which in turn predicted attachment security. Compared to these macro-temporal analyses of interaction behaviors, our perspective is that while maternal sensitivity may be an important predictor of attachment, in particular micro-temporal processes such as latency to reparation may represent critical key mechanisms in this context (compare Mesman, 2010). Maternal sensitivity is a macro-temporal measure in which the entire interaction is judged to be sensitive or insensitive on a rank ordered scale. Thus, it is likely that one misses to register the actual details of mother–infant engagement just in time which could lead to secure or insecure attachment quality. So far, there are only a few studies that have focused on micro-temporal processes (e.g., Beebe et al., 2010); the vast majority of studies use global rating systems to analyze interactive paradigms in this context (e.g., Stevenson-Hinde et al., 2013). Of course, micro- and macro-temporal parameters may be interrelated – thus,

TABLE 5 | Mixed model on cortisol measures.

	Sum of squares	Mean squares	Numerator *df*	Denominator *df*	*F*	*p*
Attachment quality	1.685	1.685	1	36	5.916	0.020
Time	3.349	1.674	2	76	5.878	0.004
Cortisol baseline	3.432	3.432	1	36	12.047	0.001

Df, degrees of freedom; F, F-statistic; p, empirical α-error.

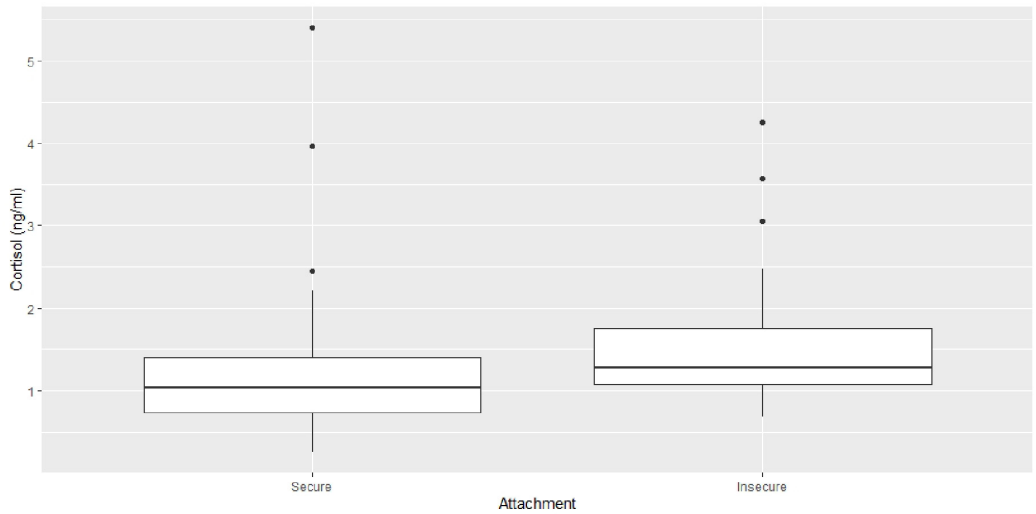

FIGURE 2 | Box-plots regarding the main effect of attachment quality on cortisol measures.

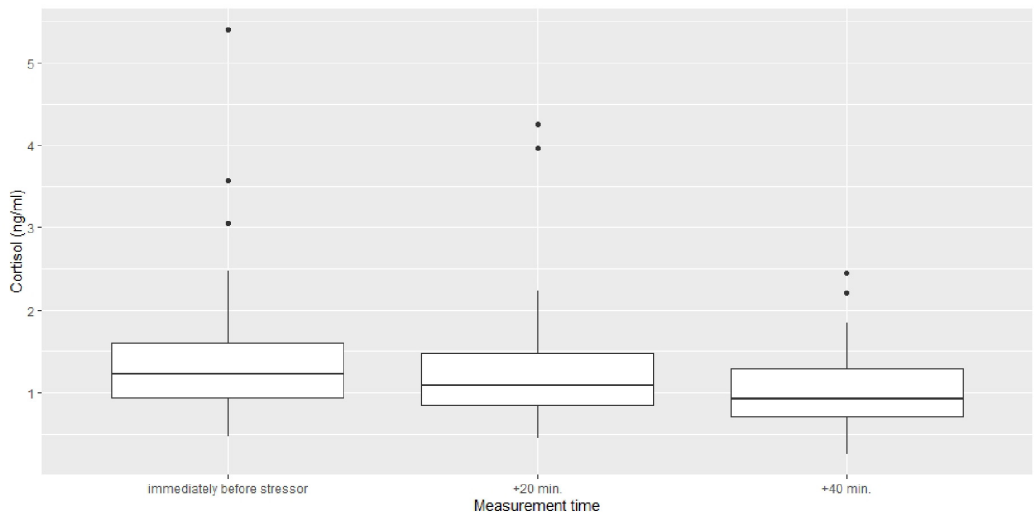

FIGURE 3 | Box-plots regarding the main effect of time on cortisol measures.

we assume that in dyads with sensitively interacting mothers, interactive reparation also succeeds more often (Noe, 2008). However, it is our perspective, that especially the micro-temporal mechanisms may hold the key to understanding the dynamic nature of these multifaceted processes (compare Provenzi et al., 2018). In our study, we examine the micro-temporal process of interactive reparation as a possible interactive mechanism underlying security of attachment. Using regression analysis on a set of possible predictors, as expected we found that apart from maternal diagnostic status, latency to reparation was the only other significant predictor for attachment insecurity.

To predict infant attachment security, not only maternal sensitivity but also infant affect regulation plays an important role. Braungart-Rieker et al. (2001), for example, were able

TABLE 6 | Descriptive statistics on main effects of attachment and time on cortisol measures in ng/ml.

Attachment	*M*	*SD*	*SE*	*Min*	*Max*
Secure	1.15	0.72	0.08	0.26	5.40
Insecure	1.52	0.81	0.14	0.68	4.25
Time					
Measure 1	1.45	0.91	0.15	0.47	5.40
Measure 2	1.28	0.80	0.13	0.44	4.25
Measure 3	1.03	0.47	0.07	0.26	2.45

M, mean; SD, standard deviation; SE, standard error; Min, minimal value; Max, maximum value.

to show that both aspects discriminate between secure and insecure infants. As proposed by DiCorcia and Tronick (2011), interactive reparation – the mutual adaptive process of the dyad oscillating between coordinated and uncoordinated states – seems to shape not only infant attachment security but also – more fundamentally – infant regulatory strategies. Also other studies show that for dyadic co-regulation, sensitive reactions of the caregivers are crucial not only for healthy development (e.g., Malmberg et al., 2016) but likewise for behavioral and physiological reactions (e.g., Haley and Stansbury, 2003; Conradt and Ablow, 2010). As maternal sensitivity is of great importance for infant attachment security, infants of insensitive mothers might frequently lack sufficient regulatory scaffolding with possible long-term consequences for child development (Leclère et al., 2014). And it is our understanding that this regulatory scaffolding is essential in the development of emotion regulation, and thus a secure attachment quality (Kerns and Brumariu, 2014). This is also in line with results of Beebe et al. (2010) showing that very high or very low interactive contingency was linked to insecure attachment in infancy in a sample of anxious mothers. Contingency can be interpreted as a measure of matched states and points toward the same direction as our results. Thus, our findings highlight the importance of specific micro-interactional patterns of mother–child interaction for infants' regulation (Müller et al., 2015) and the development of a secure attachment quality. Consequently, the interactive dysregulation could be partly responsible for the increased risk of developing mental disorders later in life (compare Verhees et al., 2021). Nevertheless, child emotion regulation and their later psychopathological development was not assessed in the current study. Future projects should focus these factors when investigating developmental dependencies between early interactive patterns and child attachment.

Furthermore, our results also showed that infants of mothers with postpartum anxiety disorders have a more than fivefold increased risk of developing an insecure attachment than the infants of the control group. This is in line with previous studies indicating higher attachment insecurity in children of anxious mothers (Stevenson-Hinde et al., 2011). Concerning the mechanism of transmission, e.g., for social anxiety it was demonstrated that particular this disorder goes along with insecure attachment patterns. Consequently, attachment patterns are often transmitted from mother to offspring (for review, see Martins and Gaffan, 2000) by verbal and non-verbal interactions (Ward and Carlson, 1995; Meins et al., 2001). However, in this study we did not assess maternal attachment patterns. Future studies should consider this mediating factor when investigating the development of infant attachment quality. Notably, the effect of anxiety disorder was independent of prepartum distress which turned out not to predict infant attachment quality in our data. This was somewhat surprising given the established effects of fetal programming (van den Bergh et al., 2017), however, this may be due to the fact that in our study prepartum distress was assessed retrospectively and via self-report and not via biological measures such as salivary cortisol. Future studies should consider controlling for prepartum distress via more reliable and objective measures. Moreover, the effect of maternal disorder was not moderated by our dyadic interaction measure as observed in other studies (e.g., Grant et al., 2010a,b). However, it is possible that this is due to the micro-temporal nature of our measurement: This measure may be more sensitive to influences that escape the detection threshold of macro-temporal scales. Thus, it may represent a more direct measure of spontaneous behavior as compared to parental sensitivity measures. Possibly, the behavioral quality we observe here fits better as mediating variable in the association between maternal disorder and infant attachment. Additionally, the power to detect moderation effects may have run too low in our models. Besides increased sample sizes, future studies should investigate the idea of mediation pathways in this context as the work of Stevenson-Hinde et al. (2013) suggests for macro-temporal measures.

In a second part, this study aimed at evaluating possible links between infant attachment quality as well as maternal anxiety disorders in the postpartum period and stress reactivity at preschool age. The results showed increased cortisol levels in insecurely attached children during a stress paradigm compared to securely attached children. This finding is consistent with other studies that have shown associations between attachment security and cortisol reactivity throughout life (Bernard and Dozier, 2010; Oskis et al., 2011; Pierrehumbert et al., 2012; Kidd et al., 2013). However, it is important to emphasize here that the relationship between attachment security and cortisol reactivity in preschool age is moderated by a wide variety of factors, e.g., maternal psychopathology. The study by Luijk et al. (2010), for instance, showed that the association between insecure attachment and cortisol reactivity is stronger in children of depressed mothers. In our study we did not find a significant interaction effect between maternal diagnostic status and attachment on cortisol reactivity in preschool aged children. One reason could be, that our clinical sample consisted of women with various and different anxiety disorders. Hence, it remains unclear whether disorder-specific effects accounted for this null finding. Future studies should consider focusing on more homogenous clinical samples. Another reason could be that we missed to observe a cortisol peak due to too short observational intervals or an ineffective stress paradigm. However, as Gunnar et al. (2009) point out, on average, psychological stress paradigms do not generally induce a cortisol reactivity in developmental studies. Thus, a decrease in cortisol means is a frequent result in infant and child studies (Gunnar et al., 2009; Jansen et al., 2010a). It must be noted that the lack of observable mean cortisol peaks does not imply that the analysis of respective cortisol values is useless. Rather, it has been argued

that their analysis may uncover potential risk factors that account for individual differences and may adversely affect developmental trajectories. Our study suggests that one of these risk factors is represented by infant insecure attachment.

Limitations

First, besides a rather small sample size, and thus low statistical power especially at the 5-6-year follow-up, mothers with different and multiple anxiety disorders were included in our clinical sample. However, the sample size did not allow subgroup analyses on disorder-specific effects. Moreover, according to the DSM-5 (Falkei and Wittchen, 2015), obsessive compulsive disorders are no longer classified as anxiety disorders. Therefore, special attention needs to be paid to these disorders with regard to the outcome variables in future research. Moreover, in respect to the small sample size, the analyses are rather complex. Thus, results should be regarded with cation and focused for replication attempts in future studies. Second, our sample is characterized by an overproportion of academic degrees, whereby our data is not representative for the overall population. Consequently, besides the occurrence of anxiety disorders or not, the sample comprises families with rather low risk-constellations. Third, infant salivary cortisol was assessed prior to, immediately after and 20 min after the stress paradigm. Due to few samples or the limited time frame, it is possible that we missed the cortisol peak. Fourth, it is important to mention the limited control of effects by meantime events between the measurements as well as by the wide age ranges of the infants in both the interaction and attachment assessments. Last, as the study design was observational, causality assumptions are not appropriate.

CONCLUSION

Taken together, our empirical results emphasize the importance to further investigate early interactional micro-temporal markers for infant and child development. Our results underline that latency to reparation is linked to infant attachment security and this in turn influences the child's stress reactivity up to preschool age. During interactions, infants experience that their success or failure in repairing mismatches affects the meanings they make about themselves in the world in relation to others and to themselves (Beeghly et al., 2011): Successful reparation leads to a sense of self as effective and a sense that we – my interactional partner and me – can overcome mismatches or failures and the certainty of being able to trust the other person. Unsuccessful reparation leads to a sense of failure and a distrust of the partner. And it is this sense of trust or distrust that leads to secure or insecure attachment. Therefore, early intervention and prevention programs may be of vital importance. Our results point toward the direction that, in addition to the treatment of clinical symptoms in parents, a promising approach might be to focus on the flexibility of interactional patterns, which is represented by latency to reparation, instead of just positive interaction patterns. As the process of interactive reparation occurs in a clearly detectable time range (seconds; see also Weinberg et al., 2006; Weinberg et al., 2008) video interventions (Reck et al., 2004; Downing et al., 2014) may turn out as useful tools for increasing the flexibility in the flow of dyadic interplay between mismatching and positive matching states. The results suggest, this might improve attachment security in infancy and children's regulatory capacities and mental health in the longer-term (Beatson and Taryan, 2003).

DATA AVAILABILITY STATEMENT

The anonymized 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 Medical Faculty of the Ruprecht-Karls-University, Heidelberg, Germany. Written informed consent to participate in this study was provided by the participants or the participants' legal guardian/next of kin respectively.

AUTHOR CONTRIBUTIONS

MM contributed to the conceptualization, methodology, formal analysis, writing – original draft, review – editing, and visualization. A-LZ contributed to the writing – original draft and review – editing. NK contributed to the attachment coding and writing – review and editing. CW and NN contributed to the writing – review and editing. ET contributed to the supervision and writing – review and editing. CR contributed to the investigation, project administration, supervision, and writing – review and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.807157/full#supplementary-material

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Birth Experience Mediates the Association Between Fear of Childbirth and Mother-Child-Bonding Up to 14 Months Postpartum: Findings From the Prospective Cohort Study DREAM

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Objective: To explore the longitudinal associations between prepartum fear of childbirth (FOC), birth experience, and postpartum mother-child-bonding, and the potential mediator role of the birth experience.

Design: Women from the prospective cohort study DREAM completed questionnaires during pregnancy, 8 weeks, and 14 months after the birth.

Participants: A community sample of $n = 645$ pregnant women from a large city in Eastern Germany participated in the study.

Results: In a regression analysis, FOC predicted negative birth experience ($\beta = 0.208$, $p < 0.001$) which in turn predicted poorer mother-child-bonding both at 8 weeks ($\beta = 0.312$, $p < 0.001$) and 14 months postpartum ($\beta = 0.200$, $p < 0.001$). FOC also predicted mother-child-bonding at 14 months postpartum ($\beta = 0.098$, $p < 0.05$). Of note, this association was mediated by birth experience both at 8 weeks, indirect effect ab = 0.065, 95% CI [0.036, 0.098], and 14 months postpartum, indirect effect ab = 0.043, 95% CI [0.023, 0.067]. These effects remained stable even when adjusting for potential confounders.

Key Conclusions: This study suggests that the association between FOC and mother-child-bonding is mediated by birth experience, pointing to the importance of a woman's positive subjective experience.

Implications for Practice: Findings reveal two targets for peripartum interventions for women at risk for poor mother-child-bonding, namely the implementation of FOC screenings during pregnancy, and birth experience as mediating factor between FOC

and mother-child-bonding. Focusing on the mother's subjective birth experience could aid to identify women at risk for impaired bonding who might need additional support.

Keywords: fear of childbirth, pregnancy, childbirth experience, mother-child-bonding, mediation analysis, DREAM study

INTRODUCTION

With an estimated pooled prevalence rate of 14% (1), severe fear of childbirth (FOC), also referred to as tokophobia, is a common phenomenon among pregnant women, with most of the research focusing on populations from Scandinavia, Australia, and the UK (2–5). Prevalence rates for FOC vary significantly between countries and seem to have increased during the last years (1, 6). This development is especially problematic as prepartum FOC is associated with various negative outcomes for mother and child, one of them being a mother's negative postpartum rating of the birth experience (3, 7–11). Negative birth experiences have an estimated prevalence rate of 7–34% (12) and may lead to a decrease in women's self-esteem and self-efficacy, a feeling of disempowerment, and mental health problems (13). Hodnett (14) concluded in her systematic review that positive expectations seem to lead to a more positive evaluation of the birth (15), whereas negative expectations may lead to a negative evaluation (16, 17). A possible explanation for FOC predicting a more negative birth experience points to the role of endocrine stress parameters during pregnancy for the course of labor. Findings suggest that cortisol awakening response and higher plasma levels of adrenalin (which could both be influenced by FOC) interfere with uterine contractions during labor (18) and thus in turn predict a more negative birth experience (19). This explanation could be applying especially to primary FOC which describes a woman's fear before her first childbirth (20). However, endocrine stress parameters can also be influenced by the birth environment: less optimal, but modifiable circumstances (e.g., the sterile surroundings of a hospital, the perceived stress of overworked staff, and the consequences on the communication with them) may increase women's biological stress response even if they are not affected by FOC (21, 22). By slowing down labor and increasing fetal distress, this biological stress response can further increase the possibility of medical interventions (23), such as instrumental vaginal birth or emergency cesarean section, which are also a risk factor for a negative birth experience (24, 25). Multiparous women who experienced one of those procedures as traumatic at their last birth may therefore fear the recurrence of these events during their next birth, which is referred to as secondary FOC (26–29).

Prepartum FOC seems to not only predict the level of fear during birth, but is also associated with higher levels of postpartum FOC (30–32). Accordingly, several studies have proposed the idea of a vicious cycle (33): during birth, women experience what they were already afraid of, which in turn predicts their postpartum fear and first interaction with their new-born. In support of this, Pazzagli et al. (34) found a moderate linear association between FOC and postpartum parenting stress. Further, the results of a qualitative study interviewing Swedish midwives suggest that FOC predicts both difficulties with breastfeeding and poorer mother-child-bonding (35). Although mother-child-bonding disorders have been identified as a risk factor for impaired emotional, behavioral, and cognitive development of the child (36, 37), to the best of our knowledge, there is only one quantitative study examining the association between prepartum FOC and postpartum bonding. The findings suggest a negative association between FOC and mother-child-bonding 6 weeks, but not 6 months postpartum (38) which prompts the additional question of the longitudinal development of this association.

Another factor influencing maternal bonding may be birth experience as it can have short- and long-term effects on the mother's postpartum well-being (39, 40) which in turn plays a crucial role for early bonding experiences (41). A systematic review by Bell et al. (42) also shows an association between a negative birth experience and poorer maternal postpartum caregiving. So far, the number of studies on the implications of birth experience for mother-child-bonding is small, and studies are limited to the link between symptoms of birth-related posttraumatic stress disorder (PTSD) and mostly poorer mother-child-bonding (43–47). Due to the high correlation between a subjective negative birth experience and birth-related PTSD (43), it seems likely that a negative birth experience could also predict poorer mother-child-bonding.

Other studies have focused on the mother's recalled labor pain (48) or distress during birth (45) and found significant associations with maternal bonding. As an explanation Kennell and Klaus (49) hypothesized that after a negative birth experience, mothers may be preoccupied with their own physical and emotional needs and engage less with their babies, thereby weakening mother-child-bonding.

However, the association between a women's subjective rating of her birth experience and postpartum mother-child-bonding remains understudied. If these two are indeed inter-related, enabling a positive birth experience could be a successful way to ensure a stronger bond between mother and child, thereby increasing the chance of positive child outcomes (50, 51).

At this point, a potential link between prepartum FOC, birth experience, and postpartum mother-child-bonding needs further clarification. Especially the role of a negative birth experience could be of major importance as it might emphasize prior vulnerabilities of the mother, like FOC, and increase the risk of impaired mother-child-relationships (52), therefore acting as a possible mediator between the two variables.

This study aims to explore the longitudinal associations between prepartum FOC, birth experience, and mother-child-bonding 8 weeks and 14 months postpartum. Furthermore, it

will be analyzed whether the association between prepartum FOC and postpartum mother-child-bonding is mediated by birth experience.

MATERIALS AND METHODS

Design

This study is based on data from the prospective cohort study Dresden Study on Parenting, Work, and Mental Health ("**DR**esdner Studie zu **E**lternschaft, **A**rbeit und **M**entaler Gesundheit"; **DREAM**). The DREAM study examines parental work participation, role distribution, stress factors, and how these affect peripartum outcomes and the long-term mental and somatic health of the family. Recruitment started in 2017 and finished at the end of 2020. Currently the study consists of six measurement points: T1 during pregnancy, T2 8 weeks after the anticipated birth date, T3 14 months, T4 2 years, T5 3 years, and T6 4.5 years after birth. Participants comprise a community sample of $N = 3{,}865$ parents from Dresden, Germany and surroundings who are expecting a child and are mainly recruited at information events of obstetrical clinics. Detailed information on the design of the study can be found in the study protocol (53).

Sample

The present study is based on version 5 of the quality-assured data files and included data of women who gave birth to one child and completed T1, T2, and T3. At time of data extraction (17th March 2020), $n = 2{,}027$ women were included in the cohort. The study's retention is presented in a flow chart in **Figure 1**. Data from T1 were excluded when the questionnaire was completed after childbirth to ensure that prepartum FOC was measured. Additionally, data of participants who did not complete T2 or T3 within a given timeframe were excluded, because previous research has shown that the rating of the birth experience and mother-child-bonding may also depend on the time point of the questionnaire (54, 55). Therefore, data from T2 were excluded if completed earlier than 6 weeks or later than 16 weeks postpartum, and data from T3 were excluded if completed earlier than 12 months or later than 16 months after childbirth. The final sample consisted of $n = 645$ women.

Measures

FOC was assessed using the German version of the Fear of Birth Scale [FOBS; (56)] during pregnancy (T1). The FOBS is a validated, shorter alternative (57, 58) to the widely used Wijma Delivery Expectancy Questionnaire [WDEQ-A; (59)]. The original version consists of a two-item visual analog scale in which expectant mothers are asked about their feelings concerning the approaching birth. The two items are anchored by the terms *calm/worried* and *no fear/strong fear*. In the DREAM study, each item generates scores of 0–100 with possible values being increments of 10. The two scores are then averaged to form a total score, where higher values indicate more fear. The reliability of the FOBS in the current study was excellent (Cronbach's $\alpha = 0.90$).

Birth experience was assessed at T2 (8 weeks after the expected birth date) using the German version of the Salmon's Item List [SIL; (60)], a validated 20-item questionnaire that encompasses the four dimensions fulfillment, physical discomfort, emotional distress, and negative emotional experience. The items of the SIL are presented as positive and negative anchors and women are asked to rate each item on a scale from 0 to 6 depending on their feelings during the birth. The sum of all items generates the total score ranging between 0 and 120. In the original version of the SIL, higher scores indicate a more positive birth experience, but in the current analyses the items were reversed in terms of a better understanding so that higher scores indicate a more negative birth experience. The reliability of the SIL was excellent (Cronbach's $\alpha = 0.92$).

Mother-child-bonding was assessed using the German version of the frequently used Postpartum Bonding Questionnaire [PBQ; (61, 62)] which screens for bonding disorders and contains 25 items on the four subscales "impaired bonding," "rejection and anger," "anxiety about care," and "risk of abuse." The PBQ asks parents (here: mothers) to think of the most difficult time with their child and to state how often they experienced each situation, with six possible answers ranging from *never* (0) to *always* (5). Item scores are added to form the scores for each subscale and a total score ranging from 0 to 125. Higher values indicate more bonding difficulties. For this study, we used data from T2 and T3. The reliability of the PBQ was excellent for both T2 and T3 (Cronbach's $\alpha = 0.90$).

The following eight variables were selected as potential confounders, because they have been associated with FOC, birth experience, and mother-child-bonding in previous research: maternal age, parity, education, financial hardship, partnership satisfaction during pregnancy, maternal depressive symptoms during pregnancy, birth complications, and infant health status after birth. Except for financial hardship, birth complications, and infant health status after birth, which were measured at T2, all potential confounders were measured at T1 during pregnancy.

Education was measured by an item, which asks about the professional qualification. Participants were then divided into one group without a university degree and one group with a university degree (bachelor's degree or higher).

Financial hardship was measured by an item, which asks about financial problems during pregnancy or after the birth. It is part of a questionnaire asking about former and current critical life events and their burden based on the Life Event Questionnaire from the Avon Longitudinal Study of Parents and Children (63).

Partnership satisfaction was measured by the validated German short version of the Partnership Questionnaire (64) which comprises three subscales with three items each and an additional item assessing the general happiness of the partnership. The four possible responses range from *never/very rare* (0) to *very often* (3). The total score is generated by summation of all items and ranges from 0 to 27. The reliability of the PFB-K in the current sample was good (Cronbach's $\alpha = 0.80$).

Maternal depressive symptoms were measured by the German version of the Edinburgh Postnatal Depression Scale [EPDS; (65, 66)] which assesses symptoms of depression during the past week. It consists of ten items with four possible responses respectively that are scored on a scale from 0 to 3. The total score is generated by summation of all items and ranges from 0 to

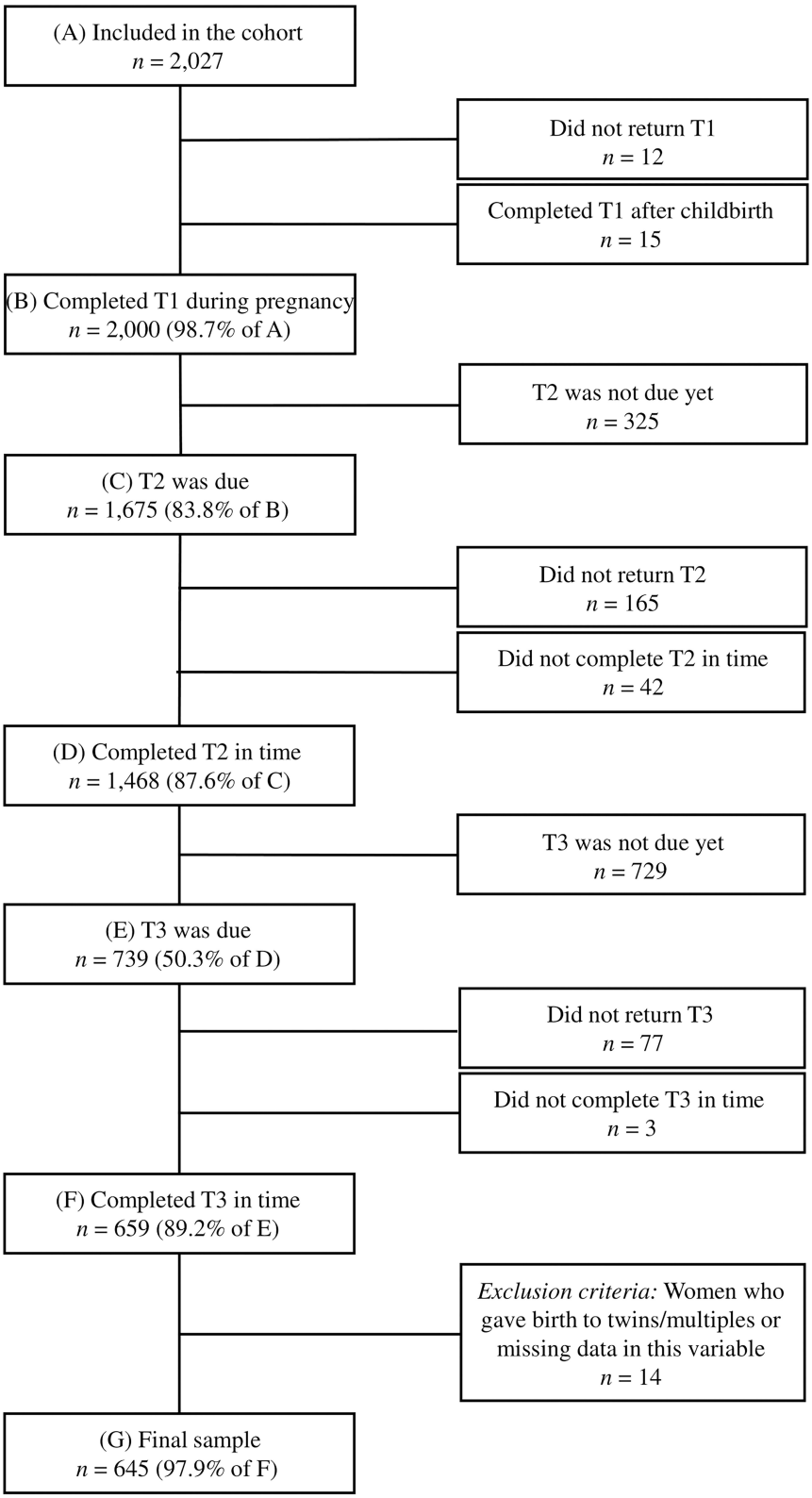

FIGURE 1 | T1, during pregnancy; T2, 8 weeks after the anticipated birth date; T3, 14 months after the birth.

30. The reliability of the EPDS in the current sample was good (Cronbach's $\alpha = 0.83$).

Birth complications and health status of the infant after birth were measured by questions based on the maternity records and the child's medical records. Complications during birth included the number of severe complications concerning the mother, e.g., failure to progress in labor, hemorrhage, perineal tear, vaginal/labial/clitoris tear, or premature or difficult abruption of the placenta. The infant's health status was measured dichotomously as complications during the first 3 days after birth (e.g., icterus, infection, hypoglycemia) which led to a hospitalization of the child.

Data Analysis

All analyses were conducted using IBM SPSS Statistics (Version 27.0). First, data were adjusted and checked for outliers. When items from psychometric scales were missing, they were replaced by the woman's mean value in cases where <20% of the items were missing. Second, descriptive analyses (N, rates in %, mean, SD) for the sociodemographic characteristics of the sample and FOC, birth experience, mother-child-bonding, and the potential confounders were computed. Additionally, correlations between all variables were examined to identify statistically significant confounders. Third, associations between FOC, birth experience, and mother-child-bonding and the potential mediator role of birth experience were analyzed via ordinary least squares regression within the SPSS modeling tool PROCESS (67). The tool computes standardized path coefficients and the standardized total, direct, and indirect effect in a mediation model. For the confidence intervals and inferential statistics bootstrapping with 5,000 iterations and heteroscedasticity consistent standard errors (68) were used. The level of significance was set to $p < 0.05$ with 95% confidence intervals (CI). Due to missing data, *n* varied slightly between analyses.

For the interpretation of the mediated effect we followed the recommendations of Zhao et al. (69) and Rucker et al. (70) who suggest to only consider the indirect effect ab to detect mediation. According to the authors, a significant total effect between the predictor and the outcome is not a requirement for mediation, thus it was reported but not interpreted.

Ethical Statement

All parts of the study were approved by the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (No: EK 278062015). The couples were informed about the aims and procedures of the DREAM study, the pseudonymization of their data, and their right to withdraw from the study at any time. All participants provided written informed consent.

RESULTS

Sample Characteristics

The final sample at T3 (14 months postpartum) consisted of $n = 645$ women (**Table 1**). The mean age of the women during pregnancy was 30.1 years ($SD = 3.9$). Most were born in Germany

TABLE 1 | Sample description.

Sample characteristics	Total ($n = 645$)	
	M (SD)	**Range**
Maternal age at T1 (in years)	30.1 (3.9)	15–42
Week of pregnancy at T1	30.7 (5.8)	11–41
Age of child at T2 (in weeks)	8.5 (1.9)	6–16
Age of child at T3 (in months)	13.8 (0.5)	13–16
Fear of childbirth (FOBS score; T1)	36.6 (22.8)	0–100
Birth experience (SIL score; T2)	42.0 (21.0)	0–108
Mother-child-bonding (PBQ score; T2)	13.0 (10.2)	0–93
Mother-child-bonding (PBQ score; T3)	14.0 (9.9)	0–102
Depressive symptoms (EPDS score; T1)	5.5 (4.0)	0–23
Partnership satisfaction (PFB-K score; T1)	21.6 (4.0)	5–27
	***n*[a]**	**%[b]**
Country of birth		
Germany	621	96.6
Other	22	3.4
Education		
No university degree	254	39.5
University degree	389	60.5
Partnership status		
Partner	637	99.4
No partner	4	0.6
Parity		
Nulliparous	507	79.3
Primiparous	114	17.8
Multiparous	18	2.9
Employment status[c]		
Full-time employed	284	44.1
Part-time employed	114	17.7
Maternity leave	93	14.4
Number of birth complications		
0	347	53.8
1	218	33.8
2	67	10.4
≥ 3	13	2.0
Infant health status during the first 3 days		
Healthy	572	89.2
Hospitalized due to complications	69	10.8
Financial hardship		
No financial problems	488	78.3
Financial problems during pregnancy after birth or	135	21.7

FOBS, Fear of Birth Scale; SIL, Salmon's Item List; PBQ, Postpartum Bonding Questionnaire; EPDS, Edinburgh Postnatal Depression Scale; PFB-K, short version of the Partnership Questionnaire; T1, during pregnancy; T2, 8 weeks after the expected birth date; T3, 14 months after birth.

[a]n varies slightly due to missing data of some participants. [b]Valid percent. [c]Multiple answers possible.

(96.6%), in their third trimester of pregnancy (76.6%), expecting their first child (79.3%), and living in a stable partnership (99.4%). Compared to the general population in Dresden, the women in the sample had higher education, with 60.6% holding a university degree (71). The mean scores of the FOBS, SIL, and PBQ at T2 and T3 were all below the suggested clinically relevant cut-offs, indicating low FOC, positive birth experiences, and strong mother-child-bonding, respectively.

Dropout Analyses

Dropout analyses were conducted for the predictor, the mediator, all potential confounders, and sociodemographic characteristics for completers vs. non-completers. Compared to completers, non-completers more often had no university degree (54.2 vs. 39.5%, $\chi^2(1, n = 715) = 5.76$, $p = 0.016$) and had a 7.40 points, 95% CI [1.51, 13.01], higher mean FOBS score than completers, $t(708) = 2.62$, $p < 0.05$, indicating more FOC. There were no differences between completers and non-completers regarding any other variable (tables on request).

Association Between FOC, Birth Experience, and Mother-Child-Bonding

First, correlations between all variables were computed (see **Table 2**), revealing small to medium correlations between FOC, birth experience, mother-child-bonding, and several potential confounding variables.

Second, associations between FOC, birth experience, and mother-child-bonding were examined using ordinary least squares regression within PROCESS. **Figure 2A** shows that higher FOC scores significantly predicted a more negative birth experience ($\beta = 0.208$, $p < 0.001$) which in turn significantly predicted poorer mother-child-bonding at T2 ($\beta = 0.312$, $p < 0.001$). While FOC had no significant direct effect on mother-child-bonding at T2, the effect was mediated by the birth experience, completely standardized indirect effect ab = 0.065, 95% CI [0.036, 0.098]. **Figure 2B** shows that a more negative birth experience also significantly predicted poorer mother-child-bonding at T3 ($\beta = 0.200$, $p < 0.001$). In this model, FOC had a significant direct effect on mother-child-bonding ($\beta = 0.098$, $p < 0.05$), but the effect was also mediated by the birth experience, completely standardized indirect effect ab = 0.043, 95% CI [0.023, 0.067].

Confounding variables which correlated with the two outcome variables can be found in the correlation matrix of **Table 2**. When maternal education, prepartum depressive symptoms, birth complications, and parity were included as confounders in the regression model with mother-child-bonding at T2 (see **Figure 2C**), higher FOC was still a significant predictor for a more negative birth experience, which in turn was still a significant predictor for poorer mother-child-bonding. FOC had no direct effect on mother-child-bonding at T2, but the mediated effect remained significant. The same was true for the regression model with mother-child-bonding at T3, which included the confounders maternal education, prepartum depressive symptoms, financial hardship, and partnership satisfaction (see **Figure 2D**). The associations between FOC and birth experience as well as birth experience and mother-child-bonding remained significant, but FOC had no significant direct effect on mother-child-bonding. Instead, the effect was significantly mediated by birth experience.

DISCUSSION

This study aimed to explore the longitudinal associations between prepartum FOC, birth experience, and mother-child-bonding. We found that FOC significantly predicted a more negative birth experience, which in turn significantly predicted poorer mother-child-bonding at 8 weeks and 14 months postpartum. However, FOC did not have a direct effect on mother-child-bonding. Instead, the association was mediated by birth experience.

Association Between FOC and Birth Experience

FOC was a significant predictor for a more negative birth experience, even when adjusting for maternal education, parity, depressive symptoms during pregnancy, and birth complications (Model at 8 weeks postpartum) and maternal education, depressive symptoms during pregnancy, financial hardship, and partnership satisfaction (Model at 14 months postpartum). This finding is in line with previous research: On the one hand, endocrine stress parameters during pregnancy, like cortisol awakening response and higher plasma levels of adrenalin (which could both be influenced by FOC), may disrupt labor by interfering with uterine contractions (18) and thus in turn predict a more negative birth experience (19). On the other hand, in the current study the association between FOC and birth experience was still significant when adjusting for birth complications, suggesting that the objective birth process is only one of many explanations for the subjective postpartum birth evaluation. The way a woman's expectations of childbirth affect her perception, recall, and therefore her re-interpretation of the birth, seems to be at least equally important as the course of labor and medical interventions (32, 72). Some studies have argued that women should be encouraged to have more realistic expectations of birth to reduce negative experiences and posttraumatic stress responses (73). Instead of having a birth plan, the idea of a birth flow chart is suggested, which considers various possible events and outcomes during labor and birth (74). In contrast, other researchers highlight the importance of women's belief in birth as a natural process and their own body's capability as a way to reduce FOC and medical interventions during birth (75). Clearly, more research is needed to identify the optimal strategy for preparing women for labor and birth.

Association Between Birth Experience and Mother-Child-Bonding

A more negative birth experience was a significant predictor for poorer mother-child-bonding, both at 8 weeks and 14 months postpartum. However, the association was stronger 8 weeks postpartum, suggesting that the impact of birth experience on mother-child-bonding weakens over time. These results are consistent with previous research (42, 45), although, to the

TABLE 2 | Correlation matrix including the predictor, mediator, outcome, and potential confounders.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. FOBS	–											
2. SIL	0.21***	–										
3. PBQ (T2)	0.13**	0.32***	–									
4. PBQ (T3)	0.14**	0.22***	0.61***	–								
5. Age	0.05	0.07	−0.00	−0.03	–							
6. Parity	−0.02	−0.21***	**−0.16*** **	0.06	0.30***	–						
7. Education	−0.07	0.08*	**0.13****	**0.11****	0.19***	−0.01	–					
8. EPDS	0.41***	0.14**	**0.18*****	**0.21*****	0.02	0.09*	−0.08	–				
9. PFB-K	−0.04	−0.06	−0.06	**−0.12****	−0.07	−0.27***	0.07	−0.20***	–			
10. Birth complications	−0.05	0.12**	**0.09***	0.03	0.03	−0.14**	−0.00	−0.07	0.05	–		
11. Financial hardship	0.06	−0.03	0.04	**0.10***	−0.10*	0.07	−0.16***	0.22***	−0.02	−0.05	–	
12. Infant health	0.02	0.05	0.00	−0.00	0.00	−0.08	−0.03	0.02	0.07	−0.05	0.07	–

All associations were calculated using Pearson correlation coefficient, except for the association between dichotomous variables, which were calculated using phi coefficient. Significant correlations of potential confounders with the outcome variables, PBQ (T2) and PBQ (T3), are printed in bold. FOBS, Fear of Birth Scale; SIL, Salmon's Item List; PBQ, Postpartum Bonding Questionnaire; T2, 8 weeks after the anticipated birth date; T3, 14 months after the birth; EPDS, Edinburgh Postnatal Depression Scale; PFB-K, short version of the Partnership Questionnaire.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

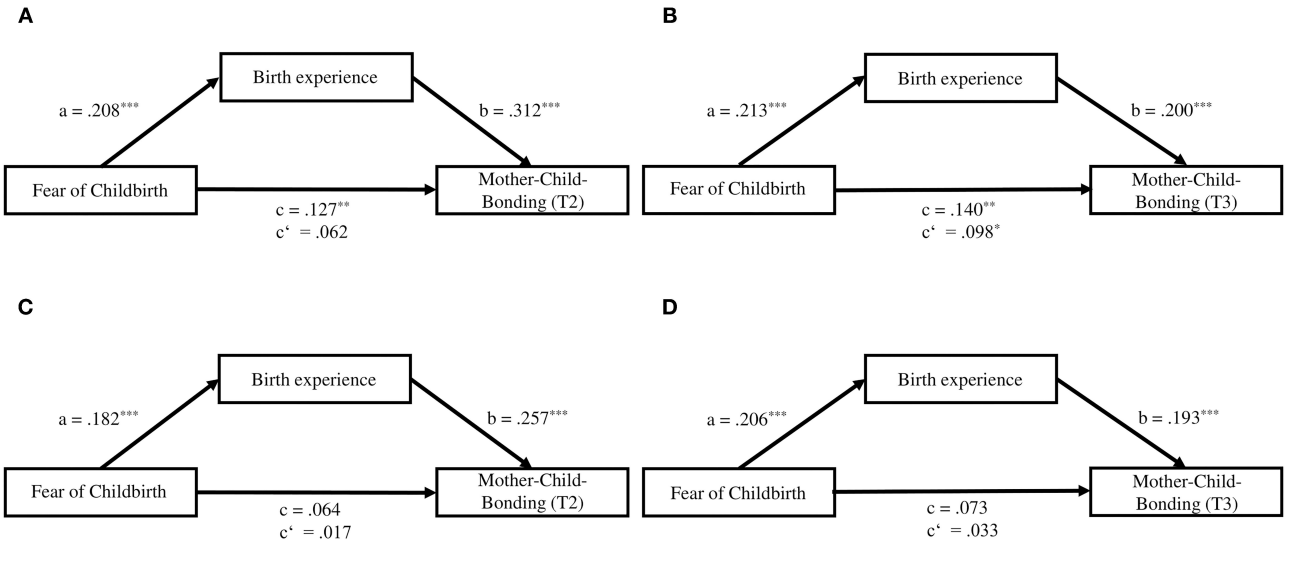

FIGURE 2 | (A) Standardized regression coefficients for the association between fear of childbirth, birth experience, and mother-child-bonding at T2. **(B)** Standardized regression coefficients for the association between fear of childbirth, birth experience, and mother-child-bonding at T3. **(C)** Standardized regression coefficients for the association between fear of childbirth, birth experience, and mother-child-bonding at T2, controlling for maternal education, parity, prepartum depressive symptoms, and birth complications. **(D)** Standardized regression coefficients for the association between fear of childbirth, birth experience, and mother-child-bonding at T3, controlling for maternal education, prepartum depressive symptoms, financial hardship, and partnership satisfaction. c, total effect; c', direct effect.
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

best of our knowledge, there are no studies which examine the longitudinal development of the relationship between the subjective birth experience and mother-child-bonding. Thus, our findings emphasize the importance of a positive birth experience for the long-term bond between mother and child. Additionally, our findings support the hypothesis that not only clinically relevant birth-related PTSD symptoms may lead to poorer mother-child-bonding, but a subjectively rated negative birth experience may have the same effect. One might hypothesize that a negative birth experience influences mother-child-bonding via similar mechanisms as birth-related PTSD, because both imply negative feelings about the birth. Thus, a negative birth experience could also contribute to maternal avoidance of contact with the infant to prevent her from thinking about the negative or traumatic birth and re-experiencing it (76, 77). Furthermore, a negative birth experience may lead to a sense of failure in the mother and weaken her feeling of self-efficacy, thereby reducing her emotional availability toward the child, resulting in poorer mother-child-bonding (13, 78, 79).

Association Between FOC and Mother-Child-Bonding and Mediator Role of Birth Experience

Except for 14 months postpartum when not considering the confounders, FOC was not a significant predictor for mother-child-bonding. At first glance, this finding contradicts previous research, which identified an association between FOC and constructs similar to postpartum mother-child-bonding. Especially the results of Klabbers et al. (38) who found a significant correlation between FOC and mother-child-bonding 6 weeks postpartum, seem to differ from our results. However, our data also showed a significant correlation 8 weeks and 14 months postpartum. It was only in the mediation analysis that it became apparent that FOC does not seem to be a direct significant predictor of mother-child-bonding, especially when considering various confounders. This is in line with further analyses by Klabbers et al. (38), in which they found no mean group differences in mother-child-bonding between women with low and high FOC, although no confounding variables were considered here. Instead, the relationship seems to be mediated by the birth experience, which, to the best of our knowledge, has not been considered in any previous studies. This indicates that FOC only influences the mother's bonding with her child via the birth experience, which is in line with the hypothesis of the vicious cycle of FOC (33): a mother who suffers from severe fear of the upcoming birth has a higher risk of experiencing a negative or traumatic birth which in turn may lead to high FOC and difficult maternal adjustment postpartum. Our study suggests that this could also affect bonding with the child even 14 months after birth.

Strengths and Limitations

Using data from the prospective-longitudinal cohort study DREAM, we examined the longitudinal associations between FOC, birth experience, and mother-child-bonding from pregnancy to 14 months postpartum. By studying a large sample of German women, this study also contributed to the literature on FOC in Germany which is still scarce as most research focusses on populations from Scandinavia, Australia, and the UK (3, 4). Additionally, to the best of our knowledge, this was the first study that examined the association between the subjective birth experience and mother-child-bonding. Many of the previous studies have investigated the association between mother-child-bonding and symptoms of birth-related PTSD which is much less common (80, 81) than a negative birth experience [prevalence rates of 3–4% for PTSD as compared to 7–34%; (12)]. This was also the first study to examine the mediator role of birth experience for the association between FOC and mother-child-bonding, thereby further emphasizing the importance of a positive birth experience for the mother and the child. For all analyses, potential confounders were included, and only validated instruments were used to measure FOC, birth experience, and mother-child-bonding.

Nevertheless, when interpreting the results, one should keep in mind the limitations of this study. Firstly, women who dropped out of the study had higher FOC and more often had no university degree than the women in the final sample. One explanation for the higher level of FOC could be that these women were more impaired and therefore dropped out of the study, which would mean that our results underestimate the effect of FOC on birth experience and mother-child-bonding. However, completers and non-completers did not differ from each other in their birth experience, their prepartum depression scores, their partnership satisfaction, or financial hardship, making it unlikely that their impairment was the reason to drop out. Additionally, the women who participated in the study had relatively low FOC levels. Although the mean scores were similar to populations in Sweden and Australia (4, 56, 57), they were still far from the clinically relevant cut-off of 50 (56), indicating a relatively healthy sample. In general, our sample was very privileged and well educated [see study protocol, (53)], as most women were in a stable partnership, had low levels of prepartum depression, and relatively high levels of bonding with their children as the mean scores were far from the clinically relevant cut-off of 26 (82). Therefore, the current findings cannot necessarily be generalized to more impaired or clinical samples, but rather be seen as valuable insights for community samples. Finally, even though the characteristics of our sample may be an indicator for relatively low general psychiatric morbidity, we cannot exclude the possibility that apart from prepartum depression, other psychiatric comorbidities could have affected our results (83).

Research and Practical Implications

Future research on the association between FOC, birth experience, and mother-child-bonding is needed to replicate these findings in more diverse samples including single mothers, less educated women, clinically impaired women, higher proportions of migrants, and LGBTQIA+ couples. Additionally, it should be tested whether there are differences in the described associations for nulliparous and multiparous women as parity was a significant confounder in our analyses. Regarding the improvement of women's birth experiences through altering their prepartum expectations, it should be investigated whether different strategies need to be followed for women with and without FOC. More precisely, women with FOC may profit from strengthening the belief in birth as a natural process, which their body can master, to escape the vicious circle described by Zar et al. (33). Instead, women without FOC may profit more from preparing for various unforeseen events during labor and birth and not narrowing their attention to one possible outcome specified in a birth plan. Further, the putative mechanisms by which a negative birth experience influences mother-child-bonding remain yet to be determined; some of them might be similar to those of birth-related PTSD.

Findings clearly point to the need for FOC screenings in pregnancy to identify women at risk for a negative birth experience and connected postpartum mental health difficulties. However, such screenings are not part of routine clinical practice in Germany yet (84). This might partly be due to the fact that this topic may play a subordinate role in the education of midwives and obstetricians, but also due to the immense time pressure clinicians experience during prenatal appointments, which may

not leave enough room for additional questions. As a first step, FOC screenings should be included in national guidelines as a mandatory aspect of prenatal care. The FOBS is a validated instrument, which could be used for this purpose because it can be completed and interpreted quickly and is therefore suitable for the busy routines in modern practices. A further challenge, which needs to be addressed, is the effective referral of pregnant women with FOC to a specialist offering targeted intervention, like antenatal psychoeducation (85).

Additionally, women who experienced their birth as negative or traumatic need to be identified, as these mothers may need additional support in caring for and interacting with their babies as they are processing their birth experience. For this reason, it should also be investigated whether postpartum partner support can have a moderating effect on the development of bonding difficulties in mothers following a negative birth experience (86). Thus, widening the perspective to a family context rather than only focusing on the mother herself could reveal additional effective approaches for building healthier families.

CONCLUSION

In this study, FOC significantly predicted a more negative birth experience suggesting that a woman's expectation of her birth might be equally important for her birth evaluation as the course of labor and medical interventions. For this reason, it could be helpful to implement FOC screenings during the routine pregnancy check-ups to refer the affected women to a specialist offering a suitable intervention. Furthermore, in this study, a negative birth experience significantly predicted poorer mother-child-bonding at 8 weeks and 14 months postpartum, although the association was stronger at 8 weeks postpartum. This stresses the importance of support for women who perceived their birth as negative and might therefore be preoccupied with emotionally processing their experience and not able to properly bond with their babies. The results of this study also suggest that the association between FOC and mother-child-bonding is mediated by the birth experience, which further emphasizes the importance of a positive birth experience for all women. It could be promising to replicate and test these findings in more diverse samples, as well as comparing them to nulliparous and parous women.

DATA AVAILABILITY STATEMENT

The dataset analyzed during the current study is not publicly available due to legal and ethical constraints, as the study's informed consent did not include public sharing of participant data. The dataset is available from the corresponding author on reasonable request. Requests to access the datasets should be directed to lara.seefeld@ukdd.de.

ETHICS STATEMENT

This study involving human participants was reviewed and approved by the Ethics Committee of the Faculty of Medicine of the Technische Universität Dresden (No: EK 278062015). All participants provided written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LS, VW, and SG-N contributed to the conception and the design of the study. VW and MK conducted data cleaning and data preparation. LS and VW performed the statistical analyses. LS wrote the first draft of the manuscript. VW, MK, SK, and SG-N wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Maternal Mood and Perception of Infant Temperament at Three Months Predict Depressive Symptoms Scores in Mothers of Preterm Infants at Six Months

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Postpartum depression is more prevalent in mothers and fathers of preterm infants compared to parents of full-term infants and may have long-term detrimental consequences for parental mental health and child development. The temperamental profile of an infant has been postulated as one of the important factors associated with parental depressiveness in the first months postpartum. This study aimed to examine the longitudinal relationship between depressive symptoms and perceived infant temperament at 3 months corrected age, and depressive symptoms at 6 months corrected age among mothers and fathers of infants born preterm. We assessed 59 families with infants born before the 34th gestational week using the Edinburgh Postnatal Depression Scale (EDPS) and the Infant Behavior Questionnaire-Revised. We found that mothers' scores on EPDS and infants' Orienting/regulation at 3 months corrected age predicted mothers' EPDS scores at 6 months corrected age. In particular, higher depressive scores were related to higher depressive symptoms at 6 months corrected age, whereas higher infant Orienting/regulation was related to lower depressive symptoms at 6 months corrected age. Due to the low internal consistency of EPDS at 6 months for fathers, we were unable to conduct similar analyses for fathers. Our results point to the importance of considering both early indices of maternal mood as well as mother-reported measures of preterm infant temperament in the attempts to predict levels of maternal depressiveness in later months of an infant's life. Further studies are urgently needed in order to better understand the associations between depressiveness and infant temperament in fathers, and with more consideration for the severity of the effects of infant prematurity.

Keywords: postpartum depression, preterm infants, mothers, fathers, temperament

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INTRODUCTION

Despite rapid advances in obstetric and neonatal care, prematurity, i.e., a birth before the 37th gestational week, remains a major health and developmental risk factor for affected children and contributes to increased distress in their parents (Wolke et al., 2019). Multiple emotional reactions of parents to their preterm infants' hospitalization in a neonatal intensive care unit have been

described, including feelings of helplessness and being out of control, uncertainty as to the infant's survival and health status, sadness, and extreme distress (Lasiuk et al., 2013; Trumello et al., 2018). Studies on the impact of preterm birth on parental mental health point to increased risk of depression and post-traumatic stress disorder as well as increased levels of anxiety and parenting stress, especially in mothers of preterm infants (Kersting et al., 2004; Karatzias et al., 2007; Vigod et al., 2010; Helle et al., 2015; Pace et al., 2016; Anderson and Cacola, 2017; Yildiz et al., 2017; Garfield et al., 2021; Genova et al., 2022). The rates of paternal depression and anxiety seem to be lower than maternal ones, but still elevated when compared to fathers of full-term infants (Treyvaud, 2014; McMahon et al., 2020; Weigl et al., 2020; Baldoni et al., 2021; Genova et al., 2022).

Literature on longer-term trajectories of perinatal depression in parents of preterm infants is still limited and existing results are mixed. Some studies have found no evidence for prolonged risks for parental mental health, at least considering the trajectories of parenting stress (Schappin et al., 2013). Others point to gradually declining, yet elevated levels of depression symptoms in mothers (Miles et al., 2007; Poehlmann et al., 2009) or in both mothers and fathers until at least the infant's corrected age of 6 months (Pace et al., 2016). In addition, some evidence has been found for the connections between prematurity/low birth weight (LBW) and parental depression to last much longer. For instance, according to Barkmann et al. (2018), very low birth weight predicts elevated levels of parental depressiveness even up to 5 years postpartum. Finally, a recent study by Genova et al. (2022) points to general decrease in depressiveness between 3 and 12 months postpartum in mothers and fathers, although with some differences, both in the severity of depressiveness and in the reduction in depressive symptoms over time, between parents of extremely LBW and very LBW infants.

The increased risk for postpartum depression should raise our particular concern as the links between perinatal parental depression and a child's mental health and developmental problems later in life have been well documented in preterm children (Cheng et al., 2016; Trumello et al., 2018; Neri et al., 2020; Pisoni et al., 2020), adding to the already complex array of challenges to child development related to biological immaturity, neonatal complications, quality of the early experience, etc. (Aarnoudse-Moens et al., 2009). One of the important factors that has recently received considerable attention from researchers as potentially related to compromised parental mental health (especially in terms of risk of depression), is infant temperament as perceived by the parents.

More and more studies point to preterm birth or its neurological complications as related to less optimal infant temperamental profile (Takegata et al., 2021), or even to "difficult" temperament (Washington et al., 1986; Larroque et al., 2005). Preterm birth is a multifold risk for child development (Wolke et al., 2019). Biological immaturity, medical complications, pain exposure, and exposure to overwhelming sensory input in the NICU are among the risk mechanisms that can alter a child's neurobehavioral functioning (Als et al., 2004; Feldman, 2009; Valeri et al., 2015; Grunau, 2020). For example, exposure to procedural pain and pain-related stress in neonatal period was found associated with the alterations in brain architecture and function (see Gaspardo et al., 2018, for review), which, in turn, may be related to poorer regulatory competencies in later developmental periods. Montirosso et al. (2016) described epigenetic mechanisms through which early NICU-related stress might be associated with temperamental difficulties at 3 months of age.

Studies using Mary Rothbart (2004, 2011) psychobiological, developmental, and dimensional approach to temperament, defined as "biologically rooted individual differences in reactivity and self-regulation in emotional, activational, and attentional processes" (Fu and Pérez-Edgar, 2015, p. 193), clearly point to specificities of preterm children's temperament. Noteworthy in this approach is that reactivity is captured by the dimensions of Negative affectivity and Surgency, whereas self-regulation is reflected in the dimension of Effortful control (Orienting/regulation in infancy) (Fu and Pérez-Edgar, 2015). Furthermore, each of the three higher-order dimensions consists of a number of lower-order temperamental traits (dimensions).

In the study by Cosentino-Rocha et al. (2014), preterm birth was associated with higher scores on high-intensity pleasure and perceptual sensitivity and lower scores on discomfort, cuddliness, and attentional focusing in children aged 18 months to 5 years. The study by Tamm et al. (2020) in the group of very preterm infants showed that early MRI-diagnosed brain abnormalities were predictive of lower parental ratings of child's temperamental features as measured by the Infant Behavior Questionnaire-Revised-Short form (Putnam et al., 2014): High Intensity Pleasure and Vocal Reactivity, High Intensity Pleasure and Cuddliness as well as Fear and Sadness at 3 months corrected age. According to a meta-analysis conducted by Cassiano et al. (2020), preterm children get lower scores in Attentional Focusing and higher scores in Activity dimensions compared to full-term children. Compromised temperamental profile in turn was found to be predictive of long-term behavioral problems (Cassiano et al., 2016, 2019; Lee and Lee, 2017; Martins et al., 2021).

Associations between maternal depressive symptoms and infant behavior and temperament have been broadly documented (e.g., McGrath et al., 2008). However, the study results do not explain the mechanisms which underlie this association, and the direction of the relationship remains unclear (e.g., Murray et al., 1996; Pauli-Pott et al., 2004; Britton, 2011; Eastwood et al., 2012; Aktar et al., 2017). And this is particularly true for preterm infants. Some studies show that the temperamental profile of preterm infants is predictive of maternal depressive symptoms. For example, according to results from Quist et al. (2019), gestational age was predictive of maternal depressive symptoms, but only in interaction with fussiness. Contrary directions were found in studies which point, that maternal depression can alter the perception of child behavior. The study by Voegtline et al. (2010), showed the stability of increased symptoms of depression and anxiety at 2 and 6 months in mothers of late preterm infants, which was related to higher maternal ratings of infant negativity at 6 months.

More research is required to better understand the relationship between parental depression and child temperament. This is especially true in parents of preterm infants due to higher

prevalence of depressive symptoms in mothers and fathers, altered temperamental profiles in infants, and numerous challenges in parent-infant interactions related to both parental (e.g., Misund et al., 2016) and infants' (e.g., Harel et al., 2011; Poehlmann et al., 2011) contributions in this population. Additionally, investigating the association between the course of parents' depressive symptoms and infant temperament might be of crucial clinical importance, as depression in the postpartum period may have long-term detrimental consequences for parental well-being (Hermens et al., 2004; Vigod et al., 2010; Helle et al., 2015) and child development (Latva et al., 2008; Cheng et al., 2016; Slomian et al., 2019).

In the current study, we aimed to analyze the relationship between the intensity of depressive symptoms (depressiveness) in parents of preterm infants and parents' perceived infant temperament at 3 months corrected age (CA). Furthermore, our intention was to verify whether both the intensity of depressiveness and the infant's temperamental dimensions, as assessed by parents at 3 months, were predictors of parental scores on the dimension of depressiveness at 6 months of the infant's CA. Taking into consideration the available research data briefly summarized in the introductory section, and Rothbart's model of temperament, we hypothesized that:

(1) The level of depressiveness will be higher in mothers than in fathers, both at 3 and 6 months infants' CA.
(2) The level of depressiveness of both mothers and fathers will decrease between 3 and 6 months of the infant's CA.
(3) Measures of infants' temperament as assessed by mothers and fathers will be positively correlated.
(4) Infant's Negative affectivity at 3 months CA will be positively related to the maternal and paternal level of depressiveness at 3 and 6 months CA, whereas indices of temperamental self-regulation (Orienting/regulation in the case of infants) and Surgency/extraversion at 3 months CA will be negatively related to both maternal and paternal depressiveness at 3 and 6 months CA.

In addition, an exploratory analysis was planned to explain possible contribution of parental depressiveness scores and parent-reported infant's temperament at 3 months to maternal and paternal levels of depressiveness at 6 months CA.

MATERIALS AND METHODS

General Information

This study was part of a larger longitudinal project on relational and biological antecedents of self-regulatory capacities of preterm infants in the first year of their lives, in which data were collected at 1, 3, 6, and 12 months infants' CA. For the purposes of the current study, only the data collected at 3 and 6 months will be used as these are specifically targeted at assessing parental levels of depressiveness and infant temperament. Our focus was on families with infants born before the 34th gestational week, hospitalized for at least 7 days in the neonatal unit, as their experiences might considerably differ from those of late preterm infants.

Participants

A convenience sample of sixty-four infants (30 girls) born before the 34th gestational week in two tertiary care hospitals in Warsaw between July 2008 and February 2010 was enrolled. The parents were invited via written information about the study distributed by the neonatal unit staff just before each infant's discharge from the hospital. The inclusion criteria also comprised both parents' consent to participate in all assessment meetings, and parents being above 19 years of age. Infants from multiple pregnancies as well as those born with additional metabolic or genetic syndromes, congenital malformations, or tumors were excluded. The study was approved by the research ethics committee of the Faculty of Psychology, University of Warsaw, and conformed to the Declaration of Helsinki. In the original project, a control group of 31 full-term infants was also included but will not be presented here as our focus is not on comparison between the groups but specifically on the interplay of factors that might explain the intensity and persistence of depressive symptoms in parents of preterm infants, and the possible links with infants' temperament.

The preterm group consisted of two subgroups in line with the WHO degrees of prematurity: 33 infants met the criteria for extreme prematurity (EPT), and 31 infants were born very or moderately preterm (VPT and MPT, respectively). Four families resigned from the study (3 from the EPT and 1 from the VPT group) by the time the infant reached 3 months CA. Apart from that, one family could not participate in the assessment for a period of 3 months for medical reasons. As no statistically significant correlations were found between infants' gestational week and either parental depressiveness scores (at 3 and 6 months) or infants' temperamental dimensions, both groups of preterm infants were merged for further analysis in this study. Group characteristics are presented in **Table 1**. Mean gestational age of the infants at birth was 28.746 weeks ($SD = 3.15$; $Mdn = 29$), mean birth weight was 1,290.8 g ($SD = 519.475$; $Mdn = 1{,}200$), mean length of hospitalization was 60 days ($SD = 34.115$; $Mdn = 34$), and the mean number of skin breaking/painful procedures was 91 per hospital stay ($SD = 95$; $Mdn = 45$). The socio-economic status of the families was controlled for, and all the families reported that their financial situation was either average or above average. Most parents had at least 12 completed years of education, and 70% of mothers and 56.7% of fathers had a higher education diploma. Mothers were between 20 and 41 years of age ($M = 31.5$, $SD = 4.2$, $Mdn = 31$), while fathers were between 20 and 52 ($M = 33.8$, SD = 5.26, $Mdn = 33$).

It is worth noting that, at the time when the infants were hospitalized, the two neonatal units adopted various elements of neurodevelopmental care such as special nests surrounding and supporting the infant's body, blankets shielding an isolette to minimize excessive and abrupt light exposure, etc. The units also offered psychological support for the parents and employed a team of physiotherapists and speech therapists to provide developmentally appropriate care for the infants.

Furthermore, participation in the project as such might have served as an additional supportive measure because it involved two home visits by a nurse and a psychologist (at the infant's CA of 1 and 3 months), with plenty of time for parents to

TABLE 1 | Group characteristics.

	N	%	Mean	SD	Median	Min	Max
Total number of infants	59	100.00					
Girls	30	50.85					
Boys	29	49.15					
Infant's gestational week at birth			28.75	3.15	29.00	22.00	34.00
Infant's birthweight in grams			1, 290.80	519.48	1, 200.00	495.00	2, 440.00
Infant's duration of hospital stay after birth			59.70	34.12	54.00	7.00	147.00
Prevalence of neurological complications:							
IVH of at least 3rd grade	8	13.56					
PVL	5	8.47					
Prevalence of retinopathy of prematurity of at least 3rd grade	14	23.73					
Prevalence of necrotizing enterocolitis (NEC)	6	10.17					
Prevalence of chronic lung disease	29	49.15					
Days on mechanical ventilation			10.76	15.84	4.00	0.00	63.00
Number of skin-breaking/stressful procedures during the whole hospital stay			91.45	94.97	45.00	5.00	384.00
Mother's age (years)			31.37	4.17	31.00	20.00	41.00
Father's age (years)			33.71	5.33	33.00	20.00	52.00
Mother's education (number of completed years)			15.73	2.28	17.00	8.00	19.00
Father's education (number of completed years)			15.10	2.78	17.00	11.00	20.00

IVH, intraventricular hemorrhage; PLV, periventricular leukomalacia.

share their concerns with the study team, and the provision of feedback on the infants' developmental progress and parent-infant interactions.

Procedure

As already mentioned, families were first approached at around the time of their infant's discharge from the hospital. Written informed consent was obtained from all adult participants, and the parents were asked to complete a socio-demographic questionnaire. In addition, the medical records of each child were analyzed by a project leader, a neonatologist, and a neonatal nurse in order to retrieve data on infants' gestational age at birth, birthweight, days of mechanical ventilation and hospitalization, number of neonatal skin-breaking procedures, and complications of prematurity (see section "Measures").

At 3 months CA, a home visit was scheduled for each family, at a time convenient for them. The appointments with the families were arranged by a research team member via a phone call, based on prior written consent from both parents. Mothers and fathers were asked to independently rate their infant's temperament and complete a screening tool for postnatal depression. Information on any changes in the infant's health status and family socio-economic status was updated. This phase of the project was completed no later than 4 months CA, mostly at 3 months and 15 days.

At 6 months CA families were invited to a baby lab at the Faculty of Psychology of the University of Warsaw and were asked to repeat completion of a postnatal depression screening tool. Apart from that, interviews with parents were also conducted with a focus on each infant's functioning across a range of typical domains (sleep patterns, feeding, arousal regulation, developmental milestones, and health, etc.). The second visit was supposed to be arranged no later than within 15 days from the time when infants were 6 months CA, and, in fact, the mean CA was 5 months and 29 days (SD = 12.00).

Measures

Socio-Demographic Questionnaire

Data on parental age, level of education (number of completed years of formal education), housing, financial situation, employment, and number of other children in the family were collected.

Data From Medical Records

The following data were extracted from the infants' medical records: birthweight, gestational age, small for gestational age (yes/no), number of days in hospital, number of days on mechanical ventilation, neurological complications (intraventricular hemorrhage/which grade, periventricular leukomalacia, and other), number of skin-breaking procedures during hospital stay, necrotizing enterocolitis (yes/no), retinopathy of prematurity (which grade), bronchopulmonary dysplasia (yes/no), and infection (yes/no), etc.

Infant Behavior Questionnaire–Revised

The Polish version of IBQ-R (Gartstein and Rothbart, 2003; Polish adaptation Dragan et al., 2011) is a 186-item parent – report measure of infant temperament based on Rothbart's approach. It can be used between the ages of 3 and 12 months, and measures 14 temperamental dimensions that load three major factors: Surgency/extraversion (comprising the scales of Approach, Vocal Reactivity, High Intensity Pleasure, Smiling and Laughter, Activity Level, and Perceptual Sensitivity), Negative affectivity (comprising the scales of Sadness, Distress to Limitations, Fear, and Falling Reactivity/Rate of Recovery from Distress), and Orienting/regulation (comprising the scales

of Low Intensity Pleasure, Cuddliness, Duration of Orienting, and Soothability). Each item is rated on a 7-point scale (from 1 – never to 7 – always), and parents are asked to report on behaviors observed during the last week. In addition, parents can choose "does not apply" option, and no numerical score is assigned to a given item in such a case. Scale scores are computed as the mean score of all scale items applicable to the child, as reported by the caregiver. Similarly, the score for each of the three major factors is represented by the mean score of the relevant scales. The internal consistency for the 14 temperamental dimensions was performed on a bigger sample of infants and turned out to be satisfactory, with Cronbach's alphas ranging from 0.73 to 0.89 for maternal ratings, and from 0.71 to 0.90 for paternal ones (Dragan et al., 2011).

Edinburgh Postnatal Depression Scale

The Edinburgh Postnatal Depression Scale (EPDS; Cox and Holden, 2003; Polish translation by Bielawska-Batorowicz) is a 10-item self-report measure for identifying the risk of postnatal depression in women, with each item rated on a 4-point scale from 0 to 3 and referring to the last 7 days. The higher the score, the higher the level of depressiveness. Although Brouwers et al. (2001) have confirmed that this measure contains a subscale of depression and a subscale of anxiety, they still recommend the use of a total score, as this seems to be a better measure of both anxiety symptoms and depressive symptoms than when subscales are used. The EPDS has also been widely used in research on fathers but with rather mixed results. Cut points of 9/10 and 12/13 have been suggested to identify a risk of minor vs. major depression. More recently, a cut-off value of 11 or higher has been found to maximize combined sensitivity and specificity (Levis et al., 2020). In the current study, we will use this measure as a continuous variable representing the level of a subject's depressiveness.

The Polish version of EPDS had high internal consistency for the assessments of mothers at 3 months CA, Cronbach's alpha = 0.88, and acceptable at 6 months CA, Cronbach's alpha = 0.78. The internal consistency for the assessment of fathers was also high at 3 months CA, Cronbach's alpha = 0.80, and lower than acceptable at 6 months, Cronbach's alpha = 0.67.

Statistical Analyses

First, we used a non-parametric test to compare mothers' and fathers' EPDS scores at 3 months CA. Second, we tested whether mothers' EPDS scores changed from 3 to 6 months CA. Third, we compared mothers' and fathers' ratings of infants' temperament at 3 months CA. Then, we performed correlation analysis to search for possible predictors of mothers' EPDS scores. In order to determine whether infants' perceived temperament at 3 months CA predicted mothers' EPDS scores at 6 months CA, controlling for mothers' EPDS scores at 3 months CA, we conducted a regression analysis. Due to the low internal consistency of EPDS at 6 months CA for fathers, analyses with those scores were not performed.

RESULTS

Mothers' and Fathers' Scores on the Edinburgh Postnatal Depression Scale and Infant Behavior Questionnaire–Revised

Table 2 presents descriptive statistics for EPDS and IBQ-R scores. Mothers scored significantly higher than fathers on the EPDS at 3 months CA, $U = 1344.00$, $z = -2.01$, $p = 0.044$. A related-samples Wilcoxon signed rank test revealed that there was a statistically significant difference between mothers' EPDS scores at 3 and 6 months postpartum, $T = 417.00$, $z = -2.49$, $p = 0.013$. Mothers' EPDS scores decreased between 3 and 6 months of children's CA.

There were no significant differences between mothers' and fathers' assessments of their infants' Negative affectivity or Surgency/extraversion; both ps > 0.05. Regarding Orienting/regulation, there was a trend approaching significance, suggesting higher scores of mothers than fathers, $U = 1314.00$, $z = -1.89$, $p = 0.059$.

Correlations Between Mothers' and Fathers' Edinburgh Postnatal Depression Scale and Infant Behavior Questionnaire–Revised Scores

Table 3 presents the results of correlation analyses for mothers' and fathers' depressive symptoms (EPDS scores) and their perceptions of their infants' temperament (IBQ-R scores). The correlations between mothers' and fathers' ratings of their infants' temperament were either non-significant or very weak. Mothers' ratings of their infants Negative affectivity and Orienting/regulations were correlated with their EPDS scores. There was no such association for fathers.

Notably, no statistically significant correlations were found between mothers' and fathers' EPDS scores at 3 months CA.

As the IBQ-R Negative affectivity and Orienting/regulation scores as assessed by mothers, and the mothers' EPDS scores at 6 months CA, were significantly correlated, we conducted

TABLE 2 | Mothers' and father's EPDS scores at 3 and 6 months CA and IBQ-R scores at 3 months CA: Descriptive statistics.

	Mdn	Min	Max	Q1	Q3
EPDS M 3 MCA	6.00	0.00	27.00	4.00	10.00
EPDS F 3 MCA	5.00	0.00	22.00	3.00	9.00
EPDS M 6 MCA	5.00	0.00	19.00	4.00	8.00
EPDS F 6 MCA	5.00	0.00	14.00	3.00	6.00
IBQ-R Surgency/extraversion M	3.90	1.99	5.54	3.47	4.39
IBQ-R Negative affectivity M	3.49	2.79	4.70	3.22	4.75
IBQ-R Orienting/regulation M	4.81	3.38	6.18	4.34	5.15
IBQ-R Surgency/extraversion F	3.84	2.48	5.49	3.36	4.28
IBQ-R Negative affectivity F	3.39	2.45	4.22	3.17	3.68
IBQ-R Orienting/regulation F	4.52	3.08	5.88	4.26	4.96

EPDS, Edinburgh Postnatal Depression Scale; MCA, months corrected age; M, mother, F, father; IBQ-R, Infant Behavior Questionnaire-Revised.

TABLE 3 | Correlations (τ_b) between mothers' and fathers' EPDS scores at 3 and 6 months corrected age and IBQ-R scores at 3 months corrected age.

	EPDS M 3 MCA	EPDS F 3 MCA	EPDS M 6 MCA	IBQ-R Surg/extr M	IBQ-R Neg aff M	IBQ-R Orient/reg M	IBQ-R Surg/extr F	IBQ-R Neg aff F
EPDS F 3 MCA	0.07							
EPDS M 6 MCA	**0.43****	0.10						
IBQ-R Surg/extr M	0.00	−0.03	−0.07					
IBQ-R Neg aff M	0.09	0.06	**0.19***	0.09				
IBQ-R Orient/reg M	−0.13	0.02	**−0.23***	**0.35****	−0.05			
IBQ-R Surg/extr F	0.01	−0.04	0.02	**0.24***	−0.07	0.05		
IBQ-R Neg aff F	**−0.20***	0.04	−0.13	−0.11	0.12	0.05	0.10	
IBQ-R Orient/reg F	0.02	−0.07	−0.11	**0.24****	−0.01	0.15	**0.40****	0.00

*EPDS, Edinburgh Postnatal Depression Scale; MCA, months corrected age; M, mother; F, father; IBQ-R, Infant Behavior Questionnaire-Revised; Surg/extr, surgency/extraversion; Neg aff, negative affectivity; Orient/reg, orienting/regulation. Bold text indicates a statistically significant correlation; *p < 0.05; **p < 0.001.*

TABLE 4 | Regression: maternal EPDS scores, infant negative affectivity, and infant Orienting/regulation at 3 months as predictors of EPDS scores at 6 months.

Model	Coefficients							
	B	B SE	Beta	*p*	95% CI for *B*		Collinearity statistics	
					LL	UL	Tolerance	VIF
(Constant)	2.76	0.68		0.000	1.39	4.12		
ESDP 3 m.	0.49	0.07	0.66	0.000	0.34	0.63	1.00	1.00
(Constant)	4.55	4.63		0.330	−4.73	18.83		
ESDP 3 m.	0.44	0.07	0.60	0.000	0.30	0.58	0.95	1.05
Neg aff 3 m.	1.77	0.93	0.18	0.063	−0.10	3.64	0.97	1.03
Orient/reg	−1.59	0.65	−0.23	0.018	−2.89	−0.28	0.97	1.03

EPDS, Edinburgh Postnatal Depression Scale; Neg aff, negative affectivity; Orient/reg, orienting/regulation; CI, confidence interval; LL = lower limit; UL = upper limit; VIF, variance inflation factor.

regression analyses with these two dimensions of infant temperament perceived by the mothers at 3 months CA as predictors of the mothers' depressive symptoms at 6 months CA.

Regression: Infant Temperament Predicting Depression Symptoms

We tested whether infants' Negative affectivity and Orienting/regulation at 3 months CA as perceived by the mother predicted mothers' depressive symptoms at 6 months CA, controlling for mothers' depressive symptoms at 3 months CA (see **Table 4**).

In the first step, we entered the control variable: mothers' scores on the EPDS when the infant was 3 months CA. These scores were significantly positively associated with EPDS scores at 6 months CA, and explained 44% of variance, $R^2 = 0.438$.

In the second step, we entered the IBQ-R Negative affectivity scores and the IBQ-R Orienting/regulation at 3 months CA. The relation between Negative affectivity at 3 months CA and EPDS scores at 6 months CA was not statistically significant, $p > 0.05$. The IBQ-R Orienting/regulation scores at 3 months CA were significantly positively associated with the EPDS scores at 6 months. Orienting/regulation scores at 3 months CA predicted lower EPDS scores at 6 months CA. The overall model was statistically significant and explained 53% of variance in EPDS scores at 6 months CA, $R^2 = 0.53$, $F(3, 54) = 19.87$, $p < 0.001$.

DISCUSSION

This study aimed to examine the associations between the levels of parental depressive symptoms and preterm infants' parents – reported temperament at 3 months, and the risk of maternal and paternal depression at 6 months postpartum. We found an association between self-reported depressive symptoms at 3 months and infant temperament assessment in mothers. Moreover, maternal depressiveness combined with the infant's temperamental characteristics assessed by mothers at 3 months turned out to be predictive of depressiveness scores at 6 months.

In line with the large body of research, we found higher levels of depressiveness in mothers compared to fathers at 3 months postpartum. It should be emphasized, however, that we have measured depressiveness which is not equivalent to identifying clinically significant depression. The EPDS is a screening tool, not a diagnostic one. Our participants represented a full range of scores with the mean far below the suggested cut point for the risk of major depression. Further studies are, therefore, needed on groups of preterm infants' parents with clinical diagnosis of mood disorders.

Moreover, contrary to the results of other authors (Neri et al., 2020; Thiel et al., 2020), we have not found a statistically significant correlation between maternal and paternal depressiveness scores. In addition, due to the low internal consistency of EPDS for the assessment of fathers at 6 months,

these results could not be used in the analyses. This, in turn, prevented us from checking correlations with maternal depressiveness scores at 6 months, and made a comparison of paternal levels of depressiveness at 3 and 6 months ineligible. Despite our problems with internal consistency of EPDS for fathers at 6 months CA, one of the reasons for this apparently surprising result of not finding correlations between maternal and paternal scores at 3 months CA might be the nature of EPDS as such. Further studies should address this issue with the item by item analysis of maternal and paternal scores on bigger samples. Although EPDS was validated as a measure of postpartum mood in men (Matthey et al., 2001), our results add to the growing literature which emphasizes the need for using gender-specific tools in screening for perinatal depression (Carlberg et al., 2018; Walsh et al., 2020; Yogman, 2021). More and more authors point to the specificity of paternal depression and paternal depressive symptoms, which are not included in EPDS, e.g., irritability, abnormal illness behaviors, heightened anxiety, or addictions (Kim and Swain, 2007; Baldoni and Giannotti, 2020; Walsh et al., 2020; Garfield et al., 2021). Using gender-specific tools could shed more light on the specificity of depressive symptoms in mothers and fathers of preterm infants.

The level of postpartum depressiveness in mothers in our sample was higher at 3 than at 6 months. This is in line with studies showing that the severity of maternal depressive symptoms decreases over time (Miles et al., 2007; Pace et al., 2016; Garfield et al., 2021). However, it is noteworthy that despite the fact that the risk of depression tends to decline over time in the majority of women, about 30% of mothers affected by postpartum depression remain depressive throughout the first year of the child's life and beyond (Vliegen et al., 2014). The percentage of mothers who meet the criteria of depression many months after delivery turned out to be even higher in women with depression in life history. The risk for depression has been proven to be higher in mothers of preterm infants compared to mothers of full-term infants not only shortly after delivery but also throughout the following months (Vigod et al., 2010; Neri et al., 2020). Moreover, although the directions of these associations are complex, researchers point to the links between preterm infants mothers' postpartum depression and the chronicity of maternal mental health problems (Miles et al., 2007; Pace et al., 2016), paternal depression (Carlberg et al., 2018; Neri et al., 2020), and less than optimal child developmental outcomes (Cheng et al., 2016; Narayanan and Nærde, 2016). For this reason, investigating factors predictive of the persistence of maternal depressiveness is of crucial importance for clinical practice and early intervention addressed to families of preterm infants. Further studies are needed to disentangle possible links between trajectories of maternal and paternal depressiveness and all the different factors related to the severity of infant's prematurity and the comorbid medical complications.

We did not find any significant differences in infants' temperamental characteristics obtained from mothers and fathers. This result is in line with studies showing similarities between maternal and paternal assessments of infant's temperament (Sechi et al., 2020; Vismara et al., 2021). The reliability of parental perceptions may indicate that regardless of the specificity of and possible differences in experiences mothers and fathers shared with their infants, the parental assessments of the infant's temperament were related to the child's actual behaviors. On the other hand, the correlations between maternal and paternal assessments of infants' temperament were rather weak in our study, quite contrary to previous research findings (Dragan et al., 2011). This may point to a presumably complex nature of parental perceptions of preterm infants' temperament, and calls for including observational or at least independent measures of temperament when assessing this at-risk group.

According to our results, Orienting/regulation, but not Negative affectivity, as assessed at 3 months predicted maternal depressiveness at 6 months, which means that our hypothesis as to the links between maternal perceptions of infant temperament and self-reported depressiveness has only partly been supported. In accordance with our hypothesis, heightened scores in EPDS, combined with assessing the child as low on Orienting/regulation at 3 months, turned out to be predictive of mothers' depressiveness at 6 months. At the same time, we haven't found any support for Negative affectivity, as assessed at 3 months, to be a predictor of maternal depressiveness at 6 months. This is quite in contrast to the results obtained by Sechi et al. (2020) for parents of full-term infants, where maternal depression and anxiety symptoms were positively correlated with Negative affectivity, but not with Orienting/regulation, at 3 and 12 months.

Our results point to behaviors that may be particularly significant for mothers of preterm infants in the context of postpartum depression. Data on early preterm infants' temperament indicate that in the first weeks and months of life, preterm infants may be less rhythmic, more difficult to soothe, more withdrawn, and spend less time in alert states, which may hinder rewarding experiences in early parent-infant interaction (Eckerman et al., 1995; Hughes et al., 2002). The Feldman and Eidelman (2007) confirmed a slower maturation of preterm infants' autonomic nervous system and decreased capability to maintain alert states. The authors described the double interactional risk linked to the attention regulation in preterm infants as lower infants' interactional availability and compromised maternal ability to coordinate their interactional behaviors with the fragile infant. Maternal depressiveness turned out to be associated with both mothers' interactional behaviors and infants' vagal tone. These results may show that preterm birth, maternal depressiveness, and mothers' as well as infants' interactional behaviors constitute a multitude of factors that put preterm children and their parents at risk.

Our results add to this knowledge and confirm the complexity of the mechanisms underlying early mood problems in parents of preterm infants. They contribute to the literature on risk mechanisms of postpartum depression in parents of preterm infants by linking parental mood with the temperamental profile of preterm infants. They also show possible links between preterm infant temperament and the chronicity of postpartum depressiveness. Our results further suggest that special clinical attention should be given during screening to those mothers of preterm infants whose depressiveness at 3 months co-occurs

with perceiving the infant as difficult to soothe, showing little enjoyment at being held in the arms of the adult, and having problems with maintaining alert states or attending to/interacting with people and objects for extended time.

There are studies that indicate early interventions focused on parental perception of the preterm infant's behaviors, as well as on sensitive caregiving, are effective in supporting parental assessment of a child's emotionality and soothability (Landsem et al., 2020). Offering early support to mothers who perceive their infants as temperamentally challenging, and whose rates of depressiveness are elevated, might prevent them from further mood problems.

We did not find a significant relationship between paternal depressiveness and child temperament assessment at 3 months CA. This is in contrast with studies in which paternal depression was related to child temperamental characteristics (Hanington et al., 2010). In research using Rothbart's approach to temperament, depression symptoms in fathers were found to be significantly related to the assessment of distress (Ramchandani et al., 2011) and negative affectivity (Sechi et al., 2020) in 3-month-old infants. Those studies, however, were conducted on the group of full-term infants' fathers. Far less is known about the links between depressive symptoms and infant temperament assessment in fathers of preterm infants. Due to the low internal consistency of EPDS for fathers, we could not verify our hypotheses referring to the links between paternal depressiveness at 3 and 6 months, and child temperamental assessment. This remains a direction for future studies. However, as we found similarities between maternal and paternal perceptions of a child's temperament and the temperamental assessment correlated with the severity of depressive symptoms in mothers, we hypothesize that interaction between parent-specific caregiving and child's temperamental characteristics may be related to the risk for postpartum depression. This hypothesis requires further investigation.

Future studies should also address a contribution of child gender to parental perceptions of preterm infants' temperament, which we haven't analyzed as this is outside of the scope of the present study. Research with full-term children points to an infant's gender as a significant predictor of parental assessment of their temperamental characteristics (Else-Quest et al., 2006; Sechi et al., 2020). Far less is known in this respect about preterm infants. In the study by Pesonen et al. (2006), infant perinatal status turned out to be significant for parental assessments of a child's temperament regardless of the birth term. The child's gender did not differentiate parental perceptions either. One might hypothesize that perinatal status, which has a strong impact on early infant and parent experiences, may have more impact on the maternal and paternal assessment of infant behavior and temperament than a child's gender *per se*. This hypothesis may be a direction for future studies.

Another promising direction for further research is the analysis of possible links between the severity and complications of prematurity, and maternal/paternal perceptions of infant temperament and parental mental health. This is especially relevant in light of recent findings on early programming of preterm infants' temperament, via gene methylation processes, due to neonatal exposure to pain and stress related to medical procedures and treatment in the Neonatal Intensive Care Unit (NICU) (Cassiano et al., 2016; Montirosso et al., 2016). Furthermore, interconnections between the severity of preterm infant medical conditions and parental mental health have already been established (Agostini et al., 2014; Carson et al., 2015; Neri et al., 2020). Neonatal data that we have collected and included in our sample characteristics clearly point to the numerous challenges that the infants under study were exposed to, not to mention an additional emotional burden for the parents. A question arises as to the possible role of infants' medical conditions in explaining the links between infant temperament and mothers' and fathers' depressiveness. Future studies should make an attempt at disentangling this important issue.

LIMITATIONS

Finally, several limitations of our study should be addressed. First of all, the size of our sample was rather small, with numerous implications for data analysis and the results. For example, with smaller samples the assumption of variables' distribution normality is often violated, preventing the use of more powerful statistical tests. In addition, a small sample size hinders the inclusion of more variables in the regression analysis, thus limiting the possibilities for testing different, more complex models of relationships among the variables. Furthermore, our sample was characterized by relatively high rates of parents with higher education and medium to high socio-economic status. Hence, the results cannot be generalized to samples with lower SES and education. Apart from that, the study design required the active participation of both parents, which is not a limitation in itself but does narrow the possibilities of extending our results to single-parent families or families with less involved fathers. Although this was outside of our study's scope, a lack of the inclusion of infants' medical conditions in the analyses can certainly be treated as a limitation in generalizing the results. Another limitation is the choice of EPDS as a measure of depressiveness in the case of fathers. As already mentioned, this screening tool, although widely used in other studies with fathers as participants, may not be well suited for discerning specific features of depressive symptoms that are characteristic for men, such as acting out, aggression, psychosomatic complaints, etc. This should be a focus of attention in future studies, with a possible choice of screenings specifically addressed to fathers (Baldoni and Giannotti, 2020), or the additional inclusion of other measures of depressive symptoms such as Center for Epidemiologic Studies Depression Scale (CES-D) or Patient Health Questionnaire-9 (PHQ-9). Furthermore, no information on the levels of depressiveness before childbirth was included in our study, not to mention the history of parental mental health in general. Last but not least, detailed information on the participants' current use of psychotherapy, parental support groups, and other sources of emotional support should have been included.

CONCLUSION AND IMPLICATIONS

Our study points to the importance of taking into account maternal mood along with perceptions of preterm infants' temperament as early as at the age of 3 months CA in the analysis of mothers' level of depressiveness later in the first year of the child's life. Complex, transactional relationships between an infant's temperament as assessed by the parents and parental mental health in the face of prematurity can be postulated and require further investigation. With bigger, multi-site cohorts of preterm infants and their parents and the newest statistical methods, longer-term trajectories of the interplay between the intensity of depressive symptoms and parental perceptions of child reactivity and self-regulation can and should be studied. Further studies should also assume a more fine-grained approach to temperament and, with bigger samples, assess more detailed temperamental profiles of preterm infants on all 14 lower-order dimensions, with closer attention to the severity of prematurity.

In terms of methodology, our results raise a concern regarding the use of the EPDS for measuring depressiveness in fathers of preterm infants. Thus, we add to the already existing call for more gender-sensitive screening tools for the risk of depression.

From a practical, clinical point of view, the associations we have found between infant temperament and maternal depressiveness may be of particular importance for designing assessment, prevention, and intervention measures specifically addressed to parents of prematurely born children. Considering the additional risks to child development and family well-being impinged by compromised parental mental health, psychological support for mothers and fathers of preterm infants should be offered far beyond an infant's stay in the NICU.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion 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 Research Ethics Committee of the Faculty of Psychology, University of Warsaw. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

GK, EK, and AN: study concept, design, data collection, data analysis, writing the manuscript, critical review, and approved the submitted version.

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Postpartum Depressive Symptoms and Their Selected Psychological Predictors in Breast-, Mixed and Formula-Feeding Mothers

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Background: Although breastfeeding is recommended by WHO and professionals as the most beneficial for newborn babies, many women find it challenging. Previous research yielded ambiguous results concerning the role of breastfeeding in the development of postpartum depression. The study aimed to identify the best predictors of depressive symptoms for each of these feeding method.

Methods: The participants were 151 women (mean age 29.4 yrs; SD = 4.5) who gave birth within the last 6 months and included 82 women classified as breastfeeding, 38 classified as mixed-feeding (breast and bottle), and 31 as formula-feeding. The study had a cross-sectional design using a web-based survey for data collection. The following measures were administered: The Edinburgh Postnatal Depression Scale; Sense of Stress Questionnaire; The Postpartum Bonding Questionnaire; Parenting Sense of Competence Scale; Infant Feeding Questionnaire.

Results: Women in study groups differed in stress, bonding difficulties, and beliefs related to feeding practices and infancy. There were no significant differences in the severity of depressive symptoms, but all mean EPDS scores were above 12. Maternal satisfaction, intrapsychic stress, and concerns about feeding on a schedule were the best predictors of EPDS scores for breastfeeding women. For mixed-feeding – emotional tension, concern about infant's hunger, overeating, and awareness of infant's hunger and satiety cues; while for the formula-feeding group, predictors included emotional tension, bonding difficulties, and such maternal feeding practices and beliefs as concern about undereating, awareness of infant's hunger and satiety cues, concerns about feeding on a schedule and social interaction with the infant during feeding.

Conclusion: Differences in predictors of postpartum depression for study groups suggest that breastfeeding itself may not be a risk for postpartum depression. However, the specificity of maternal experiences with the various types of feeding is related to difficulties promoting postpartum depression. Providing emotional and educational support appropriate for different types of feeding may be an essential protective factor for postnatal depression.

Keywords: postpartum depression, feeding methods, feeding beliefs, feeding behaviors, maternal competencies, stress, mother-child bonding disorders

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INTRODUCTION

Breastfeeding is strongly advised for at least the first 6 months of a child's life. It is advocated for its benefits for infants' health and emotional development (1). Breastfeeding is also considered the main maternal task, and women are expected to choose it and continue as long as possible. A variety of strategies used to promote breastfeeding include those concentrated on the benefits of such a feeding method and those focused on the risk of formula feeding (2). Initiation of breastfeeding usually takes place in postnatal wards. In this process, the support from medical staff plays an important role (3). Despite benefits for children, breastfeeding is also analyzed in the context of its effects for mothers, especially the risk of postpartum depression.

Postpartum depression (PPD) is considered a public health issue. It might affect as many as 9.6% of new mothers in high-income and 19.6% in low-income countries (4). Among factors associated with PPD, breastfeeding is often considered. However, its role either as a risk or as a protective factor is debated. Earlier studies indicated that exclusive breastfeeding increased the risk of PPD (5, 6) and that postpartum depression was more common among breastfeeding mothers (7). Such a view was not universal, as findings from other studies indicated the opposite – there were more cases of PPD among bottle-feeding mothers (8). More recent studies examining the effect of breastfeeding on PPD revealed a different pattern. According to Toledo et al. (9) and Gila-Diaz et al. (10), women who currently breastfed their infants or breastfed them for a more extended time expressed significantly lower PPD risk. In line with this finding are the results from the study by Islam et al. (11) that have pointed to the role of early cessation of exclusive breastfeeding for the increased risk of PPD. The mixed-feeding method might also be related to increased depression symptoms postpartum (12, 13). However, such results are not universal, as Fukui et al. (14) have found that breastfeeding did not affect PPD. The lack of clear breastfeeding – PPD link was also confirmed in the systematic review and meta-analysis conducted by Woldeyohannes et al. (15).

The relationship between breastfeeding and postpartum depression seems well documented, although the type of such association – whether breastfeeding decreases or increases the PPD risk – is still debated. The inclusion of additional factors might help in such a debate. One of such factors that might moderate the association of PPD and infant feeding is maternal breastfeeding self-efficacy. Its low level was associated with higher PPD scores in studies by Zubaran and Foresti (16) and Kossakowska (17). Another factor was maternal positive breastfeeding attitude associated with lower depressive symptoms at 6 months postpartum (18). Yet another factor was the satisfaction with breastfeeding – it was higher in women without PPD symptoms (19). Thus the relationship between breastfeeding and postpartum depression was analyzed in the context of various aspects of breastfeeding (i.e. duration, self-efficacy, positive/negative experiences, or attitudes toward breastfeeding) rather than in the context of the type of feeding itself. It is unclear whether the same factors are related to PPD symptoms for mothers who apply either of three feeding methods: breastfeeding, mixed, or formula feeding. Our study aimed to clarify whether mothers were at similar risk of postpartum depressive symptoms for each of these feeding methods. As the benefits of breastfeeding for maternal bonding were advocated for, we aimed to verify whether the mother-child bond developed differently in either of three feeding methods and whether PPD was similarly connected to maternal feeding beliefs, maternal self-esteem, and stress. Thus we aimed to identify the best predictors of depressive symptoms for each of these feeding methods.

MATERIALS AND METHODS

Study Design

This descriptive web-based cross-sectional study was conducted to identify predictors of postpartum depression for different feeding methods.

Ethical Consideration

The research procedure was performed in accordance with the Helsinki Declaration of Human Rights (20). The study was approved by the university advisory board. As the study was of an informative cross-sectional purely descriptive nature, no formal ethical approval was required under the country's legislation. Participants were informed of the purpose, risks, and benefits of the survey. They were told they could withdraw from the study at any time and for any reason and provided electronic informed consent. Such consent form was prepared following the Ethics Guidelines for Internet Mediated Research (21).

Inclusion Criteria

The following inclusion criteria were applied: at least 19 years of age at the time of admission to the study, giving birth to a healthy child within the last 6 months[1], no past or current clinical diagnosis of any psychiatric disease, including depression. As our study aimed to identify risk factors for postpartum depression depending on whether women are exclusively breastfeeding, mixed or formula milk only, the classification criteria for each of these groups were based on the WHO-recommended definitions. Exclusive breastfeeding was defined as infants being fed with breast milk only, without any additional food or drink, not even water (allowable exceptions were expressed breast milk, oral rehydration solutions, and drops or syrups of vitamins and minerals and medicines) (22). Mixed-feeding (MF) suggested that infants were fed breast milk with formula or complementary food. Formula-feeding (FF) was defined as infants being fed with any formula (23).

Procedure and Data Collection

The presented data were collected from July 2017 to March 2018. Women were recruited through social media (such as Facebook and Instagram) advertisements, information distributed at birth classes or pediatric clinics, and snowball sampling of participants' friends and relatives. Women interested in participating in the

[1]This criterion was set for the purpose of ensuring that mixed feeding or the formula feeding was not related to the introduction of complementary foods after 6 months. According to the WHO guidelines (1), up to the age of 6 months, the infant should be fed only with mother's milk.

study first contacted the researcher by e-mail (the e-mail address was given in the recruitment advertisement). They had to agree to participate by signing an electronic informed consent form. After that, they received a personalized link to the web-based survey.

Initially, a total of 187 mothers were interested in participating in the study. Of these, 31 were rejected at the recruitment stage due to failure to meet the inclusion criteria (i.e. more than 6 months from childbirth, younger than 19 years of age). Of the remaining 156 volunteers, five women did not fully complete questionnaires. Finally, results from 151 mothers (BF: $n = 82$; MF: $n = 38$; FF: $n = 31$) who met the eligibility criteria were included in the analyses.

Measures

Sociodemographic and Perinatal Questionnaire

Sociodemographic and perinatal characteristics included maternal age, level of education, financial status, relationship status, personal health history, number of weeks from childbirth, course of pregnancy, childbirth, and feeding experiences.

Postpartum Depression Symptoms

The Edinburgh Postnatal Depression Scale (EPDS) (24) assessed depressive symptoms among participants. EPDS is a well-validated 10-item self-report scale constructed to measure the intensity of depressive symptoms within the last seven days. Each item is rated on a 4-point scale ranging from 0 to 3. The higher scores indicate greater symptom severity (the Authors recommend a 12/13 cut-off point). Original research reports good internal consistency (24) – Cronbach's alpha = 0.87, which was confirmed in the validation study of the Polish version of EPDS (Cronbach's alpha = 0.91) (25). In the present sample, Cronbach's alpha was 0.83.

Stress Level

Sense of Stress Questionnaire (KPS – Kwestionariusz Postrzeganego Stresu) (26) measured the experienced stress. The questionnaire allows assessing total stress level and its three dimensions: emotional tension, external stress, and intrapsychic stress. KPS is a 27-items self-report measure. Each item is rated on a 5-point scale ranging from 1 (false) to 5 (true). The authors of the questionnaire reported high internal consistency for all scales, ranging from 0.70 to 0.81. In our sample, Cronbach's alpha value for total scores was 0.93.

Mother-Child Bond

The Postpartum Bonding Questionnaire (PBQ) (27) was used to assess the bond between mother and baby. The PBQ is a 25-item self-report instrument. In our study, we used the pre-validated Polish language version of the questionnaire (Bieleninik, unpublished materials). Each item of PBQ is rated on a 6-point scale ranging from 0 to 5. It consists of four subscales: impaired bonding (scale 1), rejection and anger (scale 2), anxiety about care (scale 3), and risk of abuse (scale 4). The total scores can also be calculated, and higher scores suggest poorer bonding. Reliability of PBQ in validation study was satisfactory - Cronbach's alpha for total scores was 0.80 (28, 29) and 0.92 in the current sample. In the present study, the risk of abuse scale results was not analyzed because it is a factor with only two items and the Cronbach's alpha was below the recommended value of 0.70.

Maternal Self-esteem

Parenting Sense of Competence Scale (PSOC) (30, 31) in Polish validated version (32) was used to examine maternal self-esteem on two dimensions – satisfaction and efficacy. PSOC is a self-report scale with 16 items assessed on a 6-point scale (ranging from 1 – strongly agree to 6 – strongly disagree). The satisfaction subscale refers to mothers' anxiety, motivation, and frustration, while the efficacy subscale assesses competence, problem-solving ability, and capability in the maternal role. Higher scores suggest higher competencies. The internal consistency of PSOC is satisfactory. The Cronbach's alpha coefficients for the total score were 0.79 in the original and 0.78 in the current study.

Maternal Feeding Behaviors and Beliefs

Infant Feeding Questionnaire (IFQ) (32) was used to identify maternal feeding practices and beliefs during infancy. IFQ is a 28-item self-report instrument. Items are rated on a 5-point scale, from 0 (never/disagree a lot) to 4 (always/agree a lot). In case of some statements (e.g. "I believed it was important for him to finish all of the formulae in his bottle,") "not applicable" response was added to make IFQ suitable for exclusively breastfeeding mothers. The questionnaire allows to assess maternal feeding behaviors/practices and beliefs on seven dimensions: concern about infant undereating or becoming underweight (factor 1), concern about infant's hunger (factor 2), awareness of infant's hunger and satiety cues (factor 3), concern about infant overeating or becoming overweight (factor 4), feeding infant on a schedule (factor 5), using food to calm infant's fussiness (factor 6), social interaction with the infant during feeding (factor 7). Original development and validation study revealed internal consistency for seven factors from 0.24 to 0.74 (32). Internal consistency on all seven scales in our sample was slightly higher than reported in the original validation study and ranged from 0.41 to 0.74. IFQ was designed to identify maternal feeding behaviors and beliefs during the first 12 months of their children's lives related to children becoming overweight in the second year of life. In the current study, the questionnaire was used to compare feeding attitudes in different feeding type mothers and to assess their predictive role for the occurrence of symptoms of postpartum depression.

Data Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25.0 for Windows. Demographic characteristics were summarized as the mean (standard deviation, SD) for continuous variables and frequency counts (percentages) for categorical variables. The chi-square test was then used to estimate the significance of differences between mothers with different feeding practices. The Shapiro-Wilk test was used to check the normality of distributions for all analyzed variables. Due to the lack of normality of the distribution, the non-parametric Kruskal-Wallis test (with the Dunn's pairwise tests adjusted by the Bonferroni correction) was applied to compare more than two independent groups. Spearman's

correlation coefficient was used to assess a possible association between all continuous variables. Finally, the multivariate linear regression with a backward-elimination approach was used to estimate the predictors of postpartum depression for each type of feeding. For each regression model presented, the VIF (Variance Inflation Factor) value and its tolerance to detect multicollinearity in the regression analysis were determined. A VIF of 1 indicates no predictors of collinearity. The higher the value of VIF, the more significant the correlation of the outcome variable with other variables. According to the recommendation of Vittinghoff et al. (33), it was assumed that the VIF of 10 and more is regarded as very high, indicating strong collinearity of the predictors. In this case, the analyzed model should be corrected. Less liberal assumptions indicate that a VIF value> 5 means moderate multicollinearity (34), which is a cause for concern. The VIF values for the EBF and MF mothers regression models were not greater than 5 (from 1.014 to 1.020 for EBF and 1.014 to 1.246 for the MF group). In the FF group, the VIF value for impaired bonding was 6.858, indicating moderate collinearity based on more restrictive criteria. Therefore, the value of the tolerance coefficient for VIF was checked, which, according to Hair et al. (35), indicates a problem with multicollinearity when it is less than 0.2. In the current study, the tolerance for VIF in each regression model was more than 0.2. Therefore, the impaired bonding predictor was left in the regression model for the FF group. The level of statistical significance for the study was set at $p < 0.05$.

RESULTS

Study Sample Characteristics

One hundred and fifty-one women aged 19 to 41 years (M = 29.4; SD = 4.5) who gave birth within the last 6 months participated in this study. Infants aged between 2 and 24 weeks (M = 17.5; SD = 5.5). Eighty-two women were classified as exclusively breastfeeding (EBF group), 38 were classified as mixed-feeding (breast and bottle) (MF group), and 31 as fully formula-feeding (FF group). According to the Kruskal-Wallis test, there were no differences between feeding groups in terms of women's age ($H_{(2)} = 0.134$; p = 0.935) as well as infants' age ($H_{(2)} = 0.678$; p = 0.935). In the sample, most women were primiparous (59.6%), without previous miscarriages (76.2%), planned pregnancy (78.8%), without complication (74.8%). Most of the participants had skin-to-skin contact with their baby soon after delivery (78.1%), and most women planned to breastfeed before childbirth (90.7%). Chi-square tests indicated a significant difference between the feeding method groups only for the infant's gender (?22,151 = 8.533; $p < 0.05$). In the EBF group, male infants predominated (67.1%), while in the MF and FF group, there were more female infants (55.3 and 58.1%, respectively). Detailed demographical and obstetrics characteristic of the feeding sub-samples is presented in **Table 1**.

Postpartum Depression Symptoms

The mean EPDS scores were 13.4 (SD = 4.2), 12.6 (SD = 4.1), 14.6 (SD = 5.4) for EBF, MF, and FF groups, respectively. There were no significant differences in the severity of postpartum depression symptoms between groups ($H_{(2)} = 1.656$; p = 0.437), but all mean EPDS scores were above 12 cut-off points. The range of EPDS scores for each group is shown in **Figure 1**.

Stress Level, Parental Competencies, and Bonding

The scores for three groups of mothers calculated for the Sense of Stress Questionnaire (KPS), Postpartum Bonding Questionnaire (PBQ), Parenting Sense of Competence Scale (PSOC) as well as Infant Feeding Questionnaire (IFQ) are given in **Table 2**.

A Kruskal-Wallis test indicated differences between the mean ranks of Impaired bonding ($H_{(2)} = 9.272$; p = 0.010), rejection and anger ($H_{(2)} = 15.116$; p = 0.001) and total bonding difficulties scores ($H_{(2)} = 11.033$; p = 0.004) across the groups. Thus, Dunn's pairwise tests were carried out, and the evidence was found for differences between the EBF and FF groups on impaired bonding, rejection, and anger and on the total score ($p < 0.01$, $p < 0.001$, and $p < 0.01$, respectively; with the Bonferroni correction). The median of Impaired bonding scores for EBF mothers was 68.85 compared to 96.77 in the FF mothers. The median of rejection and anger scores for EBF mothers was 65.12 compared to 100.35 in the FF mothers. And the median of total bonding difficulties scores for EBF mothers was 67.72 compared to 98.32 in the FF mothers. There was no evidence for a difference between the other groups and Anxiety about care scores ($H_{(2)} = 5.265$; $p = 0.072$).

Similarly, the use of the Kruskal-Wallis test to compare the three dimensions of stress and overall stress level by feeding method showed that there is a difference between the mean ranks of the emotional tension ($H_{(2)} = 7.201$; $p = 0.027$), intrapsychic stress ($H_{(2)} = 7.063$; $p = 0.029$) and total level of stress across the study groups ($H_{(2)} = 6.963$; $p = 0.031$). According to Dunn's pairwise tests, this difference exists between the EBF and FF groups in emotional tension ($p < 0.05$), intrapsychic stress ($p < 0.05$) and total stress level ($p < 0.05$).

The median score of emotional tension for EBF mothers was 68.69 compared to 93.27 for FF mothers. The median score of intrapsychic stress for EBF mothers was 70.55 compared to 94.50 for FF mothers. Finally, the overall stress level median score for EBF mothers was 69.44 compared to 93.76 for FF mothers. There was no evidence for a difference between the other groups and External stress ($H_{(2)} = 3.407$; $p = 0.182$).

There were no differences in maternal efficacy ($H_{(2)} = 5.096$; $p = 0.078$), maternal satisfaction ($H_{(2)} = 5.658$; $p = 0.059$), and overall competences ($H_{(2)} = 5.048$; $p = 0.080$) measured by PSOC among the study groups.

Feeding Beliefs

According to data presented in **Table 2** women differed in their beliefs related to feeding practices at infancy, but only in case of concern about infant overeating ($H_{(2)} = 14.895$; $p < 0.01$) and feeding infant on a schedule ($H_{(2)} = 26.076$; $p < 0.001$).

For the concern about infant overeating, the differences were found according to Dunn's pairwise tests between EBF and MF groups ($p < 0.05$) and between FF and MF groups ($p < 0.001$). The median of concern about overeating for the MF mothers was the lowest (Mdn = 56.75) in comparison to EBF (Mdn =

TABLE 1 | Characteristic of the study sample by the type of feeding.

	EBF $n = 82$		MF $n = 38$		FF $n = 31$		χ^2 (df)	*p* value
	N	%	*N*	%	*N*	%		
Place of residence							6.900 (4)	0.141
City over 500,000 residents	51	62.2	20	52.6	25	80.6		
City below 500,000 residents	18	22.0	10	26.3	5	16.1		
Countryside	13	15.9	8	21.1	1	3.2		
Education							2.247 (2)	0.325
Higher education	64	78.0	29	76.3	20	64.5		
Marital status							0.281 (2)	0.869
Married	67	81.7	30	78.9	26	83.9		
Assessment of the financial situation							0.670 (2)	0.175
Good/very good	77	93.9	35	92.1	30	96.8		
The number of pregnancies							3.040 (4)	0.551
First	46	56.1	22	57.9	22	71.0		
Second	26	31.7	12	31.6	5	16.1		
Third and more	10	12.2	4	10.5	4	12.9		
Was the pregnancy planned							1.084 (2)	0.582
Yes	65	79.3	28	73.7	26	83.9		
Infant's gender							**8.533 (2)**	**0.014***
Male	55	67.1	17	44.7	13	41.9		
Previous miscarriages							1.048 (2)	0.592
No	65	79.3	27	71.1	23	74.2		
Complications in the last pregnancy							0.446 (2)	0.800
No	63	76.8	28	73.7	22	71.0		
Complications of the last childbirth							2.494 (2)	0.287
No	63	76.8	25	65.8	20	64.5		
Delivery mode							0.560 (2)	0.756
Natural childbirth	45	54.9	20	52.6	19	61.3		
Feeding plan planned before the baby was born							3.387 (4)	0.495
EBF	77	93.9	32	84.2	28	90.3		
MF	3	3.7	3	7.9	1	3.2		
FF	2	2.4	3	7.9	2	6.5		
Skin-to-skin contact immediately after delivery							2.588 (2)	0.274
Yes	67	81.7	30	78.9	21	67.7		

*EBF, exclusively breastfeeding; MF, mixed-feeding (both breast and bottle); FF, formula-feeding. *indicate $p < 0.05$.*

77.96) and FF mothers (Mdn = 99.68). There were no differences between breastfeeding and formula-feeding mothers.

For the Feeding infant on a schedule, Dunn's pairwise tests indicated the differences between FF and EBF ($p < 0.001$), as well as FF and MF groups ($p < 0.01$). The median of Feeding infant on a schedule for the FF mothers was the highest (Mdn = 106.47) in comparison to MF (Mdn = 72.91) and EBF mothers (Mdn = 65.91). There were no differences between breastfeeding and mixed-feeding mothers.

There were also no significant differences in other feeding beliefs such as concern about infant undereating or becoming underweight ($H_{(2)} = 2.563$; $p = 0.278$), concern about infant's hunger ($H_{(2)} = 2.645$; $p = 0.266$), awareness of infant's hunger and satiety cues ($H_{(2)} = 2.147$; $p = 0.342$), using feeding to calm infant's fussiness ($H_{(2)} = 4.949$; $p = 0.084$), and social interaction with the infant during feeding ($H_{(2)} = 1.919$; $p = 0.383$).

Predictors of Postpartum Depression Among EBF, MF, and FF Groups

The multiple linear regression analysis was used to determine predictors of postpartum depression for each infant feeding method group. Before it was performed, Spearman's correlation analyses were conducted in the total sample to determine the relations between the variables considered for inclusion in regression analysis. **Table 3** shows the relationships between the EPDS and the total scores and scores for each dimension of measured variables.

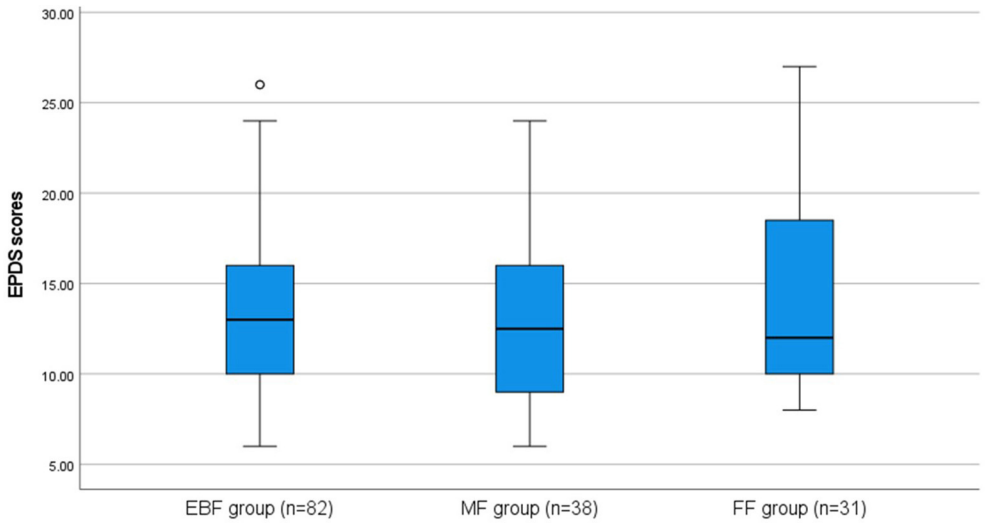

FIGURE 1 | Range, means, and SD of EPDS scores by the feeding method.

TABLE 2 | Descriptive statistics for psychological variables analyzed in the study according to the feeding method.

	EBF $n = 82$			MF $n = 38$			FF $n = 31$		
	M (SD)	**Skewness**	**Kurtosis**	**M (SD)**	**Skewness**	**Kurtosis**	**M (SD)**	**Skewness**	**Kurtosis**
Maternal Self-efficacy (PSOC)	33.3 (4.2)	−0.14	−0.82	35.3 (3.5)	−0.29	−0.29	33.6 (4.6)	−0.09	−0.86
Maternal satisfaction (PSOC)	30.5 (4.8)	−0.21	−0.43	30.4 (4.8)	0.15	0.15	28.4 (5.2)	0.28	1.04
Maternal competence (PSOC total)	63.9 (7.1)	−0.03	−0.06	65.8 (6.8)	0.08	0.08	62.0 (7.2)	0.71	−0.31
Emotional tension (KPS)	19.3 (6.8)	0.11	−0.73	20.8 (7.8)	0.06	−1.06	23.5 (8.1)	−0.57	−0.57
External stress (KPS	18.5 (5.1.)	0.39	−0.78	19.1 (6.0)	0.30	−1.08	20.7 (5.5)	0.14	−0.99
Intrapsychic stress (KPS)	15.4 (5.9)	0.69	−0.16	15.8 (6.6)	0.33	−1.32	19.6 (7.9)	0.41	−0.65
Stress level (KPS total)	53.2 (15.9)	0.37	−0.73	55.8 (19.4)	0.24	−1.21	63.9 (19.6)	−0.02	−0.74
Impaired bonding (PBQ)	10.8 (3.7)	0.35	−0.63	12.4 (6.6)	1.67	3.73	14.9 (7.9)	1.51	2.87
Rejection and anger (PBQ)	3.3 (2.6)	0.65	−0.32	5.1 (4.8)	1.27	1.57	7.7 (6.3)	1.19	1.00
Anxiety about care (PBQ)	6.3 (2.9)	1.17	2.12	6.3 (2.8)	0.78	0.60	7.0 (2.6)	0.71	1.15
Bonding difficulties (PBQ total)	29.9 (6.7)	0.35	−0.53	33.2 (12.4)	1.58	2.74	39.2 (14.9)	1.34	2.23
Concern about infant undereating (IFQ)	8.0 (2.4)	0.35	−0.79	8.1 (2.7)	0.23	−0.54	8.9 (2.9)	−0.36	−1.22
Concern about infant's hunger (IFQ)	5.4 (3.8)	1.55	0.98	4.7 (2.6)	1.51	1.56	5.3 (2.6)	1.29	1.25
Awareness of infant's hunger and satiety cues (IFQ)	6.3 (1.9)	0.43	−0.84	5.9 (1.7)	0.35	−1.29	6.7 (2.2)	0.34	−1.10
Concern about infant overeating (IFQ)	4.5 (1.7)	1.03	0.11	3.6 (1.1)	3.09	1.24	5.1 (1.7)	−0.05	−1.47
Feeding infant on a schedule (IFQ)	6.2 (0.9)	−0.04	4.35	6.5 (0.9)	2.27	5.03	7.3 (1.1)	−0.20	−0.86
Using food to calm infant's fussiness (IFQ)	5.5 (1.2)	−0.69	0.65	5.5 (1.2)	−0.11	0.26	4.8 (1.5)	−0.72	−1.01
Social interaction with the infant during feeding (IFQ)	7.9 (2.0)	−0.90	0.04	7.6 (2.0)	−0.35	−1.18	7.5 (1.8)	−0.85	1.35

EBF, exclusively breastfeeding; MF, mixed-feeding (both breast and bottle); FF, formula-feeding.

For the postpartum depression (EPDS scores), the strongest relationships were found between EPDS and maternal satisfaction ($rho = -0.50$; $p < 0.01$), and between EPDS and overall level of maternal competences ($rho = -0.48$; $p < 0.01$). As both correlation coefficients are negative, they indicate that a lower level of maternal satisfaction and overall level of maternal competencies are linked to higher intensity of postpartum depression symptoms.

EPDS scores were also positively but weakly correlated with all stress dimensions such as emotional tension ($rho = 0.35$; $p < 0.01$), external and intapsychic stress ($rho = 0.36$ and $rho = 0.25$, respectively; $p < 0.01$), and overall stress level ($rho = 0.36$; $p < 0.01$). That indicates that the higher stress is related to the higher intensity of postpartum depression symptoms.

A statistically significant but very weak positive correlation was also found between EPDS and impaired bonding ($rho = 0.26$;

TABLE 3 | Correlation of EPDS and other psychological variables scores ($N = 151$).

Variable	Maternal self-efficacy (PSOC)	Maternal satisfaction (PSOC)	Maternal competence (PSOC total)	Emotional tension (KPS)	External stress (KPS)	Intrapsychic stress (KPS)	Stress level (KPS total)	Impaired bonding (PBQ)	Rejection and anger (PBQ)	Anxiety about care (PBQ)	Bonding difficulties (PBQ total)	Concern about infant undereating (IFQ)	Concern about infant's hunger (IFQ)	Awareness of infant's hunger and satiety cues (IFQ)	Concern about infant overeating (IFQ)	Feeding infant on a schedule (IFQ)	Using food to calm infant's fussiness (IFQ)	Social interaction with the infant during feeding (IFQ)
Postpartum Depression (EPDS)	−0.28*	−0.50*	−0.48*	0.35*	0.36*	0.25*	0.36*	0.26*	0.28*	0.24*	0.29*	0.11	0.18*	0.22*	0.07	0.09	0.03	−0.04

*$p < 0.05$.

$p < 0.01$), rejection and anger ($rho = 0.28$; $p < 0.01$), anxiety about care ($rho = 0.24$; $p < 0.01$), and total bonding difficulties ($rho = 0.29$; $p < 0.01$), indicating that bonding difficulties were accompanied by higher intensity of postpartum depression symptoms. Among the behaviors and beliefs about infant feeding, only two were significantly related to EPDS scores: concern about infant's hunger ($rho = 0.18$; $p < 0.05$), and awareness of infant's hunger and satiety cues ($rho = 0.22$; $p < 0.01$). The results indicate that the more mothers were concerned about infant undereating and hunger and were aware of infant's hunger and satiety cues, the higher was the intensity of postpartum depression symptoms. However, these coefficients indicated a very weak correlation.

Multiple linear regression optimized by the backward-elimination method was conducted separately for each group of mothers to assess the predictors of postpartum depression (outcome variable). In all analyses, explanatory variables introduced into the regression equation included: maternal satisfaction, self-efficacy and overall level of maternal competencies, emotional tenses, external and intrapsychic stress and general stress level, impaired bonding, rejection, and anger, anxiety about care, and maternal feeding behaviors and beliefs such as concern about infant undereating or becoming underweight, concern about infant's hunger, awareness of infant's hunger and satiety cues, concern about infant overeating or becoming overweight, feeding infant on a schedule, using food to calm infant's fussiness, and social interaction with the infant during feeding, represented by the relevant scores from administered measures.

Based on regression analysis results, it was found that the model proposed to predict postpartum depression in the EBF group was proven significant ($F_{(3,81)} = 10.347$; $p < 0{,}001$). Three variables: maternal satisfaction, intrapsychic stress, and belief in feeding infants on a schedule, were significant in this model (adjusted $R^2 = 0.257$, $p < 0.01$), and they simultaneously can explain 25.7% of the variance. The results of regression analysis are presented in **Table 4**.

The significant regression analysis model proposed to predict postpartum depression in the MF group (**Table 5**) included such variables as emotional tension, mothers' concerns about infants' hunger, awareness of infant's hunger and satiety cues, and concern about infant overeating ($F_{(4,37)} = 28.259$; $p < 0{,}001$). All these variables simultaneously explain 74.7% of variance of postpartum depression (adjusted $R^2 = 0.747$, $p < 0.01$).

In the regression analysis for the last group – FF mothers, it was found that the model proposed to predict postpartum depression was proven significant ($F_{(7,30)} = 18.391$; $p < 0{,}001$). The model (**Table 6**) included seven variables that altogether explain 80.3 % of variance of postpartum depression (adjusted $R^2 = 0.803$, $p < 0.001$). Thus, the predictors of postpartum depression in the FF group were maternal emotional tension, impaired bonding and anxiety of infant care, concern about infant undereating, awareness of infant's hunger and satiety cues, feeding infant on a schedule, and social interaction with the infant during feeding.

The predictive values of the β coefficient for Emotional tension ($\beta = -0.551$) and Impaired bonding ($\beta = -0.924$) are negative,

TABLE 4 | The multiple regression analysis for variables predicting postpartum depression among exclusively breastfed mothers (EBF group).

Variable in the equation	*B*	*SE B*	*β*	*t*	*p-value* [LL; HL 95% CI]	*VIF*
Maternal satisfaction (PSOC)	−0.353	0.098	−0.349	−3.608	0.001 [−0.549; −0.158]	1.018
Intrapsychic stress (KPS)	0.179	0.069	0.249	2.570	0.012 [0.040; 0.317]	1.020
Feeding infant on a schedule (IFQ)	−1.338	0.540	−0.239	−2.479	0.015 [−2.413; −0.263]	1.014

B, non-standardized regression coefficients; SE B, non-standardized regression coefficients error; β, standardized regression coefficient.

TABLE 5 | The multiple regression analysis for variables predicting postpartum depression among mix-fed mothers (MF group).

Variable in the equation	*B*	*SE B*	*β*	*t*	*p-value* [LL; HL 95% CI]	*VIF*
Emotional tension (KPS)	0.355	0.044	0.678	8.131	<0.001 [0.266; 0.444]	1.014
Concern about infant's hunger (IFQ)	0.692	0.134	0.435	5.159	<0.001 [0.419; 0.964]	1.037
Awareness of infant's hunger and satiety cues (IFQ)	0.542	0.227	0.220	2.386	0.023 [0.080; 1.004]	1.246
Concern about infant overeating (IFQ)	−0.859	0.327	−0.241	−2.623	0.013 [−1.525; −0.193]	1.238

B, non-standardized regression coefficients; SE B, non-standardized regression coefficients error; β, standardized regression coefficient.

TABLE 6 | The multiple regression analysis for variables predicting postpartum depression among formula-fed mothers (FF group).

Variable in the equation	*B*	*SE B*	*β*	*t*	*p-value* [LL; HL 95% CI]	*VIF*
Emotional tension (KPS)	−0.551	0.098	−0.820	−5.628	0.001 [−0.753; −0.348]	3.220
Impaired bonding (PBQ)	−0.924	0.117	−1.675	−7.879	<0.001 [−1.166; −0.681]	6.858
Anxiety about care (PBQ)	1.125	0.224	0.682	5.022	<0.001 [0.662; 1.588]	2.795
Concern about infant undereating (IFQ)	1.639	0.219	0.893	7.467	<0.001 [1.158; 2.093]	2.171
Awareness of infant's hunger and satiety cues (IFQ)	1.743	0.264	0.700	6.603	<0.001 [1.927; 2.289]	1.707
Feeding infant on a schedule (IFQ)	1.980	0.441	0.389	4.491	<0.001 [1.068; 2.893]	1.136
Social interaction with the infant during feeding (IFQ)	−4.327	0.543	−1.441	−7.965	<0.001 [−5.451; −3.203]	4.967

B, non-standardized regression coefficients; SE B, non-standardized regression coefficients error; β, standardized regression coefficient; VIF, value of variance inflation factor.

which indicates that the occurrence of postpartum depression symptoms is explained by the low level of emotional tension and the lack of difficulties in building a mother-infant bond. We refer to this result in the Discussion section.

DISCUSSION

The first aim of our study was to clarify whether, for each of the analyzed feeding methods, mothers were at similar risk of postpartum depressive symptoms. Our findings indicate that there were no significant differences in the severity of such symptoms. These results seem to differ from some of those published so far, which indicate that the infant feeding method may be related to a maternal mood where breastfeeding mothers are less depressed (9, 10) or formula feeding women have higher rates of depression than women who breastfeed (36). Islam et al. (11) analysis show that non-exclusively breastfeeding mothers were more likely to experience depressive symptoms than exclusively breastfeeding mothers. Similarly, in the study

conducted by Takashori (37), there was a significant difference in the prevalence of alleviated EPDS scores between breastfeeding and non-breastfeeding mothers (2.5 and 19.4%, respectively). Our results contradict those findings and indicate that maternal depressive symptoms are not related to the feeding method. However, it should be noted that the relationship between postpartum depressive symptoms and breastfeeding (including exclusive breastfeeding) is ambiguous and might be considered reciprocal – as the experience of depressive symptoms might affect breastfeeding initiation and its duration adversely.

Moreover, the relationship between depressive symptoms and feeding methods is more profound when additional variables are taken into account, such as breastfeeding self-efficacy (17) or breastfeeding intention (38). The study by Bora et al. (38) also indicates a link between breastfeeding and maternal depression, that is mediated by feeding intention, i.e. mothers who planned to breastfeed and went on to do so were around 50% less likely to become depressed than mothers who had planned to, and did not breastfeed. In our study, the mean EPDS scores in all feeding-type groups were above 12, the cut-off point indicating the depression risk. Therefore, they seem to confirm that the causes of depressive symptoms in the postpartum period are more complex and should be searched for among other factors, than the type of feeding.

The previous study has shown that prolactin and oxytocin production during breastfeeding is associated with lower maternal stress levels and enhanced mother-infant bonding (39). Our results indicate that formula-feeding mothers also experience greater emotional tension and higher intrapsychic and general stress than women who breastfeed exclusively. Also, the most increased bonding difficulties (reflected in higher scores on impaired bonding and rejection and anger) occurred in the formula-feeding group, while the lowest was among exclusively breastfeeding women. However, without considering the other factors that may mediate or moderate between feeding patterns and bonding with the baby, our findings should be interpreted with care and caution. Such an approach is supported by Hairston et al. (40) study, indicating that mother-infant bonding is not associated with feeding type. It suggests that if the mother has no other difficulties or mental disorders, breastfeeding is neither a threat to developing a bond with the child nor a protective factor for this bond.

The maternal feeding behaviors and beliefs were only partially connected to how the infant was fed. In the formula-feeding group, concerns related to providing feeding on a schedule were the highest compared to the other groups, while they were the lowest in the exclusive breastfeeding group. However, what seems important is that there were no differences between the exclusively breastfeeding and mix-feeding groups. These results seem to suggest that breastfeeding might be a factor preventing excessive worrying about whether the baby is being fed regularly, and it seems understandable, as breastfeeding should be on-demand. Thus, if the baby signals their hunger and the baby's weight and height increase in line with developmental norms, the mother does not have to additionally control the feeding hours, which reduces the number of concerns about caring for the baby. Perhaps this is one of the factors related to breastfeeding that minimizes the risk of postpartum depressive symptoms in breastfeeding women. Another difference between the groups is maternal concern about infant overeating or becoming overweight. The weakest concerns about overeating occurred in the group of mix-feeding mothers, while the strongest fears were typical for formula-feeding mothers. Similarly, as above, there were no differences between the exclusively breastfeeding and mix-feeding groups. Assuming that the fear of overeating in formula-feeding mothers may be accompanied, on the one hand, by the desire to strictly "stick to the feeding schedule" to ensure the child's proper physical development, and on the other hand, doubts as to whether the feeding times set by the schedule correspond to the baby's hunger, this may also be an explanation of the higher severity of depression among women who feed their children with formula milk.

Our findings concerning identifying the best predictors of depressive symptoms for each feeding method clearly indicate that there are differences in each group of mothers.

A lack of maternal satisfaction emerged as the most crucial predictor of mothers' EPDS scores in regression analysis for exclusively breastfeeding mothers. Although included in the regression equation, maternal satisfaction was previously not differentiated by the type of feeding. Previous studies have indicated a negative correlation between maternal satisfaction and postpartum depression (31, 41, 42). Similarly, in our study negative correlation between those variables was found as well. It may indicate that satisfaction or dissatisfaction associated with maternal role is primarily related to breastfeeding. Possible feeding failures may lower maternal satisfaction and thus increase the risk of depressive symptoms.

Moreover, the recent findings by Avilla et al. (19) indicate a positive association between maternal satisfaction with breastfeeding and PPD symptoms. In the current study, maternal satisfaction in general meaning was measured. However, since its association with postpartum depression did not appear anywhere except in the regression equation for the EBF group, mothers in this group likely assessed their satisfaction through the prism of breastfeeding. Two other predictors of depressive symptoms in this group are intrapsychic stress and concerns about feeding on a schedule. It should be clarified here that intrapsychic stress refers to the result of a woman's confrontation with herself as a mother. Thus, a high level of intrapsychic stress describes experiencing fears, worries, and a sense of losing meaning in life resulting from difficulties in overcoming the challenges of everyday life and achieving goals, tasks, and plans. Adaptation to motherhood, especially in its initial period, is often accompanied by difficulties in implementing tasks resulting from the new role, which may contribute to the occurrence of depressive symptoms. In addition, breastfeeding mothers who experience potential failure (e.g., due to inexperience in breastfeeding or difficulty in latching on to the breast) may be worried about their baby being provided with enough milk, which fosters depression.

In the group of mixed breastfeeding mothers, emotional tension was found among the predictors of postpartum depression. Further factors are related only to maternal concerns and behaviors associated with the course of feedings, such as concern about infant's hunger, awareness of infant's hunger and

satiety cues, and concern about infant overeating. It appears that combining breastfeeding with formula milk may be associated with psychological benefits for mothers. On the one hand, while breastfeeding, they do not experience a feeling of failure as a mother, as they fulfill the social expectation for breastfeeding. Additionally, they share the special closeness that comes from physical contact with the baby during latching on to the breast, even if - as mentioned above - the influence of breastfeeding on the formation of the mother-infant bond is not as strong as it was supposed (40). On the other hand, formula milk gives a certain sense of security when feeding difficulties arise, or the mother gives up breastfeeding for personal reasons. At the same time, it should be noted that in this group - apart from emotional tension - the predictors of postpartum depression were factors related to the physiological aspects of a child's nutrition.

The highest number of predictive factors were found for formula-feeding mothers. Additionally, the direction of the indicated relationships is surprising. In univariate analysis, emotional tension and impaired bonding were positively correlated with maternal postpartum depression. Both emerged as the most important predictors of formula-feeding mothers' EPDS scores in regression analysis, and were negatively related to postpartum depression symptoms. It seems to us that the reasons for such results may be twofold. Firstly, univariate correlation analysis was carried out on the entire group, including all women participating in the study, regardless of the feeding method. Secondly, the role of fear of being judged by the environment should be considered. After having a baby, many women experience social pressure to breastfeed their babies. We assume that mothers nursing formula milk might fear ostracism and stigma when not breastfeeding. Thus, the disclosure of emotional tension and impaired bonding risks is being assessed even more negatively. This explanation seems to confirm the congruent direction of the relationship for another predictor of bonding disorders - anxiety about care. In this case, a higher level of anxiety predicts the onset of symptoms of postpartum depression. It can be assumed that concerning experiencing anxiety about care, there is no need to hide from the environment because caring for a child, also in social perception, is associated with numerous difficulties and challenges, so feeling uncertainty usually does not cause a negative assessment.

The other predictors, as in the MF group of mothers, refer to issues related to the child's feeding and include concern about infant undereating, awareness of infant's hunger and satiety cues, feeding infant on a schedule, and social interactions with the infant during feeding. The relationship between the first three and PPD is positive. It indicates that the greater the anxiety associated with various aspects of formula-feeding, the greater the risk of developing postpartum depression symptoms. It is worth noting that concern about infant undereating appeared in the regression model only in this group (FF group). Such results seem to complement the studies by Anato et al. (43), which indicate that maternal postpartum depression strongly correlates with inappropriate complementary feeding practices of infants and is a strong predictor of infants' undernutrition measured as stunting and underweight. The last predictor of postpartum depression in this group is poor interactions with the baby during feeding. This relationship, although noted in the current study, should, in our opinion, be interpreted with caution in order not to stigmatize formula-feeding mothers as having difficulties in establishing social interactions with the baby and further developing a mother-infant bond. The reason for this may be the presence of other factors that were not controlled in our study. At the same time, if the mother experiences difficulties in interacting with the baby during breastfeeding and sees the reasons for them in the fact that she feeds with bottles and formula milk, and the baby has no physical contact with the breast and breast milk, this may be a factor increasing the feeling of guilt over being an insufficiently good mother and thus aggravating the symptoms of PPD.

Study Limitations and Implications for Further Research

Despite the high importance of identifying predictors of postpartum depression in terms of how the baby is fed in the first 6 months of life, our study has certain limitations that should be considered. First, the cross-sectional nature of the study precludes drawing causal conclusions. Thus, prospective longitudinal studies are needed to explore the association between postpartum depression symptoms and its potential risk among women in groups that differ in the feeding pattern. In addition, these studies should consider the relationship between breastfeeding intention and initiation when controlling for other PPD risk factors. Secondly, as participants were volunteers and the study sample was relatively small, especially when divided into different feeding types groups, and may not represent the total population. Thirdly, the limitations of the online survey as a data collection method (despite our various recruitment strategies) should also be mentioned, particularly sample bias. Those who, for various reasons, do not have access to the Internet, are not users of social media, or are unable to use information technology fluently cannot take part (44). Indeed, in our study, most women were well-educated, married, with satisfying economic situations, and living in large urban areas. This could call into question the generalizability of the findings. On the other hand, as Callegaro et al. (45) recommend, the possibility to complete the set of questionnaires in a safe Internet environment without any pressure may protect from social desirability bias. An additional limitation that should be taken into account is the low value of Cronbach's alpha coefficient for the IFQ factor describing the social interactions of the mother with the baby during feeding. A low value ($\alpha < 0.50$) means low internal consistency, and thus may affect the reliability of the results obtained in the measurement for this factor. In spite of it, we included the obtained results because this factor appeared as a predictor only in the MF mothers group. However, we are aware of this limitation and its consequences. In further studies using IFQ, we recommend checking the factor structure of the questionnaire and, if necessary, determining factors with acceptable reliability for the tested sample. It should be noted as well that in most research EPDS is used usually by the 4^{th} month postpartum. Some women in our study filled in the EPDS at a later time, as our inclusion criteria considered

delivery within the last 6 months. As EPDS Manual (46) presents evidence of the administration of the scale in the additional context (including women in the antenatal period and men) we decided to administer EPDS in our study even if more than usual time might have passed since delivery. As the scale was used as the indicator of depressive symptoms and not as the criterion for depression diagnosis the later time of its administration should not compromise its role as the screening tool. Finally, our study was not based on direct observation of mother-infant dyads during feeding episodes. Thus it relies on maternal self-reports related to feeding concerns and practices. Direct observation of maternal behavior in real feeding interactions might provide additional data on such concerns and possibly on predictors of depression. It is quite likely as a previous study (47) provided evidence on the difference in maternal-infant interactions between breastfeeding and bottle-feeding mothers.

Nevertheless, the study results indicate several vital relationships between postpartum depression symptoms among new mothers depending on how they feed their infants, which should be further investigated in prospective research.

CONCLUSIONS

The differences in predictors of postpartum depression between three various types of infant feeding suggest that breastfeeding itself may not be a risk for postpartum depression. The specificity of maternal experiences with the various type of feeding is related to difficulties that can – in different ways – promote postpartum depression. Thus, providing emotional and educational support appropriate for different types of feeding may be an essential protective factor for postnatal depression. Participation in support groups for new mothers may facilitate the exchange of experiences and concerns and show women the similarity of their problems, while techniques adapted from cognitive-behavioral therapy (CBT) may help to manage maternal distress, what was already advocated for (48). Future investigation should focus not only on whether a woman breastfeeds but also on the importance of feeding methods for an individual and experiences related to feeding.

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 study was conducted according to the guidelines of the Declaration of Helsinki and approved by the university advisory board. As the study was of an informative cross-sectional purely descriptive nature, no formal ethical approval was required under the countries' legislations. Participants were informed of the purpose, risks, and benefits of the survey. They were told they could withdraw from the study at any time and for any reason and provided electronic informed consent. Electronic informed consent was obtained from all subjects involved in the study in accordance with the Ethics Guidelines for Internet-mediated Research by British Psychological Society.

AUTHOR CONTRIBUTIONS

KK and EB-B: conceptualization, resources, data curation, writing—original draft preparation, writing—review and editing, and supervision. KK: methodology, formal analysis, investigation, and project administration. All authors have read and agreed to the published version of the manuscript.

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Physical and Psychological Childbirth Experiences and Early Infant Temperament

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Objective: To examine how physical and psychological childbirth experiences affect maternal perceptions and experiences of early infant behavioural style (temperament).

Background: Unnecessary interventions may disturb the normal progression of physiological childbirth and instinctive neonatal behaviours that facilitate mother–infant bonding and breastfeeding. While little is known about how a medicalised birth may influence developing infant temperament, high impact interventions which affect neonatal crying and cortisol levels could have longer term consequences for infant behaviour and functioning.

Methods: A retrospective Internet survey was designed to fully explore maternal experiences of childbirth and her postnatal perceptions of infant behaviour. Data collected from 999 mother–infant dyads were analysed using Pearson's correlations and multiple analyses of covariance, employing the Bonferroni method of correction to establish initially significant variables. Multiple linear regressions were conducted to determine major perinatal contributors to perceived early infant temperament.

Results: Multiple regression analyses on each of the eight Mother and Baby Scales outcome variables indicated that early infant behavioural style (0–6 months) was largely predicted by subjective maternal states during and post-childbirth, postnatal depression scores, maternal personality traits and infant age. For example, infant age (Beta = 0.440, $p = 0.000$) was the most significant predictor of Alert-Responsive infant behaviour, followed by maternal Postnatal Positive experience (Beta = 0.181, $p = 0.000$). In contrast, depression (EPDS) scores (Beta = 0.370, $p = 0.000$) were the most significant predictor of Unsettled-Irregular infant behaviour, followed by Anxious-Afraid Birth Emotions (Beta = 0.171, $p = 0.000$) and infant age (Beta = –0.196, $p = 0.000$). Mothers also perceived their infants as more Alert-Responsive (Beta = 0.080, $p = 0.010$) and Easier overall (Beta = 0.085, $p = 0.008$) after a Supported birth experience.

Conclusion: Maternal and infant outcomes were influenced by multiple physical and psychological perinatal variables. The mother's subjective experience appeared to be of equal significance to more objective factors (e.g. birthplace/mode). Social support

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enhanced the mother's childbirth experience, benefitting her perceptions of her baby's early temperament. These findings provide further support for current World Health Organisation intrapartum guidelines (2018) on the importance of making childbirth a '*positive experience*' for women.

Keywords: childbirth experience, infant temperament and behaviour, mother-infant bonding and attachment, postnatal anxiety and depression, post-traumatic stress disorder

INTRODUCTION

Rising levels of childbirth interventions have become a major concern in recent years (Dahlen, 2014; NHS England National Maternity Review, 2016; WHO, 2018). The term 'childbirth/obstetric intervention' is used here to refer to any medical interference with the spontaneous physiological progression of 'normal' labour and birth, whether due to medical indication, complications or maternal request. While interventions, such as induction and Caesarean section (C-section), were designed to preserve the life and wellbeing of mother and infant, unnecessary interventions may disturb the progression of normal physiological labour and birth, leading to an increased risk of further interventions and complications (Uvnäs-Moberg et al., 2019). This may impede instinctive neonatal behaviours that facilitate mother–infant bonding and breastfeeding post-birth (Widström et al., 2019). Moreover, obstetric interventions increase the risk of the mother developing postpartum depression (PPD) or childbirth-related post-traumatic stress disorder (CB-PTSD; Ayers et al., 2016; Horsch and Garthus-Niegel, 2019).

Therefore, we know that a negative birth experience can have an impact on postnatal maternal mood. Postnatal depression in turn may lead to emotional and behavioural problems in the infant and young child (Murray et al., 2014, 2018). Although infants whose mothers still manage to engage despite their diagnosis can develop well, children are at an increased risk of having behavioural problems aged 3.5 years and cognitive and psychological problems in adolescence if postnatal depression persists (Netsi et al., 2018). Similarly, evidence shows that CB-PTSD may have negative impacts on mother–infant interactions and maternal sensitivity toward her baby (Figueiredo et al., 2008; Parfitt and Ayers, 2009). As well as being very distressing for women suffering from such perinatal psychological disorders, CB-PTSD in the longer term may have negative consequences for the infant's social–emotional and cognitive development (Garthus-Niegel et al., 2017). Thus, it appears that there could be an indirect pathway between childbirth and infant behaviour *via* postnatal maternal mood.

It is also possible that there are direct links through the inter-connected maternal–infant neurohormonal systems during childbirth (Buckley, 2015; Buckley and Uvnäs-Moberg, 2019). Furthermore, and contrary to previous beliefs (Anand, 2001), we know that the foetus and newborn infant can feel physiological pain and pain-related distress (Anand and Hickey, 1987; Grunau and Craig, 1987; Craig et al., 1993). Certain obstetric interventions, such as assisted birth, have been directly associated with increased levels of neonatal cortisol and crying (Taylor et al., 2000; Gitau et al., 2001). However, comparatively little attention has been given to the possible impacts of childbirth on longer term infant behavioural style, otherwise known as temperament (Thomas and Chess, 1977; Carey and McDevitt, 2016).

Temperament has been defined as '*a quality that varies among individuals, is moderately stable over time and situation, is under some genetic influence, and appears early in life—a coherent profile of behavior, affect (emotional state), and physiology (neurochemistry of the brain)*' (Kagan, 2018, p. 38). It is also '*the behavioral style of the individual, the characteristic pattern of experiencing and reacting to the external and internal environment*'. (Carey and McDevitt, 2016, p. 26). These ideas, which together describe temperament as an interaction between genes and the environment, have become widely accepted. Thus, temperament appears to be based on a combination of biological and psychological or experiential substrates.

Assessing infant temperament independently is an intensive activity and therefore research often relies on maternal self-report, although the mother's mental health post-birth might affect actual or perceived infant temperament. The potential disruptive impact of maternal PPD on normal mother–infant interactions (Murray et al., 2014, 2018; Matthies et al., 2017) may disturb the development of an enduring positive relationship (Feldman, 2017) and subsequent infant behaviour (Feldman et al., 2009). Conceivably, an unsettled infant might exacerbate any maternal mental health issues (Britton, 2011), further affecting mother–infant relationships and longer term infant behaviour.

As well as the finding that newborn infants up to 8 weeks are more likely to be unsettled after an assisted birth (using forceps or ventouse extraction) or emergency C-section (Taylor et al., 2000; Gitau et al., 2001), some authors (Dahlen et al., 2013; Douglas and Hill, 2013) have further suggested that birth complications could affect longer term infant temperament due to the subsequent increase in maternal and foetal cortisol levels (Gitau et al., 1998). This 'stress response' may over-stimulate the neonatal hypothalamic–pituitary–adrenal (HPA) axis, with potentially long-term emotional and behavioural consequences for the infant (Dahlen et al., 2013; Douglas and Hill, 2013).

Nevertheless, research exploring how childbirth may (directly or indirectly) affect early infant behaviour and developing temperament is sparse. Our previous qualitative research explored maternity care providers' perceptions of how this might occur (Power et al., 2019). Our findings highlighted that, while infants may react directly to physical birth events, such as induction, they could also be responding to their mother's subjective birth experience. Infants who experienced obstetric complications or interventions were perceived as more challenging to care for

after birth and often required more comforting. Furthermore, newborns whose mother was distressed or overwhelmed by the birth were also more likely to be unsettled, reflecting her emotional state. This was a possibility originally suggested by Taylor et al. (2000) who argued that a mother's psychological reaction to the birth could potentially mediate her infant's crying and stress response to inoculations at 8 weeks after an assisted birth.

This suggestion led to the current study, which aimed to examine whether mothers' physical and psychological experiences of pregnancy, childbirth and the early postnatal period are associated with perceptions of their infants' behavioural style, while also considering broader maternal demographic factors, personality and postnatal mood.

MATERIALS AND METHODS

Design

A retrospective online survey examining physical and psychological experiences of childbirth, maternal mental health and infant behaviour.

Participants

Mothers were eligible to participate if they were over 18 years of age, had an infant aged 0–30 weeks from a singleton pregnancy, resided in the United Kingdom and had no major health problems. Exclusion criteria were: any major health problems in mother or infant; premature birth (<37 weeks); multiple birth (>1 infant) or low birthweight (<5.5 lb) (WHO, 2022).

Measures

Participants completed an anonymous online survey about their physical and psychological experiences of pregnancy, childbirth and the early postnatal period, alongside a validated measure of perceived infant behavioural style. The survey included items examining the following criteria.

Maternal and Infant Demographic Factors

Maternal age, ethnicity, education, postcode, monthly household income and relationship status were reported by mothers, as well as parity (number of children), infant age, gender, gestational age and birthweight (if known).

Physical Perinatal Factors

Birthplace (hospital, midwife led unit, home), how labour commenced (e.g. induction or spontaneous) and progressed (e.g. acceleration), timings for each labour stage (hours/minutes), birth interventions (e.g. foetal scalp electrode), birth mode (normal, assisted, planned or emergency C-section), pain ratings, pain relief methods (e.g. 'gas and air', pethidine, epidural, water and hypnobirthing) and pre/postnatal complications (e.g., infection, urinary retention) (Stephansson et al., 2016). Items also examined complications, such as foetal distress, meconium in the waters or resuscitation, alongside whether their baby's head was born gently, whether they had immediate skin-to-skin contact and how they first fed and currently feed their baby (breast, expressed or formula).

Psychological Perinatal Factors

Mothers reported how they felt physically and emotionally during pregnancy, childbirth and the postpartum period (e.g. how happy, fearful, energetic or vulnerable they felt). Responses were captured *via* five-point Likert scales (1 = strongly disagree to 5 = strongly agree). Many validated psychological tools, such as the Edinburgh Postnatal Depression Scale (Cox et al., 1987) and the State and Trait Anxiety Inventory (Spielberger et al., 1970), use four-point Likert scales. Thus, the Likert scale is a typical response scale in similar questionnaires that allows for variation between responses to be fully explored.

The subjective measures of pregnancy, birth and postnatal experiences were based on the literature around women's psychological responses to childbirth and the perinatal period. To the best of our knowledge, at the time of designing this survey, there was no single validated tool that could measure the mother's actual experience and emotional responses to her experience throughout the perinatal period. Indeed, although there are some validated tools relating to maternal interpretations of the birth experience, such as the Birth Satisfaction Scale (Martins and Fleming, 2011), which examines the mother's satisfaction with the birth and her care, and a tool by Siassakos et al. (2009) which looks at women's perceptions of their *operative* birth experience, no one tool covered the period with the breadth required. Furthermore, while maternal satisfaction with the birth, including operative birth experiences and the care she receives, are very important, we were specifically interested in the wider potential impacts of the mother's *physical* and *psychological* responses to her pregnancy, birth and postnatal experiences on her baby. Consequently, we developed our own questions with a focus on how the mother felt during each stage of her journey, which we could then compare with her perceptions of her baby's early behavioural style.

Infant Behaviour

Infant behaviour was measured using the Mother and Baby Scales (MABS; Wolke and James-Roberts, 1987). This 63-item questionnaire assesses maternal confidence and self-efficacy alongside the mother's perceptions of specified infant behaviours over the past 7 days. Participants respond *via* six-point Likert scales (0 = not at all to 5 = often/very much) to items, such as '*My baby has settled quickly and easily*' and '*During feeds my baby has tended to fuss and cry*'. The scale contains eight sub-scales: Alert-Responsive (A-R); Unsettled-Irregular (U-I); Easiness (E); Alertness during Feeds (ADF); Irritable during Feeds (IDF); Lack of Confidence in Caretaking (LCC) and Breastfeeding (LCBF); and Global Confidence (GC) (see **Table 1** for definitions and distribution of MABS scores).

The MABS have high levels of reliability and validity (Wolke, 1995) and have also demonstrated validity in relation to newer self-report infant temperament questionnaires (Oates et al., 2018). While originally designed for newborn infants, research has employed the MABS with infants aged 0–6 months (Oates et al., 2018), as well as older infants (Field et al., 2002), and in research exploring relationships between infant behaviour, maternal confidence, postpartum depression and low-self-esteem (Denis et al., 2012).

TABLE 1 | Mother and baby scales (MABS) and distribution of scores.

MABS area of interest *(abbreviations)*	Description of measure	Mean	SD	Range (min-max)
General	**General categories**			
Alert-responsive (A-R)	Infant alertness, attentiveness and communicativeness with caregivers	39.27	5.13	30.00 (16–46)
Unsettled-irregular (U-I)	Crying/fussing + regularity of eating, sleeping and elimination routines	49.63	12.79	69.00 (19–88)
Lack of confidence in caretaking (LCC)	How capable the mother feels when caring for her baby	32.40	9.12	60.00 (10–70)
Overall impressions	**Maternal perceptions of her baby's behaviour and her own confidence**			
Easiness (easy)	How calm, alert and settled the infant appears overall	24.28	2.30	12.00 (16–28)
Global confidence (GC)	How confident the mother feels about coping; general anxiety level	17.74	1.88	8.00 (13–21)
Feeding	**Infant behaviour during feeding**			
Alert during feeds (ADF)	Alertness during feeds	17.09	4.46	23.00 (6–29)
Irritable during feeds (IDF)	Whether the infant feeds reluctantly or with difficulty or irritability	19.18	7.05	39.00 (7–46)
Lack of confidence in breastfeeding (LCBF)	If breastfeeding, whether experienced as problematic (e.g. tension, conflicting advice, technique and birth impacts)	16.49	6.27	38.00 (7–45)

N = 999 for all MABS items except lack of confidence in breastfeeding where it is 855.

Maternal Personality and Postnatal Wellbeing

Heritability factors are known to play an important role in personality development and subsequent behaviour (McAdams and Olson, 2010), and postnatal maternal mood is known to affect infant behaviour (Glover et al., 2018). Therefore, three measures of maternal trait, state and postnatal mood were collected:

a. Maternal personality was measured using the Ten Item Personality Inventory (TIPI). The TIPI (Gosling et al., 2003) is a short version of Goldberg's original hundred-item Big Five Inventory (1992) that self-assesses the personality traits of Extroversion, Conscientiousness, Openness (to new experiences), Agreeableness and Emotional Stability *via* seven-point Likert scales (1 = 'disagree strongly'; 7 = 'agree strongly'). Gosling et al. (2003) established the TIPI's construct validity and test–retest reliability, and it has been widely used in public health research (e.g. Johnston and Brown, 2013).
b. Maternal mental health was measured using the 10-item Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) which assesses symptoms of maternal postnatal mood disorder over the previous 7 days. The EPDS presents 10 multiple choice statements (e.g. '*I have been able to laugh and see the funny side of things*'), with check box answers on a four-point Likert scale (1 = As much as I ever could/did; 4 = No never/hardly at all). Mothers with scores of 13 or above are considered high risk. The sensitivity, internal consistency, validity and reliability of the EPDS as an effective screening instrument for postnatal depression are well established, and it is widely used in both research and clinical practice in the United Kingdom and elsewhere (e.g., Shrestha et al., 2016).
c. Current maternal anxiety state may have affected the mother's interpretation of childbirth and her baby's behaviour. Therefore the six-item short form of the 'State' scale of Spielberger's State and Trait Anxiety Inventory (STAI; Spielberger et al., 1970) was included to measure mothers' current anxiety levels (Marteau and Bekker, 1992). This short version of the STAI State includes six short statements regarding emotional state (e.g. '*I feel calm/tense/content/upset*') on a four-point Likert scale (1 = not at all; 4 = very much). Positive items are reverse scored and therefore higher scores are indicative of higher anxiety levels. This tool is considered a reliable and valid measure of anxiety states (Marteau and Bekker, 1992).

Procedure

This study was designed and implemented in accordance with the ethical standards of the Declaration of Helsinki, developed by the World Medical Association (2018). A University Department of Psychology Research Ethics Committee granted ethical approval for the study.

Participants were recruited between June 2014 and March 2017 *via* advertisements on United Kingdom mother–infant sites (e.g. bounty.com) and social media (e.g. Facebook and Twitter). The study took place on SurveyMonkey®. On accessing the anonymous online survey, participants were presented with an information page outlining the purpose of the study and eligibility criteria, as well as data protection and confidentiality arrangements. Following electronic consent, participants were asked to complete standard demographic information before beginning the survey. Participation took approximately 15–30 min. Afterwards, participants were thanked and presented with a debrief page outlining where to seek further information and professional support if needed.

Data Analysis

Raw data were imported from SurveyMonkey™ into SPSS version 26 (SPSS United Kingdom Ltd). Each of the four questionnaires incorporated in the survey was first scored according to their individual instructions. Multiple statements concerning pregnancy or postnatal complications were summed and included as continuous scores rather than individual items. Continuous, nominal and ordinal data could then be quantified and interpreted *via* the associated tools for analysis: correlations and ANOVAs to establish similarities, differences and interactions of infant behaviour in relation to the birth experience and surrounding factors. Finally, multiple linear regressions were used to establish predictors. Our analysis plan is further detailed below.

To begin, factor analyses were carried out on participant-rated statements concerning their subjective perceptions of the perinatal experience. This technique was applied where multiple statements rated on a five-point Likert scale had the potential for reduction to fewer items: subjective maternal physical and psychological experiences of pregnancy, childbirth and the early postnatal period and overall maternal perceptions of the birth experience (e.g. positive/supported/directed). Mothers had responded to questions and a list of potential answers concerning their personal perceptions of the perinatal period (e.g. '*How did you feel during pregnancy/your birth*'). Principal components analyses (PCA) were conducted using Direct Oblimin rotation methods, as recommended by Field (2009) for inter-correlated socio- or psychological data. Factors with an eigenvalue over one were used; computed factors were saved as regression scores, named and used in subsequent data analyses.

To determine which confounding variables required controlling for, Pearson's bivariate correlations (with two-tailed hypotheses) and Multivariate Analyses of Variance (MANOVAs) were first performed on the sociodemographic and infant characteristics data. Thus, infant characteristics (current infant age, gender, gestational age at birth and birth weight) and sociodemographic variables (maternal age, education, ethnicity, household income, relationship status and number of children) were considered. Significantly associated maternal and infant factors were subsequently controlled for in all further statistical analyses.

Dummy coded variables (yes = 1, no = 0) were created in SPSS where required. Pearson's partial correlations, controlling for covariates and excluding cases listwise, were conducted where independent variables reflected either ratio or interval data. MANCOVAs were carried out for categorical independent variable data, using the *a priori* Bonferroni correction method of analysis, with all means comparisons chosen in advance (Howell, 2012, 2016). This method of planned comparisons produces equal or slightly more conservative results to planned *post-hoc* tests, while having the advantage of allowing covariates to remain in the equation. An alpha level of <0.05 was used to assess the results of all correlations and MANOVAs.

Monthly household income was categorised using the five income brackets taken from the Office for National Statistics (ONS) division of quintiles from 2014 to 2016, corresponding with the survey design and data collection period (Office for National Statistics, 2017). For multiple linear regression analyses, household incomes were further divided into dichotomous variables: < or >£2,700/month, corresponding to the approximate median gross household income of £2,700/month in the same period (Office for National Statistics, 2019).

Certain factors had the potential to be bi-directional in causality. However, placing perceived infant behaviour and maternal confidence as the speculated outcome variables was integral to the overall study aims: to explore how physical (objective) birth events, psychological variables and the subjective maternal experience of childbirth may influence mother-reported infant behaviour. A predictive form of analysis was chosen to establish the strongest independent variables and to indicate which factors might explain the greatest proportion of the total variance in infant behavioural scores and maternal confidence when all other factors were held constant. Multiple linear regression was used with the forced entry method, excluding cases pairwise to maximise data retention.

Finally, therefore, multiple linear regressions were performed for each of the eight MABS items. In line with Field (2009), multicollinearity was managed in a second regression run for each outcome variable to reduce the inherent inter-correlations often found in psychological data (Field, 2009). Given the large sample size, outliers were only removed if they had an exceptionally large residual (over 30), a leverage value greater than three times the average, or were considered to significantly influence the regression line. Cook's distance was then employed as a measure of outlier influence and interpreted as satisfactory when <1 in all remaining cases. The Durbin–Watson test was used to establish independence of residuals (Field, 2009). The adjusted R^2 is reported throughout.

RESULTS

Initially, 1,152 mothers completed the survey although 153 did not meet the inclusion criteria, leaving 999 in the analysis. Mean maternal age on completion of the survey was 32 years ($SD = 4.2$; range 19–44 years); mean infant age was 15.31 weeks ($SD = 7.48$; range 0–30 weeks). **Table 2** presents further demographic information.

Infant Behaviour

For inclusion in analyses, participants must have completed the Mother and Baby Scales (MABS)—999 mothers who met all the inclusion criteria completed the scale, although only 855 completed the breastfeeding section, corresponding to the breastfeeding data. The MABS data were analysed and coded according to instructions (Brazelton and Nugent, 1995).

Associations between the MABS scores, infant characteristics and maternal demographic background were explored. Infant Age, Infant Gender, Gestational Age, Birth Weight, Maternal Age, Maternal Education and Number of Children were significantly associated with MABS scores and therefore controlled for in all further analyses.

Physical Perinatal Factors, Perceived Infant Behaviour and Maternal Confidence

Pregnancy and Postnatal Complications

The number of complications experienced by mothers during pregnancy and postnatally were computed. Altogether, 37% experienced at least one pregnancy complication (mean 0.51; SD 0.78; range 0–5) and 50.3% at least one postnatal complication (mean 0.91; SD 1.20; range 0–7). Partial Pearson's correlations identified significant positive associations between the number of pregnancy complications and Unsettled-Irregular infant behaviour as well as Lack of Confidence in Caretaking and Breastfeeding. Similarly, Number of Postnatal Complications had significant positive relationships with Unsettled-Irregular and Irritable during Feeds and negative associations with maternal confidence measures (**Table 3**). Therefore, where more

TABLE 2 | Maternal demographic background.

Indicator	Group	*N*	%
Age	19–24	48	4.8
	25–29	217	21.7
	30–34	454	45.4
	35–39	243	24.3
	40–44	32	3.2
Ethnicity	White (British/Irish/Other)	948	94.9
	Mixed/Multiple ethnic group	20	2.0
	Asian/Asian British	13	1.3
	Black African/Black Caribbean	11	1.1
	Other ethnic group	4	0.4
Education (highest level)	No formal qualifications	2	0.2
	GCSE or equivalent	32	3.2
	A level or equivalent	108	10.8
	Degree or equivalent	450	45.0
	Vocational qualification	45	4.5
	Postgraduate or equivalent	361	36.1
Relationship status	Single	19	1.9
	Partner (not living with)	6	0.6
	Cohabiting	261	26.1
	Married	712	71.3
Number of children	1	544	54.5
	2	346	34.6
	3	81	8.1
	4	21	2.1
	5+	4	0.4
Household income*	Less than £1,000/month	25	2.5
	£1,000–£1700/month	103	10.3
	£1701–£2,700/month	229	22.9
	£2,701–£4,200/month	335	33.5
	£4,201 or more/month	206	20.6
United Kingdom area of residence	England	735	73.6
	Wales	130	13.0
	Scotland	67	6.7
	Northern Ireland	27	2.7

Gross household income brackets before tax and after benefits or savings (Office for National Statistics, 2017). Actual percentages (%) are reported for each demographic variable. Where percentages do not total 100, the discrepancy is due to missing data.

perinatal complications were experienced, infant behaviour was reported as more Unsettled, Irregular and Irritable and the mother felt less confident.

Birthplace

Mothers were asked where they had given birth [hospital, midwife led unit (MLU) or home]. A MANCOVA was conducted to highlight any significant differences between birth settings. Bonferroni tests highlighted that infants were rated as less Alert and Responsive after a hospital birth compared to a MLU or home birth: Hospital $M = 39.07$, $SD = 5.26$; MLU $M = 39.70$, $SD = 4.70$; Home $M = 39.83$, $SD = 4.75$ [F (2, 799) = 3.258, $p = 0.039$]. Additionally, infants were rated as more Unsettled and Irregular after a hospital or MLU birth than after a homebirth: Hospital $M = 50.58$, $SD = 12.57$; MLU $M = 50.60$, $SD = 12.56$; Home $M = 45.06$, $SD = 10.13$ [F (2, 799) = 6.788, $p = 0.001$]. Finally, mothers reported lower Lack of Confidence in Breastfeeding after homebirths rather than hospital or MLU births: Hospital $M = 17.06$, $SD = 6.61$; MLU $M = 16.43$, $SD = 5.66$; Home $M = 13.58$, $SD = 4.09$ [F (2, 799) = 6.753, $p = 0.001$].

Start of Labour

A series of MANCOVAs were conducted for each start of labour method in relation to MABS. Notably, infants were significantly less Unsettled-Irregular after Spontaneous Labour ($N = 489$) than by any means of induction: Yes Spontaneous Labour $M = 49.43$, $SD = 12.67$; No Spontaneous Labour $M = 50.67$, $SD = 11.99$ [F (1, 812) = 3.79, $p = 0.05$]. Infants were also less Alert-Responsive after a Sweep ($N = 179$) than after No Sweep: Yes Sweep $M = 38.64$, $SD = 5.50$; No Sweep $M = 39.43$, $SD = 5.00$ [F (1, 812) = 5.77, $p = 0.016$].

Mothers reported *lower* Lack of Confidence in Breastfeeding after Spontaneous Labour: Yes Spontaneous Labour $M = 15.74$, $SD = 6.01$; No Spontaneous Labour $M = 17.68$, $SD = 6.49$ [F (1, 812) = 16.87, $p = 0.000$]. Equally, mothers reported *greater* Lack of Confidence in Breastfeeding after a Membrane Sweep: Yes Membrane Sweep $M = 17.98$, $SD = 7.00$; No Membrane Sweep $M = 16.13$, $SD = 6.01$ [F (1, 812) = 5.99, $p = 0.015$]. Similarly, they reported greater Lack of Confidence in Breastfeeding when Induced by Pessary and Drip ($N = 60$): Yes Pessary and Drip $M = 19.45$, $SD = 8.01$; No Pessary and Drip $M = 16.30$, $SD = 6.07$ [F (1, 812) = 11.26, $p = 0.001$].

Duration of Stages of Labour

Pearson's partial correlations were conducted to assess associations between the length of each labour stage (latent, active and 2nd stage) and MABS scores. Length of Latent Stage was inversely associated with Alert-Responsive infant behaviour, while lengths of Active Stage and Second Stage were positively associated with Unsettled-Irregular infant behaviour and Lack of Confidence in Caretaking and Breastfeeding. Overall, infants were generally less alert, more unsettled and mothers less confident, after a longer labour (see **Table 3**).

Labour Interventions

Mothers responded to a series of questions about interventions that may have occurred during labour. These included whether they had experienced Artificial Rupture of Membranes (ARM), (continuous) Electronic Foetal Monitoring (EFM), Foetal Scalp Electrode (FSE) or a Foetal Blood Sample (FBS). **Table 4** highlights significant differences in MABS outcomes between mothers who reported the presence or absence of these interventions. ARM, acceleration of labour, continuous EFM and FSE were linked to an increase in perceived Unsettled-Irregular infant behaviours, while mothers who experienced ARM also reported their infants as being more Irritable during Feeds. In addition, mothers had greater Lack of Confidence in Caretaking and Breastfeeding after ARM, acceleration of labour, continuous EFM and FSM.

Birth Mode

A series of MANCOVAs assessed differences in perceived infant behaviour and maternal confidence according to Birth Mode. Infants were most likely to be Unsettled-Irregular after Assisted Birth (see **Table 5**). In addition, mothers felt a greater Lack of Confidence in Caretaking after Assisted Birth or Emergency Caesarean Section and greater Lack of Confidence in Breastfeeding after Assisted Birth.

TABLE 3 | Pregnancy and postnatal complications, stages of labour and MABS.

Factor	Pregnancy complications	Postnatal complications	Stages of labour		
			Latent stage (h) $n = 687$	Active stage (h) $n = 714$	2nd stage (min) $n = 750$
Alert-responsive	−0.016, $p = 0.613$	0.032, $p = 0.322$	−0.101, $p = 0.009^{**}$	0.022, $p = 0.565$	0.029, $p = 0.438$
Unsettled-irregular	0.103, $p = 0.001^{**}$	0.066, $p = 0.041^{*}$	0.045, $p = 0.240$	0.113, $p = 0.003^{**}$	0.099, $p = 0.007^{**}$
Lack of confidence in caretaking	0.140, $p = 0.000^{***}$	0.082, $p = 0.011^{*}$	0.022, $p = 0.561$	0.127, $p = 0.001^{**}$	0.104, $p = 0.005^{**}$
Easiness	−0.070, $p = 0.030^{*}$	−0.009, $p = 0.789$	−0.017, $p = 0.662$	−0.053, $p = 0.162$	−0.049, $p = 0.188$
Global confidence	−0.074, $p = 0.021^{*}$	−0.086, $p = 0.008^{**}$	−0.044, $p = 0.255$	−0.032, $p = 0.392$	−0.068, $p = 0.066$
Alert during feeds	0.010, $p = 0.762$	−0.009, $p = 0.774$	0.033, $p = 0.396$	0.018, $p = 0.630$	−0.019, $p = 0.609$
Irritable during feeds	0.105, $p = 0.001^{**}$	0.086, $p = 0.008^{**}$	0.049, $p = 0.205$	0.022, $p = 0.562$	−0.013, $p = 0.717$
Lack of confidence in breastfeeding	0.088, $p = 0.011^{*}$	0.140, $p = 0.000^{***}$	−0.007, $p = 0.872$	0.095, $p = 0.019^{*}$	0.114, $p = 0.004^{**}$

*Pearson's r: $p < 0.05$.
**Pearson's r: $p < 0.01$.
***Pearson's r: $p < 0.001$.

Pain Ratings and Pain Relief During Labour

Pearson's partial correlations found that Pain Ratings during labour were positively associated with Unsettled-Irregular infant behaviour and inversely associated with overall infant Easiness. Pain Ratings were also associated with lower maternal confidence ratings—both globally and in relation to caretaking (**Table 6**).

In terms of pain relief, nitrous oxide (Entonox) was positively associated with Unsettled-Irregular infant behaviour and Lack of Confidence in Breastfeeding; Pethidine was positively associated with Irritable during Feeds and Lack of Confidence in Caretaking and inversely associated with Global Confidence; Spinal Block was associated with Lack of Confidence in Breastfeeding; while Epidural was associated with less perceived infant Easiness, more Unsettled-Irregular behaviour and lower maternal Confidence in Caretaking and Breastfeeding (**Table 6**).

Natural Methods of Pain Relief During Labour and Birth

Partial correlations highlighted significant associations between certain natural methods of pain control and infant behaviour. Hypnobirthing was inversely associated with Unsettled-Irregular, $r\ (234) = -0.068$, $p = 0.033$. Reflexology during labour was positively associated with perceived infant Easiness [$r\ (9) = 0.071$, $p = 0.026$] and Acupuncture during labour was inversely associated with Alert during Feeds [$r\ (6) = -0.071$, $p = 0.026$]. Thus, infants were reported as 'easier' after Reflexology and as more 'relaxed during feeds' after Acupuncture. However, both Acupuncture ($n = 8$, 0.8%) and Reflexology ($n = 11$, 1.1%) had small sample sizes, undermining the reliability of these findings. Therefore, Reflexology and Acupuncture were excluded from further analyses.

Tearing and Episiotomy

A MANCOVA employing the Bonferroni correction explored differences between mothers who had or had not experienced a 'Tear or Episiotomy'. Notably, Episiotomy was too small a group to include as a stand-alone item ($n = 4$, 0.4%). Although there were no significant differences in perceived infant behaviour, differences in maternal Global Confidence were seen between 'No Tear' ($n = 187$) and 'Tear or Episiotomy' ($n = 812$): No Tear $M = 18.20$, $SD = 1.76$; Tear or Episiotomy $M = 17.63$, $SD = 1.86$ [$F\ (1,\ 815) = 10.351$, $p = 0.001$].

Foetal and Neonatal Distress

MANCOVAs were conducted between MABS and foetal or neonatal distress signals. Significant increases were seen for Unsettled-Irregular and Irritable during Feeds after Foetal Distress (**Table 7**). Maternal confidence scores were also lower after Foetal Distress. No significant differences were seen for any MABS infant behaviour items after Meconium in Waters, although Confidence in Caretaking and Breastfeeding scores were significantly lower. Global Confidence was less after Resuscitation.

Gentle Birth of Head

Mothers were asked to recall how gently their baby's head had been born on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). This factor was then transformed into a dichotomous variable: 'Gentle Birth of Head' or 'Other' (a non-gentle birth of the head). Infants were perceived as more Alert-Responsive, less Unsettled-Irregular and Easier overall after a Gentle Birth. In addition, Gentle Birth of Head led to an increase in Global Confidence scores alongside a decrease in Lack of Confidence in Breastfeeding scores (**Table 7**).

Skin-to-Skin Care

MANCOVAs were conducted to differentiate between infants who did or did not have immediate skin-to-skin contact with their mother post-birth. Infants who experienced immediate 'Skin-to-Skin' contact were reported as less Unsettled-Irregular: Yes Skin to Skin $M = 49.63$, $SD = 12.39$; No Skin to Skin $M = 54.30$, $SD = 11.88$ [$F\ (1,\ 812) = 11.826$, $p = 0.001$]. Infants were also reported as Easier overall: Yes Skin to Skin $M = 24.25$, $SD = 2.29$; No Skin to Skin $M = 23.55$, $SD = 2.21$ [$F\ (1, 812) = 6.491$, $p = 0.011$].

Overall, mothers reported less Lack of Confidence in Caretaking if they had experienced immediate skin-to-skin contact with their baby post-birth: Yes Skin to Skin $M = 31.96$, $SD = 8.55$; No Skin to Skin $M = 34.96$, $SD = 7.72$ [$F\ (1, 812) = 4.773$, $p = 0.029$]. They also reported less Lack of Confidence in

TABLE 4 | Labour interventions and MABS.

Factor MABS	Labour intervention—M (SD) and significance														
	ARM *n* = 209			Acceleration *n* = 191			EFM *n* = 363			FSE *n* = 159			FBS *n* = 46		
	Yes	No	*Sig.*	Yes	No	*Sig.*	Yes	No	*Sig.*	Yes	No	*Sig.*	Yes	No	*Sig.*
A-R	38.66 (5.66)	39.47 (4.92)	F (1,779) = 3.11, p = 0.078	39.08 (5.29)	39.32 (5.10)	F (1, 790) = 0.38, p = 0.537	39.23 (5.06)	39.30 (5.22)	F (1,788) = 0.67, p = 0.413	39.30 (5.13)	39.30 (5.16)	F (1,740) = 0.34, p = 0.562	38.80 (4.89)	39.38 (5.07)	F (1,728) = 0.14, p = 0.708
U-I	51.42 (12.90)	49.29 (12.16)	F (1,779) = 4.59, p = 0.032*	51.62 (12.67)	49.35 (12.32)	F (1, 790) = 4.73, p = 0.030*	51.66 (12.43)	48.67 (12.34)	F (1,788) = 11.93, p = 0.001**	52.01 (11.79)	49.45 (12.71)	F (1,740) = 4.74, p = 0.030*	53.26 (12.87)	49.67 (12.47)	F (1,728) = 2.40, p = 0.122
LCC	33.49 (9.36)	31.73 (8.30)	F (1,779) = 4.67, p = 0.031*	34.14 (8.50)	31.56 (8.52)	F (1, 790) = 5.06, p = 0.025*	33.67 (8.77)	31.04 (8.22)	F (1,788) = 10.16, p = 0.001**	33.58 (8.79)	31.83 (8.48)	F (1,740) = 1.13, p = 0.287	35.46 (8.18)	31.90 (8.51)	F (1,728) = 4.23, p = 0.040*
Easy	24.28 (2.33)	24.17 (2.28)	F (1,779) = 0.40, p = 0.532	24.16 (2.25)	24.20 (2.31)	F (1, 790) = 0.09, p = 0.761	24.15 (2.17)	24.23 (2.40)	F (1,788) = 0.50, p = 0.481	24.22 (2.36)	24.20 (2.30)	F (1,740) = 0.03, p = 0.872	24.09 (2.15)	24.18 (2.30)	F (1,728) = 0.01, p = 0.927
GC	17.71 (1.85)	17.74 (1.88)	F (1,779) = 0.00, p = 0.952	17.54 (1.91)	17.80 (1.84)	F (1, 790) = 1.09, p = 0.297	17.66 (1.88)	17.81 (1.86)	F (1,788) = 0.46, p = 0.496	17.75 (1.79)	17.78 (1.88)	F (1,740) = 0.20, p = 0.655	17.22 (2.04)	17.78 (1.87)	F (1,728) = 2.39, p = 0.122
ADF	16.64 (4.26)	16.90 (4.51)	F (1,779) = 0.25, p = 0.618	16.86 (4.23)	16.77 (4.50)	F (1, 790) = 0.17, p = 0.680	17.02 (4.36)	16.59 (4.48)	F (1,788) = 1.48, p = 0.225	16.80 (4.17)	16.86 (4.47)	F (1,740) = 0.17, p = 0.679	17.09 (4.49)	16.84 (4.42)	F (1,728) = 0.273, p = 0.601
IDF	20.07 (7.25)	18.92 (6.62)	F (1,779) = 4.09, p = 0.044*	19.09 (6.80)	19.25 (6.82)	F (1, 790) = 0.48, p = 0.490	19.43 (7.04)	19.07 (6.70)	F (1,788) = 0.10, p = 0.750	19.87 (6.82)	19.10 (6.84)	F (1,740) = 1.06, p = 0.304	20.19 (6.50)	19.15 (6.83)	F (1,728) = 0.19, p = 0.661
LCBF	18.07 (7.00)	15.87 (5.85)	F (1,779) = 12.95, p = 0.000***	18.43 (6.62)	15.84 (6.02)	F (1, 790) = 12.62, p = 0.000***	17.86 (7.01)	15.43 (5.34)	F (1,788) = 19.11, p = 0.000***	17.35 (7.06)	16.15 (5.97)	F (1,740) = 1.90, p = 0.169	19.00 (7.17)	16.30 (6.17)	F (1,728) = 4.83, p = 0.028*

*MABS factors are defined in **Table 1**.*

**Multivariate analysis of covariance F ratios: $p < 0.05$.*

***Multivariate analysis of covariance F ratios: $p < 0.01$.*

****Multivariate analysis of covariance F ratios: $p < 0.001$.*

TABLE 5 | Birth mode and MABS.

Factor	Mode of birth—mean (SD)				
	Normal ***n*** **= 646**	**Assisted** ***n*** **= 147**	**Planned C-section** ***n*** **= 66**	**Emergency C-section** ***n*** **= 136**	**Significance**
A-R	39. 21 (5.19)	39.68 (4.43)	38.90 (5.55)	39.18 (5.35)	F (3, 802) = 0.69, p = 0.559
U-I	49.01 (12.14)	52.52 (13.25)	51.43 (12.07)	51.47 (12.61)	F (3, 802) = 3.20, p = 0.023*
LCC	31.18 (8.34)	34.96 (8.69)	31.75 (8.78)	34.57 (8.29)	F (3, 802) = 4.352, p = 0.005**
Easy	24.21 (2.31)	24.42 (2.37)	23.79 (2.20)	24.03 (2.09)	F (3, 802) = 1.28, p = 0.279
GC	17.85 (1.79)	17.42 (2.07)	17.51 (1.98)	17.51 (1.87)	F (3, 802) = 1.56, p = 0.196
ADF	16.56 (4.37)	17.56 (4.34)	17.90 (4.95)	16.67 (4.33)	F (3, 802) = 2.74, p = 0.042*
IDF	19.01 (6.45)	20.06 (7.72)	19.53 (7.56)	19.32 (7.48)	F (3, 802) = 0.31, p = 0.817
LCBF	15.8 (5.7)	19.2 (8.3)	17.0 (5.9)	17.5 (6.1)	F (3, 802) = 7.07, p = 0.000***

MABS items are defined in ***Table 1****.*
**Multivariate analysis of covariance F ratios: p < 0.05.*
***Multivariate analysis of covariance F ratios: p < 0.01.*
****Multivariate analysis of covariance F ratios: p < 0.001.*

TABLE 6 | Pain ratings, pain relief and MABS.

Factor	Pain ratings and pain relief						
	Pain level ***n*** **= 955**	**No meds.** ***n*** **= 79**	**G and A** ***n*** **= 696**	**Pethidine** ***n*** **= 141**	**Spinal** ***n*** **= 112**	**Epidural** ***n*** **= 224**	**General anaesthetic** ***n*** **= 12**
A-R	−0.049, p = 0.131	0.021, p = 0.506	−0.056, p = 0.081	−0.037, p = 0.256	−0.018, p = 0.572	−0.029, p = 0.375	−0.001, p = 0.972
U-I	0.142, p = 0.000***	−0.025, p = 0.430	0.073, p = 0.022*	0.056, p = 0.083	0.029, p = 0.375	0.109, p = 0.001**	0.038, p = 0.238
LCC	0.085, p = 0.009**	−0.035, p = 0.271	0.047, p = 0.141	0.090, p = 0.005**	0.043, p = 0.185	0.156, p = 0.000***	0.057, p = 0.075
Easy	−0.070, p = 0.032*	0.044, p = 0.167	−0.049, p = 0.126	0.008, p = 0.808	0.034, p = 0.292	−0.075, p = 0.020*	−0.008, p = 0.801
GC	−0.073, p = 0.026*	0.003, p = 0.930	−0.033, p = 0.299	−0.072, p = 0.024*	−0.058, p = 0.070	−0.037, p = 0.249	0.046, p = 0.151
ADF	−0.013, p = 0.683	0.031, p = 0.328	−0.041, p = 0.197	0.014, p = 0.660	0.012, p = 0.710	−0.003, p = 0.923	0.034, p = 0.294
IDF	0.055, p = 0.092	−0.048, p = 0.135	0.021, p = 0.505	0.068, p = 0.034*	0.021, p = 0.521	0.039, p = 0.223	0.029, p = 0.374
LCBF	0.016, p = 0.657	−0.012, p = 0.546	0.073, p = 0.035*	−0.020, p = 0.559	0.072, p = 0.038*	0.148, p = 0.000***	0.034, p = 0.326

MABS items are defined in ***Table 1****; No meds., no pain relief and G and A, gas and air.*
**Pearson's r: p < 0.05.*
***Pearson's r: p < 0.01.*
****Pearson's r: p < 0.001.*

Breastfeeding after immediate skin-to-skin contact with their baby: Yes Skin to Skin M = 16.37, SD = 6.16; No Skin to Skin M = 18.90, SD = 7.43 [F (1, 812) = 8.493, p = 0.004].

Feeding Method: First Feed

The sample consisted of 882 (88.3%) mothers who initiated breastfeeding and 117 (11.7%) who began feeding by any other method, such as syringe fed, formula or expressed bottle fed. Therefore, to facilitate further analyses, First Feed was dichotomised into two groups: Breastfed ('breastfed') and Other ('expressed', 'formula' or 'other'). In a MANCOVA for First Feed and MABS, perceptions of Unsettled-Irregular infant behaviours increased if the First Feed was 'Other': First Feed Breastfed M = 49.56, SD = 12.27; Other M = 54.06, SD = 13.26 [F (1, 811) = 5.436, p = 0.020].

Current Feeding Method

Current Feed responses were likewise dichotomised: 'Currently Breastfed' and 'Other'. The sample consisted of 850 participants (85.1%) who were currently breastfeeding, while 146 (14.6%) were feeding by another method (e.g. formula). A MANCOVA was conducted for Current Feeding Method and MABS. Infants were less Alert during Feeds if currently breastfeeding: Currently Breastfed M = 16.73, SD = 4.36; Other M = 20.05, SD = 5.37 [F (1, 812) = 5.339, p = 0.021]. Mothers also understandably had *lower* Lack of Confidence in Breastfeeding if they were currently breastfeeding their baby: Currently Breastfed M = 16.45, SD = 6.20; Other M = 20.33, SD = 8.64 [F (1, 812) = 3.901, p = 0.049].

Subjective and Psychological Factors, Infant Behaviour and Maternal Confidence

As outlined in the Data Analysis section, PCA with Direct Oblimin rotation methods were used to analyse multiple subjective statements regarding mothers' personal experiences of pregnancy, childbirth and the postnatal period, as well as her overall perceptions of the birth experience.

As there was no one validated scale that covered individual maternal responses to the whole perinatal period, subjective

TABLE 7 | Foetal distress signals, gentle birth of head and MABS.

Factor M (SD)	Foetal distress Yes *n* = 194 M(SD)			Meconium in waters Yes *n* = 173 M(SD)			Resuscitation Yes *n* = 57 M(SD)			Gentle birth of head Yes *n* = 369 other *n* = 630 M(SD)		
	Yes	No	Sig.	Yes	No	Sig.	Yes	No	Sig.	Yes	Other	Sig.
A-R	39.56 (4.84)	39.19 (5.18)	F (1, 812) = 0.835, p = 0.361	39.39 (4.71)	39.23 (5.20)	F (1, 812) = 0.041, p = 0.839	39.32 (5.13)	39.26 (5.12)	F (1, 812) = 0.027, p = 0.870	39.71 (4.91)	38.98 (5.23)	F (1, 811) = 4.747, p = 0.030*
U-I	54.41 (13.22)	48.97 (12.02)	F (1, 812) = 21.168, p = 0.000***	51.21 (13.39)	49.68 (12.20)	F (1, 812) = 2.612, p = 0.106	52.94 (12.35)	49.75 (12.39)	F (1, 812) = 3.811, p = 0.051	47.51 (11.77)	51.44 (12.56)	F (1, 811) = 16.636, p = 0.000***
LCC	34.83 (8.90)	31.58 (8.35)	F (1, 812) = 12.018, p = 0.001**	34.23 (8.35)	31.74 (8.51)	F (1, 812) = 4.959, p = 0.026*	32.77 (6.88)	32.12 (8.62)	F (1, 812) = 0.647, p = 0.421	30.80 (8.03)	32.99 (8.73)	F (1, 811) = 5.551, p = 0.019*
Easy	24.08 (2.32)	24.22 (2.28)	F (1, 812) = 0.348, p = 0.555	23.96 (2.19)	24.25 (2.31)	F (1, 812) = 2.903, p = 0.089	23.55 (2.51)	24.24 (2.27)	F (1, 812) = 4.245, p = 0.040	24.47 (2.29)	24.03 (2.27)	F (1, 811) = 6.110, p = 0.014*
GC	17.19 (1.97)	17.86 (1.81)	F (1, 812) = 13.928, p = 0.000***	17.59 (1.89)	17.77 (1.85)	F (1, 812) = 0.849, p = 0.357	17.19 (2.18)	17.77 (1.83)	F (1, 812) = 4.903, p = 0.027*	18.08 (1.71)	17.53 (1.91)	F (1, 811) = 11.706, p = 0.001**
ADF	16.53 (4.22)	16.85 (4.45)	F (1, 812) = 0.667, p = 0.414	16.25 (4.32)	16.90 (4.42)	F (1, 812) = 2.888, p = 0.090	16.00 (4.03)	16.84 (4.43)	F (1, 812) = 1.362, p = 0.243	16.75 (4.44)	16.82 (4.40)	F (1, 811) = 0.068, p = 0.794
IDF	20.74 (8.02)	18.91 (6.51)	F (1, 812) = 6.911, p = 0.009**	19.72 (7.15)	19.13 (6.77)	F (1, 812) = 0.898, p = 0.344	19.85 (6.29)	19.19 (6.86)	F (1, 812) = 0.909, p = 0.341	18.52 (6.01)	19.67 (7.27)	F (1, 811) = 3.033, p = 0.082
LCBF	19.38 (8.14)	15.92 (5.63)	F (1, 812) = 14.704, p = 0.000***	18.65 (7.39)	16.11 (5.95)	F (1, 812) = 11.937, p = 0.001**	17.00 (6.54)	16.50 (6.27)	F (1, 812) = 0.451, p = 0.502	15.18 (5.22)	17.37 (6.72)	F (1, 811) = 13.307, p = 0.000***

*MABS items are defined in **Table 1**.*

**Multivariate analysis of covariance F ratios: $p < 0.05$.*

***Multivariate analysis of covariance F ratios: $p < 0.01$.*

****Multivariate analysis of covariance F ratios: $p < 0.001$.*

statements around the mother's sense of her own physical and psychological wellbeing during the three major stages (pregnancy, childbirth and the postnatal period) were derived from the literature. Questions relating to women's subjective birth and perinatal experiences were analysed using principal components analysis (PCA) and explained 62%–68% of the variance for each period, as well as for maternal overall perceptions of her birth experience. This compares well to Foley et al. (2014) validation of the Birth Memories and Recall Questionnaire (The Birth MARQ), which examines the relationship between childbirth memories and postpartum mood disorders, explaining 64% of the variance. It also compares favourably to the Childbirth Questionnaire (Dencker et al., 2010) which accounted for 54% of the total variance, with a focus on maternal satisfaction with the birth rather than on her emotional responses to birth and perinatal experiences. Our results showed good internal consistency and reliability between factors stemming from the PCA (Field, 2009) and were therefore considered fit for use in subsequent analyses in relation to infant behaviour.

Subjective pregnancy states included 'felt happy and excited/anxious and fearful about the birth' (labelled Positive Pregnancy Emotions) and 'had plenty of energy/felt tired and drained' (labelled Positive Physical Pregnancy). In both cases, a higher score indicated a more positive subjective experience. Subjective birth states included: Positive ('strong, happy, energised and focused'); Neglected ('abandoned' or 'ignored'); Aware-Alert ('aware' and 'alert'); and Anxious-Afraid ('anxious, afraid, vulnerable and overwhelmed') Birth Emotions.

These subjective pregnancy and childbirth factors in relation to MABS are presented in **Table 8**. Pearson's partial correlations identified numerous significant associations between subjective experiences of pregnancy, childbirth and the postnatal period and reported infant behaviour. Positive maternal experiences were associated with easier infant behaviour, while negative experiences were associated with more challenging infant behaviour (**Table 8**).

Next, Pearson's partial correlations were conducted between subjective maternal postnatal states, the mother's overall perceptions of her birth experience and her baby's temperament. Feeling physically and mentally positive post-birth and having an overall positive, supported experience were associated with maternal perceptions of easier and more settled infant behaviour. Equally, feeing distressed postnatally and having a more directed birth experience overall were associated with more difficult, unsettled infant behaviour (see **Table 8**). Notably, the factor Maternal Postnatal Distress comprised nine items describing negative emotions, such as anger, guilt, confusion and distress. Conversely, Postnatal Positive comprised eight items describing positive postnatal emotions, such as euphoria, exhilaration, relief and pride.

Personality, Postnatal Mood and Current State

Maternal personality (TIPI), postnatal mood (EPDS) and current state (STAI State) were significantly associated with MABS items. For example, a more positive mood, feeling calm and traits, such as Openness to new experiences and Emotional Stability, were associated with easier infant behavioural style (see **Table 9**).

Perinatal Predictors of Infant Behaviour and Maternal Confidence

As described above, multiple physical and psychological factors were associated with MABS. The next section examines the factors that best predicted infant behaviour and maternal confidence when all other significant variables were held constant. STAI State was highly correlated with EPDS (>0.7). Given that STAI State probably reflected the mother's current (postnatal) mood, it was decided that EPDS would remain. Consequently, STAI State was removed in the following analyses to reduce multicollinearity.

Regression Analyses for MABS

As multiple physical and psychological factors were associated with MABS, the next section examines the factors that best predicted perceived infant behaviour and maternal confidence. Multiple linear regression analyses were conducted for each MABS item to predict maternal reports of infant behaviour and her own self-reported confidence. Significant perinatal factors for infant behaviour and maternal confidence—as highlighted by the Pearson's correlations and MANCOVAs described above—were entered into the final regression models.

MABS items were split into infant behaviours (**Table 10**) and maternal confidence (**Table 11**). Infant behaviour was predicted by a combination of (current) infant age, maternal demographic background, subjective physical and psychological experiences of childbirth and the postnatal period (e.g. Anxious-Afraid Birth Emotions or Postnatal Physical Wellbeing) and psychological factors (e.g. EPDS scores), while more objective physical factors, such as Number of Postnatal Complications, did not remain significant in the final regression model. For example, Alert-Responsive infant behaviour was predicted by higher infant age, maternal openness, lack of maternal higher education, having a supported experience and feeling positive post-birth (**Table 10**). Therefore, infants generally grew more settled, alert and responsive with increased age, regardless of their birth experience, although infant 'easiness' or how unsettled they were perceived as was still affected by maternal mood (EPDS scores) and personality, as can be seen in the regression table for infant behaviour (**Table 10**).

The predominant predictors of maternal confidence were whether she had given birth before, known as parity (Number of Children), her subjective perinatal experience (e.g. Postnatal Positive) and psychological factors, such as EPDS and Emotional Stability (**Table 11**).

In summary, **Figure 1** highlights the main factors identified as having the strongest associations and predictive values for infant behavioural outcomes. It emphasises the equal importance of physical and psychological factors at all stages of the perinatal journey and the ability of appropriate levels of social and professional support to shield and protect mother and infant from the immediate and potentially long-lasting impacts of a negative birth experience.

DISCUSSION

The aim of this study was to examine how maternal physical and psychological experiences of pregnancy, childbirth and the early postnatal period may be associated with the mother's

TABLE 8 | Subjective pregnancy states, birth emotions, postnatal states, overall birth experience and MABS.

Factor	Pregnancy states $n = 981$		Birthing emotions $n = 944$				Postnatal states $n = 945$			Overall birth experience $n = 908$		
	Positive emotions	Positive physical	Positive	Neglected	Aware-alert	Anxious-afraid	Postnatal distress	Postnatal positive	Postnatal physical wellbeing	Positive	Supported	Directed
A-R	0.085, $p = 0.009^{**}$	0.067, $p = 0.039^{*}$	0.189, $p = 0.000^{***}$	−0.126, $p = 0.000^{***}$	0.064, $p = 0.052$	−0.078, $p = 0.018$	−0.121, $p = 0.000^{***}$	0.243, $p = 0.000^{***}$	0.058, $p = 0.079$	0.123, $p = 0.000^{***}$	0.165, $p = 0.000^{***}$	−0.075, $p = 0.026^{*}$
U-I	−0.241, $p = 0.000^{***}$	−0.202, $p = 0.000^{***}$	−0.197, $p = 0.000^{***}$	0.148, $p = 0.000^{***}$	−0.094, $p = 0.004^{**}$	0.297, $p = 0.000^{***}$	0.259, $p = 0.000^{***}$	−0.208, $p = 0.000^{***}$	−0.256, $p = 0.000^{***}$	−0.207, $p = 0.000^{***}$	−0.112, $p = 0.001^{**}$	0.138, $p = 0.000^{***}$
LCC	−0.128, $p = 0.000^{***}$	−0.111, $p = 0.001^{**}$	−0.100, $p = 0.002^{**}$	0.136, $p = 0.000^{***}$	−0.120, $p = 0.000^{***}$	0.196, $p = 0.000^{***}$	0.221, $p = 0.000^{***}$	−0.110, $p = 0.001^{**}$	−0.149, $p = 0.000^{***}$	−0.178, $p = 0.000^{***}$	−0.104, $p = 0.002^{**}$	0.126, $p = 0.000^{***}$
Easy	0.156, $p = 0.000^{***}$	0.091, $p = 0.005^{**}$	0.148, $p = 0.000^{***}$	−0.088, $p = 0.008^{**}$	0.028, $p = 0.392$	−0.160, $p = 0.000^{***}$	−0.164, $p = 0.000^{***}$	0.193, $p = 0.000^{***}$	0.119, $p = 0.000^{***}$	0.143, $p = 0.000^{***}$	0.081, $p = 0.015^{*}$	−0.044, $p = 0.192$
GC	0.229, $p = 0.000^{***}$	0.171, $p = 0.000^{***}$	0.187, $p = 0.000^{***}$	−0.079, $p = 0.016^{*}$	0.093, $p = 0.005^{**}$	−0.205, $p = 0.000^{***}$	−0.188, $p = 0.000^{***}$	0.213, $p = 0.000^{***}$	0.211, $p = 0.000^{***}$	0.176, $p = 0.000^{***}$	0.089, $p = 0.008^{**}$	−0.049, $p = 0.143$
ADF	0.030, $p = 0.354$	0.071, $p = 0.027^{*}$	0.068, $p = 0.037^{*}$	−0.049, $p = 0.137$	0.019, $p = 0.558$	−0.040, $p = 0.224$	−0.041, $p = 0.210$	0.074, $p = 0.024^{*}$	0.058, $p = 0.076$	0.041, $p = 0.217$	0.051, $p = 0.132$	0.015, $p = 0.658$
IDF	−0.172, $p = 0.000^{***}$	−0.180, $p = 0.000^{***}$	−0.110, $p = 0.001^{**}$	0.056, $p = 0.091$	−0.095, $p = 0.004^{**}$	0.134, $p = 0.000^{***}$	0.136, $p = 0.000^{***}$	−0.137, $p = 0.000^{***}$	−0.172, $p = 0.000^{***}$	−0.092, $p = 0.006^{**}$	−0.047, $p = 0.160$	0.034, $p = 0.318$
LCBF	−0.136, $p = 0.000^{***}$	−0.048, $p = 0.163$	−0.056, $p = 0.110$	0.165, $p = 0.000^{***}$	−0.100, $p = 0.004^{**}$	0.200, $p = 0.000^{***}$	0.178, $p = 0.000^{***}$	−0.070, $p = 0.048^{*}$	−0.206, $p = 0.000^{***}$	−0.179, $p = 0.000^{***}$	−0.072, $p = 0.045^{*}$	0.155, $p = 0.000^{***}$

*MABS items are defined in **Table 1**.*

**Pearson's r: $p < 0.05$.*

***Pearson's r: $p < 0.01$.*

****Pearson's r: $p < 0.001$.*

TABLE 9 | Maternal personality (TIPI), postnatal mood (EPDS), current state (STAI State) and MABS.

Measure	Factor	Big 5 personality traits (TIPI) *N* = 953					EPDS total *N* = 922	State anxiety *N* = 947
		Extroversion	Agreeable	Conscientious	Emotional stability	Openness		
MABS	Alert-responsive	0.075, $p = 0.023^{*}$	0.095, $p = 0.004^{**}$	0.043, $p = 0.190$	0.065, $p = 0.047^{*}$	0.129, $p = 0.000^{***}$	–0.123, $p = 0.000^{***}$	–0.158, $p = 0.000^{***}$
	Unsettled-irregular	–0.122, $p = 0.000^{***}$	–0.134, $p = 0.000^{***}$	–0.162, $p = 0.000^{***}$	–0.291, $p = 0.000^{***}$	–0.150, $p = 0.000^{***}$	0.412, $p = 0.000^{***}$	0.396, $p = 0.000^{***}$
	Lack of confidence in caretaking	–0.084, $p = 0.010^{*}$	–0.050, $p = 0.128$	–0.102, $p = 0.002^{**}$	–0.240, $p = 0.000^{***}$	–0.008, $p = 0.814$	0.380, $p = 0.000^{***}$	0.315, $p = 0.000^{***}$
	Easiness	0.082, $p = 0.012^{*}$	0.105, $p = 0.001^{**}$	0.068, $p = 0.037^{*}$	0.165, $p = 0.000^{***}$	0.170, $p = 0.000^{***}$	–0.172, $p = 0.000^{***}$	–0.221, $p = 0.000^{***}$
	Global confidence	0.133, $p = 0.000^{***}$	0.116, $p = 0.000^{***}$	0.149, $p = 0.000^{***}$	0.303, $p = 0.000^{***}$	0.141, $p = 0.000^{***}$	–0.350, $p = 0.000^{***}$	–0.335, $p = 0.000^{***}$
	Alert during feeds	0.084, $p = 0.010^{*}$	0.004, $p = 0.895$	0.138, $p = 0.000^{***}$	0.070, $p = 0.033^{*}$	0.079, $p = 0.016^{*}$	–0.088, $p = 0.008^{**}$	–0.072, $p = 0.028^{*}$
	Irritable during feeds	–0.091, $p = 0.005^{**}$	–0.104, $p = 0.001^{**}$	–0.082, $p = 0.012^{*}$	–0.209, $p = 0.000^{***}$	–0.117, $p = 0.000^{***}$	0.310, $p = 0.000^{***}$	0.286, $p = 0.000^{***}$
	Lack of confidence in breastfeeding	–0.093, $p = 0.008^{**}$	–0.052, $p = 0.142$	–0.027, $p = 0.448$	–0.145, $p = 0.000^{***}$	–0.013, $p = 0.716$	0.227, $p = 0.000^{***}$	0.181, $p = 0.000^{***}$

**Pearson's r: p < 0.05.*
***Pearson's r: p < 0.01.*
****Pearson's r: p < 0.001.*

TABLE 10 | Predictors of infant behaviour (0–6 months).

MABS	Variables	Unstandardised coefficients		Standardised coefficients	*t*	*p*
		B	*SEB*	*β*		
Alert-responsive	Constant	33.941	0.825		41.165	0.000
	Infant age	0.302	0.020	0.440	14.884	0.000
	Higher education	–1.198	0.432	–0.082	–2.772	0.006
	Postnatal positive	0.929	0.161	0.181	5.784	0.000
	Experience supported	0.409	0.159	0.080	2.565	0.010
	Maternal openness	0.348	0.132	0.079	2.642	0.008
Unsettled-irregular	Constant	48.555	1.040		46.695	0.000
	Infant age	–0.331	0.051	–0.196	–6.653	0.000
	Anxious-afraid BE	2.180	0.419	0.171	5.204	0.000
	Number of PN complications	–0.323	0.330	–0.031	–0.981	0.327
	EPDS total	0.902	0.079	0.370	11.400	0.000
Easiness	Constant	22.958	0.434		52.900	0.000
	Infant age	0.054	0.010	0.176	5.476	0.000
	Higher education	–0.547	0.213	–0.083	–2.576	0.010
	Postnatal positive	0.306	0.078	0.133	3.923	0.000
	Birth partner and birth companion	0.551	0.208	0.085	2.645	0.008
	Maternal openness	0.244	0.065	0.124	3.754	0.000
	EPDS total	–0.046	0.015	–0.104	–3.054	0.002
Alert during feeds	Constant	14.785	0.836		17.692	0.000
	Infant age	0.139	0.018	0.234	7.566	0.000
	Higher education	–1.000	0.401	–0.078	–2.494	0.013
	Breastfed currently	–1.904	0.396	–0.151	–4.810	0.000
	Conscientiousness	0.498	0.119	0.129	4.183	0.000
Irritable during feeds	Constant	24.086	1.603		15.026	0.000
	Infant age	–0.179	0.030	–0.190	–6.035	0.000
	Birth weight	–1.363	0.419	–0.102	–3.254	0.001
	PN physical wellbeing	–0.697	0.233	–0.099	–2.991	0.003
	EPDS total	0.380	0.045	0.279	8.443	0.000

B, unstandardised coefficient; SEB, standard error of unstandardised coefficient; β, standardised beta; BE, birth emotions; PN, postnatal; and EPDS, Edinburgh postnatal depression scale (total scores).

perceptions of her infant's behaviour, taking into account broader maternal demographic factors, postnatal mood and personality. The study had several notable findings, and numerous aspects of childbirth and the perinatal period were associated with perceived early infant behaviour. Although certain childbirth interventions, complications, birth mode and types of pain

TABLE 11 | Predictors of maternal confidence and self-efficacy (MABS).

MABS	Variables	Unstandardised coefficients		Standardised coefficients	*t*	*p*
		B	*SEB*	*β*		
Global confidence	Constant	17.481	0.313		55.887	0.000
	Postnatal positive	0.215	0.063	0.114	3.445	0.001
	PN physical wellbeing	0.200	0.063	0.106	3.179	0.002
	Emotional stability	0.172	0.050	0.133	3.427	0.001
	EPDS total	−0.075	0.015	−0.206	−5.116	0.000
Lack of confidence in caretaking	Constant	30.836	0.770		40.052	0.000
	Number of children	−1.987	0.361	−0.166	−5.503	0.000
	EPDS total	0.650	0.053	0.369	12.253	0.000
Lack of confidence in breastfeeding	Constant	30.293	0.775		39.103	0.000
	Number of children	−1.824	0.359	−0.153	−5.081	0.000
	Meconium in waters	2.579	0.726	0.107	3.554	0.000
	EPDS total	0.624	0.053	0.357	11.828	0.000

B, unstandardised coefficient; SEB, standard error of unstandardised coefficient; and β, standardised beta.

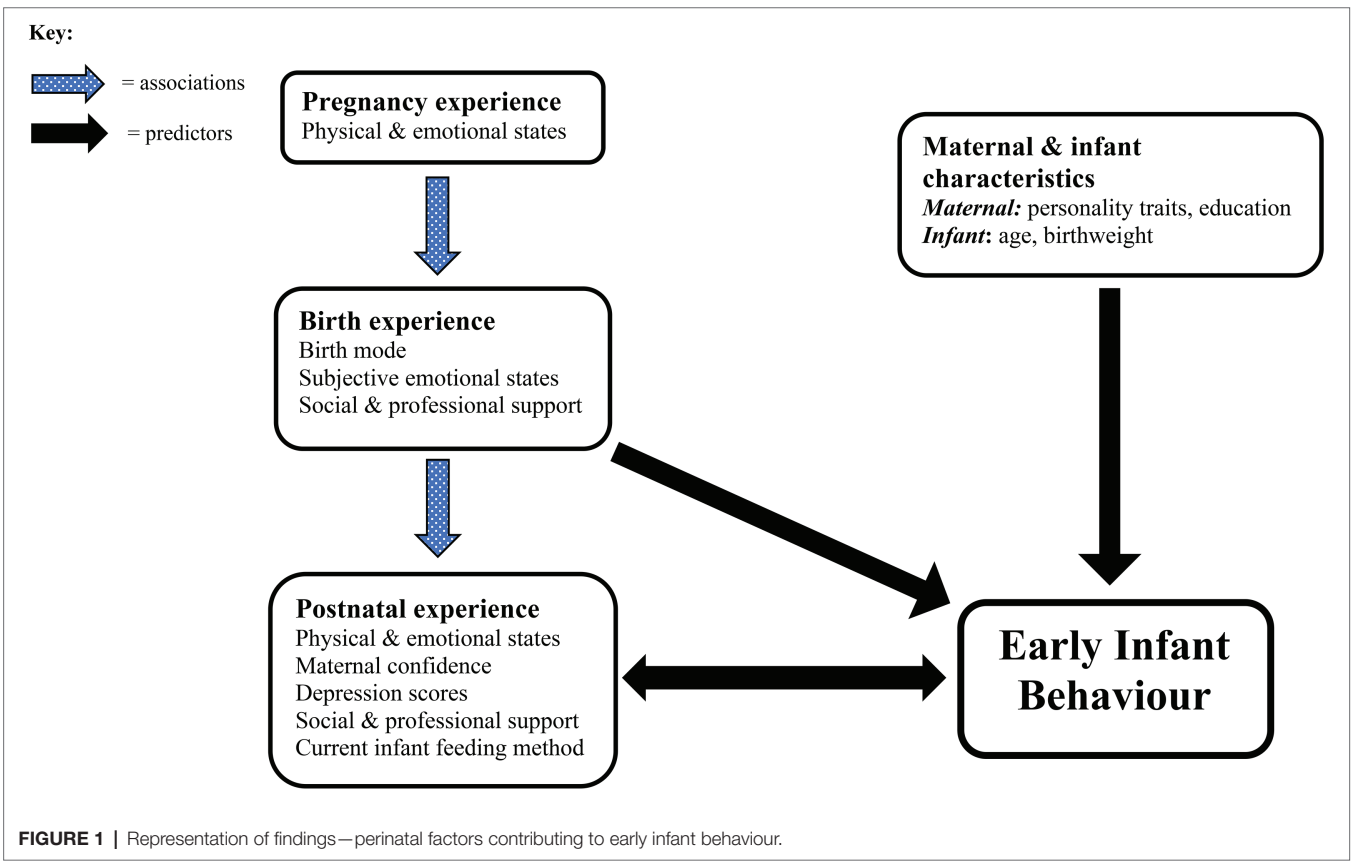

FIGURE 1 | Representation of findings—perinatal factors contributing to early infant behaviour.

relief were associated with less settled infant behaviour (0–6 months), regression analyses highlighted that subjective and psychological factors, alongside maternal personality traits, largely predicted perceived infant behavioural style and maternal confidence outcomes.

In addition, the mother's sense of wellbeing during and post-birth was reflected in higher levels of reported confidence and self-efficacy alongside her perceptions of easier infant behaviour. The predictability of birth events could play a key role in situations where the mother's sense of agency and control is increased or diminished, as research shows that agency in relation to free choice is particularly important for unpredicted negative events (Tanaka and Kawabata, 2019). More specifically, a Dutch study found that women were less happy with the care they received if they had experienced an instrumental vaginal (assisted) birth, an emergency C-section, less control during the active (dilation) stage or a more directed second (pushing) stage (Baas et al., 2017). This may help to explain the differences in maternal and infant responses between planned or unplanned C-sections in the present study. An

elective C-section should involve at least an element of predictability, choice and a chance to prepare.

These findings support the concept that subjective maternal perceptions of childbirth may contribute to early infant temperament development or to maternal perceptions of her baby's behavioural style. This could have important implications for maternity and midwifery practice, particularly for more vulnerable mother–infant pairs, or those who experience a challenging birth. The main findings are further discussed under the following headings.

Physical Perinatal Factors

Although many of the more objective factors, such as interventions, birthplace, birth mode and gentle birth of the infant's head, were associated with infant and maternal outcomes, breastfeeding was the only physiological perinatal factor that retained significance in the regression models for perceived infant behaviour. Specifically, 'currently breastfeeding' was associated with less Unsettled-Irregular behaviour over the first 6 months. Furthermore, infants were reported as less Alert during Feeds if they were currently breastfeeding, indicating that breastfeeding could be less stimulating and more relaxing for the infant. Breastfeeding is an instinctive newborn behaviour, highly sensitive to external stimuli from emotions, such as anxiety and fear (Moore et al., 2016). Its initiation and continuation could therefore be affected by the mother's physical and emotional response to her birth and her new baby, including whether mother and newborn infant were able to have immediate skin-to-skin contact. Moreover, a mother feeling able to breastfeed her baby could signify that she had a more physiological birth with less pain relief (Widström et al., 2011; Brown and Jordan, 2013). Indeed, a systematic review by Uvnäs-Moberg et al. (2019) highlights the associations of spontaneous physiological birth experience with increased hormonal and physiological wellbeing of mother and infant post-birth, which is likely to make initiating and continuing breastfeeding easier.

This finding may also be connected to the close skin-to-skin contact that naturally occurs during breastfeeding, regulating hormonal systems after a challenging birth, enhancing oxytocin and lowering cortisol levels, reducing the negative impacts of pain and stress on neonatal and maternal HPA axes and benefitting mother–infant neurobiological wellbeing and synchrony post-birth (Carter, 2014; Feldman, 2015; Mooney-Leber and Brummelte, 2017).

The Psychological Birth Experience

Consistent with a meta-analysis highting how maternal perceptions of a traumatic birth may contribute more to symptoms of CB-PTSD than objective physical factors, such as birth mode (Ayers et al., 2016), we found that self-reported infant behaviour was largely predicted by psychological and subjective maternal factors. However, this finding could also indicate that strong psychological variables, such as postnatal depression, may override other contributory factors (Leigh and Milgrom, 2008). Indeed, EPDS scores were the strongest predictor of several infant and maternal outcome variables including unsettled, irritable and irregular infant behaviour alongside lower general maternal confidence as well as confidence in caretaking and breastfeeding. These findings could mean that depressed mothers perceive their infant as more difficult (McGrath et al., 2008). Furthermore, they may indicate that the mother's personal feelings of birth trauma, represented here by negative birth and postnatal emotional states, such as Anxious-Afraid, Neglected and Postnatal Distress, contribute equally to PPD and CB-PTSD, with an adverse impact on mother–infant bonding (Stuijfzand et al., 2020), in turn affecting infant temperament. Alternatively, a challenging birth experience could lead directly to increased unsettled infant behaviour *via* physiological pathways, as discussed. This may result in lower maternal confidence combined with more negative thoughts and feelings. Thus, the relationship between mother and infant states of wellbeing or otherwise is likely to be bi-directional (see **Figure 1** above).

Also consistent with Ayers et al. (2016), correlational analyses here showed that certain subjective factors, such as Anxious-Afraid, Postnatal Distress and EPDS scores, were directly related to more interventionist birth modes. Therefore, these findings provide further support for a pathway between obstetric interventions, lack of control, negative birth emotions and postpartum mood disturbances (Blom et al., 2010; Ayers et al., 2016; Field, 2017). In turn, negative postnatal maternal mood may adversely impact on mother–infant interactions and subsequent infant behaviour and development (Murray et al., 2018). Our results show that maternal interpretations of the birth could be equally important to more objective measures, such as birth mode and obstetric complications and interventions.

How Maternal Wellbeing Might Be Associated With Infant Behaviour

There are several potential pathways for how the mother's birth experience, maternal wellbeing and infant behaviour could be interacting with one another.

Maternal Psychological Experience of Birth

Mothers who experienced a difficult birth were more likely to report feeling Anxious-Afraid or Neglected ('ignored' or 'abandoned') during childbirth and distressed postnatally, and these negative emotional states were associated with maternal reports of Unsettled-Irregular infants. As speculated by prior research (Douglas and Hill, 2013), this may be connected to the interacting hormonal systems of mother and infant. Higher cortisol levels can dysregulate the HPA axis, potentially causing long-term changes to the infant microbiome and epigenome (Dahlen et al., 2013, 2014; Almgren et al., 2014), with consequences for future behaviour and development (Gitau et al., 2001; Wolke et al., 2009; Schmid et al., 2010; Prokasky et al., 2017).

In contrast, having a more 'supported' experience and feeling positive post-birth predicted higher scores for Alert-Responsive infant behaviour and overall perceived infant Easiness. These mothers rated their midwife as helpful and informative and felt 'emotionally supported' throughout, reflecting evidence that

mothers experience less anxiety post-childbirth if they feel well cared for during the birth (Field, 2017). This pathway could occur physiologically *via* an easier birth and maternal recovery, with the mother's wellbeing during and post-birth encouraging neonatal wellbeing *via* their inter-connected hormonal systems (Buckley, 2015; Buckley and Uvnäs-Moberg, 2019). Alternatively, a mother who experiences positive birth emotions and therefore increased levels of oxytocin and beta-endorphins, may simply *perceive* her newborn infant more positively. Subjective maternal response to childbirth may therefore be a factor in the mother's own postnatal wellbeing (Ayers et al., 2016) and her subsequent perceptions of and interactions with her baby (Murray et al., 2014, 2018) as well as affecting the infant's behavioural response (Taylor et al., 2000).

Postnatal Mood

Higher maternal postnatal depression (EPDS) scores predicted perceptions of unsettled, irregular and irritable infant behavioural style, supporting previous research identifying a link between postnatal depression and perceptions of more 'difficult' infant behaviour (Gonidakis et al., 2008; Britton, 2011). This relationship is likely to be bi-directional: a crying, irritable infant may affect maternal mood, exacerbated by sleep deprivation (Eastwood et al., 2012), and an infant may become unsettled in response to negative maternal mood (Martini et al., 2017).

EPDS postnatal depression scores were associated with maternal Postnatal Distress, which in turn was associated with both the physical and emotional birth experience, aligning with evidence that negative birth experiences and postnatal psychological states contribute to postpartum depression (Bell and Andersson, 2016). Moreover, a difficult or interventionist birth might lead directly to increased unsettled infant behaviour; and excessive infant crying predicts later EPDS scores, particularly if the mother feels unable to console her baby (Radesky et al., 2013).

Oxytocin promotes bonding and attachment (Feldman, 2017; Uvnäs-Moberg et al., 2019). Conversely, depressed mothers with lower oxytocin levels are more likely to ignore their infant's cues (Mah et al., 2017). Consequently, postnatal depression and maternal withdrawal are associated with interactional difficulties, affecting mother–infant bonding and infant outcomes even after maternal mood improves (Murray et al., 2014, 2018; Oyetunji and Chandra, 2020).

Maternal Personality

As expected, heritable maternal character traits predicted self-reported infant behavioural style and maternal confidence ratings. The mother's personality influences outcomes on three levels: how she feels, the way she responds to her newborn baby and the postnatal environment she creates (Carey and McDevitt, 2016). Therefore, the impact of maternal personality on infant behaviour occurs through a combination of genetic and environmental influences. Although the personality trait 'Emotional Stability' was not retained as a predictor variable for perceived infant behaviour, it predicted Global Confidence and was inversely related to EPDS scores which came through as a strong predictor of Unsettled-Irregular infant behaviour over the first 6 months. Thus, maternal mood, personality and infant temperament were reciprocally associated.

Birth Companions

A less anticipated finding was that the presence of an extra birth companion alongside the birth partner positively predicted maternal perceptions of infant Easiness. Potentially, having two continuously supportive figures in the birthing room contributes more effectively to a positive birth experience with positive outcomes, including enhanced maternal perceptions of her baby. Furthermore, we know that continuous emotional support from a female companion, such as a doula, may lessen maternal stress levels, boost oxytocin (Buckley, 2015) and encourage a shorter labour and a normal birth, with lower use of analgesia and higher infant Apgar scores (Bohren et al., 2017). Decades of research illustrate the positive psychological impacts of doula support (Sosa et al., 1980; Kennell et al., 1991; Bohren et al., 2017). For instance, mothers accompanied in labour by a doula are known to have increased confidence in caretaking, lower levels of depression and to think more positively of their infants (Klaus and Kennell, 1997).

Sociodemographic Status and Maternal Expectations of Motherhood

Finally, sociodemographic variables were associated with certain types of infant behaviour. Mothers who did not attend higher education perceived their infants as more alert, responsive and easier overall. These findings might be explained through examining previous research which shows that mothers with higher education in established careers can find the transition to motherhood more challenging and have lower life satisfaction after having a baby (Harwood et al., 2007). This general negative mood could in turn affect the mother's perceptions of her baby's behaviour (McGrath et al., 2008). Furthermore, parents of higher social classes may have higher expectations of their children's future (Lareau, 2011; Irwin and Elley, 2013). Unrealistic expectations of their baby could result in disappointment and contribute to depressive symptoms (Martin et al., 2013), in turn negatively impacting on maternal confidence and ability to bond with her infant.

Strengths and Limitations

This study provided an in-depth exploration of a concept previously only alluded to in the research literature on childbirth and infant behaviour: that potentially long-term physiological impacts of childbirth on the infant's behavioural style and stress response system (Douglas and Hill, 2013) could possibly be mediated by the mother's subjective response to the birth (Taylor et al., 2000). Indeed, our findings showed that the mother's subjective response to the birth affected her perceptions of her baby's behaviour more than the objective physical experience. However, care needs to be taken between statistical and clinical significance, particularly where effect sizes are small. Quantitative psychological data often has this issue, in part due to the common inter-correlation of psychological

variables (Field, 2009), the difficulty in separating out such variables and thus the small individual contribution that each one finally makes to the overall picture. Nevertheless, as a whole and often supplemented by qualitative data (e.g. Power et al., 2019), the summative effect of multiple small statistical differences for different though inter-related physical and psychological variables (such as birth mode and postnatal psychological wellbeing/distress) might make an actual difference to real life experiences. Therefore, they become meaningful to maternity and perinatal care in the context of the other research evidence in this area.

Nevertheless, this research is not without limitations. First, while the online nature of the study allowed for a nationwide data collection strategy, this increasingly popular research method may contain drawbacks, especially in equity of recruitment. For instance, non-native English speakers or those without a good level of written English may have felt intimidated by the length of the survey as well as the language contained within the survey. To encourage maximum inclusivity, questions were made as straightforward and self-explanatory as possible with the majority of responses (except for, e.g. birth weight) recorded *via* check boxes. However, ethnic minority use of the Internet is slightly below average (Gov.uk, 2019). This may have contributed to a mostly white Caucasian sample population, which was also skewed toward breastfeeding, older mothers who were living with a partner. Despite this, and although an online survey did not cater for women without Internet access due to factors such as socio-economic deprivation, reportedly most women of childbearing age in the United Kingdom have access to the Internet (Gov.uk, 2019). There was a wide variation in participants' socio-economic status and women from a diverse range of socio-economic groups took part in the survey.

There are drawbacks to employing a self-report retrospective survey linked to the issue of subsequent validity of findings in regard to accurate recall of autobiographical memories (Belli, 1998). However, having had a period of reflection since an emotive or anxious birth situation might in fact aid more accurate recall. Retrospective questionnaires have become a popular, cost-effective and acceptable method of collecting pregnancy and childbirth data (Intong et al., 2017). Moreover, questionnaires about childbirth have been found to have excellent validity during the first few months post-birth (Bat-Erdene et al., 2013).

Retrospective reports of infant behaviour could be affected by biased memories of events and current behaviours during periods involving growth spurts, teething or weaning, all of which may alter the infant's normal behavioural patterns. They could also be influenced by maternal mood, although this effect is considered small (McGrath et al., 2008). Maternal ratings of infant behavioural scores are significantly associated with trained observer ratings (Rothbart et al., 2001; Henderson and Wachs, 2007; Zentner and Bates, 2008). Thus, an infant behaviour questionnaire was chosen that focused on specific everyday infant behaviours over the past 7 days (MABS), and the survey was completed within 6 months of the birth.

As this was a cross-sectional study, a future prospective longitudinal study could measure the same sample of women and infants at various time points throughout their perinatal experience. Importantly, the sample population was self-selecting. This undoubtedly affected the type of participant who completed the online questionnaire, rendering the recruitment strategy less inclusive. Potentially, however, a more homogeneous sample could help clarify findings in terms of specific impacts of childbirth experience on perceived infant behaviour.

Given that these findings provide support for those of a previous qualitative study, with health professional data collected over a similar period (Power et al., 2019), a future study should include a measure of perceived birth trauma and CB-PTSD symptoms as well as a scale for mother–infant interactions and bonding–attachment behaviours. This may provide a more complete picture, such as that suggested by **Figure 2**. The 'hypothetical contributors' shown in **Figure 2** represent items for future testing based on the findings in this study, the aforementioned health professional data and the wider research literature.

Difficulties in bonding and attachment processes could be a key point in this connection between the mother's response to childbirth (e.g. Postnatal Positive/Distress) and interpretations of her baby's behaviour. Stuijfzand et al. (2020) study showed that maternal distress at 1 month postpartum—which was associated with a traumatic birth experience—adversely impacts mother–infant bonding at 3 months postpartum. These authors also highlighted antenatal support in the pathway to a positive or negative birth experience and CB-PTSD. Similarly, Davies et al. (2008) found associations between CB-PTSD symptoms post-childbirth and more negative maternal perceptions of her infant alongside lower attachment; and a large Internet survey of mothers giving birth during the COVID-19 pandemic found that acute stress during childbirth had adverse impacts on mother–infant bonding and breastfeeding (Mayopoulos et al., 2021).

Despite their possible contribution to infant behavioural outcomes, no direct measures were used here to assess symptoms of CB-PTSD or bonding and attachment behaviours between the mother and her baby. Nevertheless, the suggested pathway in this study between maternal birth experience and perceived infant behavioural style—*via* the influences of postpartum maternal mood on mother–infant bonding and attachment—warrants further investigation. To include measures of CB-PTSD symptomology alongside early mother–infant interactions and bonding would therefore add to a more complete theoretical model for future testing (see **Figure 2**). In line with Stuijfzand et al. (2020) findings, professional and social support during pregnancy have been added to this model. Thus, **Figure 2** aims to provide a broader picture of the potential mechanisms behind the associations found in this study between maternal childbirth experience and infant behavioural style. The 'Potential pathway' box illustrates how a negative birth experience may be part of a pathway involving (maternal) Postnatal Distress, symptoms of CB-PTSD, bonding and attachment issues and maternal perceptions of more difficult, unsettled infant behaviour.

Our results add to a large body of research illustrating the complexity of childbirth and its potential outcomes for mother and infant. They highlight how infant and maternal outcomes of childbirth appear to be mutually influenced by one another's response to birth and by multiple physiological and psychological perinatal variables, such as feeling anxious and afraid or neglected

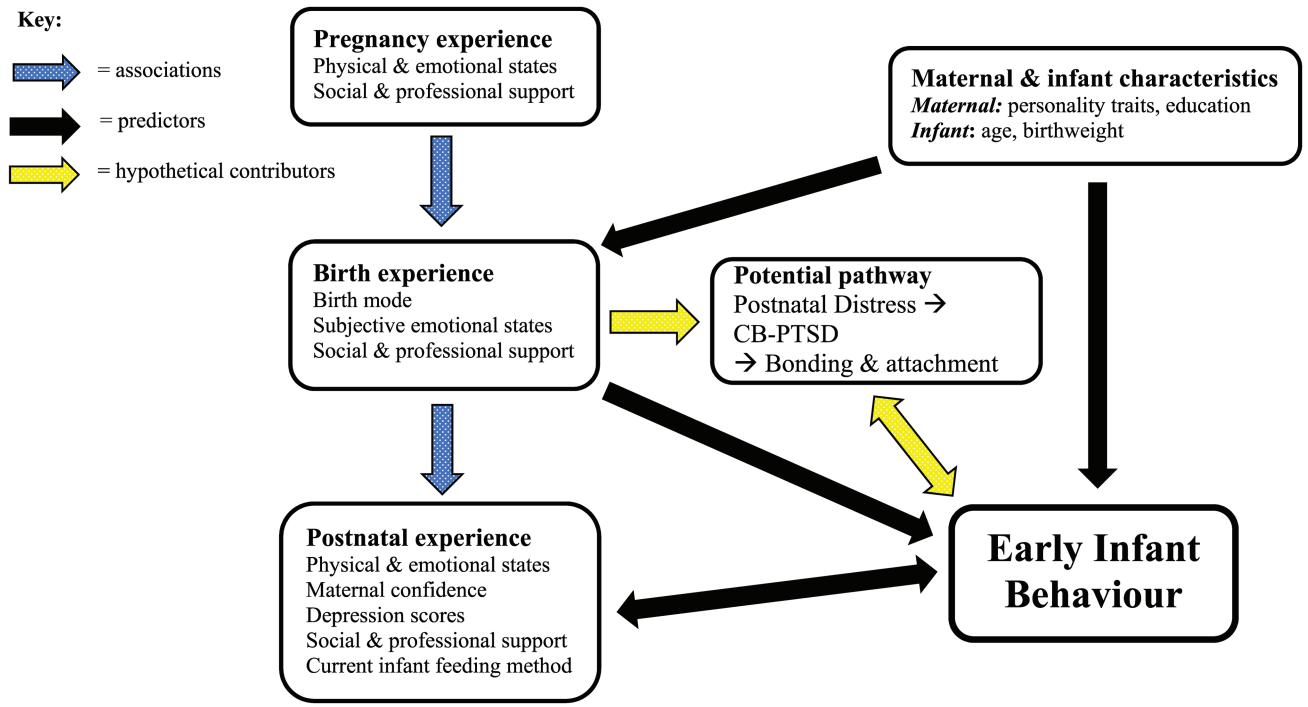

FIGURE 2 | A theoretical model of perinatal factors contributing to early infant behaviour.

during childbirth. Social and professional support the mother receives during the perinatal period may positively enhance her response to childbirth, in turn benefitting her infant's behavioural style. This finding is particularly pertinent in light of United Kingdom maternity policies involving restrictions on home births, water births and partner accompaniment in early labour during the COVID-19 pandemic. In some areas, this led to an increase in women opting for 'free-births' without any professional care—often to keep their partner with them throughout labour and birth and, for others, to avoid catching COVID (Feeley et al., 2021). Restrictions on partner accompaniment during early labour also led to more women accidentally giving birth alone in hospital settings if there happened to be staff shortages and labour was unexpectedly quick (Feeley et al., 2021).

Our findings therefore provide further support for the current United Kingdom maternity and midwifery services' objective to increase staffing numbers, reduce risk and promote a model of safe, consistent, continuous and emotionally supportive care for all expectant mothers (NHS England National Maternity Review, 2016; Scottish Government, 2017; The Regulation and Quality Improvement Authority, Northern Ireland, 2017; Healthcare Inspectorate Wales, 2020). Overall, these United Kingdom-wide reviews emphasise that health care should be both individualised and family centred with a focus on equity of care and informed choice.

The most recent of these maternity reviews—namely the Welsh review (Healthcare Inspectorate Wales, 2020)—although notably its investigations were carried out *pre*-March 2020, observed that maternity services have been very stretched during the COVID-19 pandemic. These problems arising in maternity care across the United Kingdom are intensifying previous issues of staff shortages and a lack of emotionally supportive care and are leading to increased reports of psychological distress in new mothers (Alcindor, 2021). Considering the impacts of the sudden reduction in face-to-face support for mothers and their babies during the early pandemic (Silverio et al., 2021), which is still occurring in some areas of maternity and perinatal care, it is vital that these services are made a priority in the government's plans to 'build back better'. Following the MBRACE report (MBRACE-UK, 2020), an urgent emphasis must especially be placed on equity of care. Thus, both physical and psychological wellbeing during and after childbirth need to become the objective for all mothers and their infants.

Maternity research collaboratives, including The Lancet Midwifery Series (ten Hoope-Bender et al., 2014) and the European Cooperation in Science and Technology (COST, 2020), have highlighted the importance of promoting and valuing high-quality and compassionate midwifery and newborn care for this all-important mother–infant health and wellbeing. This notion of 'quality' midwifery care was set out by ten Hoope-Bender et al. (2014) to include providing preventative, respectful and supportive care to women and their infants, swift medical treatment where required and using medical interventions only when clinically indicated. Consistent with our findings, research evidence around the importance of facilitating optimal neurohormonal states during physiological labour and birth emphasises the inter-connectedness of psychosocial and physiological factors for positive birth outcomes (Downe et al., 2020; Olza et al., 2020). Aligning with prior evidence around the significance of mother–infant

neurobiological wellbeing and synchrony post-birth (Carter, 2014; Feldman, 2015; Mooney-Leber and Brummelte, 2017), our findings show how a positive birth experience enhances postnatal maternal mood and the mother's perceptions and experiences of her baby's early temperament, encouraging a happier and more fulfilling long-term relationship for both.

CONCLUSION

As recommended by the WHO (2018, p. 1) in their intrapartum guidelines supporting women's right to a '*positive birth experience*', this should include '*giving birth to a healthy baby in a clinically and psychologically safe environment with continuity of care and emotional support*'. Promoting maternal emotional wellbeing alongside physical safety during and after childbirth is of paramount importance. High-quality one-to-one midwifery care during childbirth may benefit the mother's physiological and psychological states (Olza et al., 2020) and consequently enhance her perceptions and experiences of her baby's behaviour. Conceivably, protecting the mother's neurohormonal state during childbirth and postnatally could also help to protect her against postpartum mood disorders and in this way promote more sensitive parenting and increase mother–infant bonding behaviours, with a positive impact on infant socio-emotional and cognitive development (Murray et al., 2014, 2018; Field, 2017; Tichelman et al., 2019). This could benefit not only the mothers and infants themselves but also their families and the wider society in which they live.

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 Swansea University Department of Psychology Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CP: design, conceptualisation, methodology, data collection, formal analysis, writing—original draft, writing—review and editing, and project administration. CW and AB: design, conceptualisation, methodology, data analysis support, writing—review and editing, and supervision. All authors gave approval for submission, contributed significantly to the article, and are responsible for its contents.

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Do Maternal Self-Criticism and Symptoms of Postpartum Depression and Anxiety Mediate the Effect of History of Depression and Anxiety Symptoms on Mother-Infant Bonding? Parallel–Serial Mediation Models

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Introduction: History of depression symptoms, including before and during pregnancy, has been identified as an important risk factor for postpartum depression (PPD) symptoms. This condition has also been associated with diverse implications, namely, on the quality of mother–infant bonding. Moreover, the role of self-criticism on PPD has been recently found in several studies. However, the link between these factors has not been explored yet. Furthermore, anxiety symptoms in postpartum has been less studied.

Methods: This study analyzed whether the history of depression symptoms predicted mother–infant bonding, *via* self-criticism and PPD symptoms. The same model was repeated with a history of anxiety and postpartum anxiety symptoms. A total of 550 mothers of infants <24 months old participated in this cross-sectional study and answered an online survey.

Results: Through a parallel–serial mediation model, the results show that in a first step, self-criticism dimensions of inadequate-self, hated-self, and reassuring-self, and in a second step, PPD symptoms, mediate the relationship between the history of depression symptoms and mother–infant bonding. However, the relationship between the history of anxiety symptoms and bonding is not mediated by all the considered chain of mediators, being only mediated by one of the self-criticism dimensions, inadequate self.

Conclusions: The current study confirmed the association of history of both depression and anxiety with mother–infant bonding. While in the case of history of anxiety symptoms, the relation was only mediated by inadequate self-dimension of self-criticism, in the case of history of depression symptoms, the relation was mediated by self-criticism and postpartum depressive symptoms. The buffering effect of reassuring-self on bonding and

negative affect was also evidenced. Psychological and preventive interventions should address this evidence to target interventions for mother–infant bonding problems in accordance with previous and actual current maternal risk factors.

Keywords: bonding, depression, anxiety, self-criticism, mothers, postpartum

INTRODUCTION

With the pregnancy and the birth of a child, mothers face important physiological, psychological, and social challenges and, for some, these periods may entail substantial emotional pain and distress (Staneva et al., 2015). Depression affects 7–25% of women during the antenatal period (Gavin et al., 2005; Field et al., 2006; Dubber et al., 2015; Staneva et al., 2015), and 11–20% of women during the postpartum period, making postpartum depression (PPD) the most prevalent clinical condition after childbirth and an important public health problem (de Tychey et al., 2005). Also, it is estimated that 30–50% of cases will last 6 months or more and 25% of mothers will continue to be depressed 1 year later (National Institute for Health and Care Excellence, 2003). Recent studies had even highlighted the stable and chronic trajectory of these symptoms until at least 24 months after childbirth (Kiviruusu et al., 2020). The PPD is a relatively common postpartum complication with a global pooled prevalence of 17.7% with significant heterogeneity across different nations (Hahn-Holbrook et al., 2018). The PPD is characterized by disabling symptoms such as persistent sadness, low self-esteem, anxiety, irritability and sleep/appetite alterations, dysphoria, loneliness, emotional lability, insomnia, confusion, guilt, and suicidal ideation (Letourneau et al., 2011). The previous psychopathology, specifically the history of prior depression, has been highlighted as one of the most important PPD risk factors (Robertson et al., 2004). More importantly, PPD may not only impact a mother's self-care but also the ability to cope with the care of the child.

In addition to the postpartum depressive symptoms, the symptoms of anxiety symptomatology are also common in postpartum and during pregnancy. Although it remains less studied than PPD and is largely underdiagnosed (Sawers and Wong, 2018), the two conditions are mostly comorbid (Hofmeijer-Sevink et al., 2012; Kubota et al., 2014; Takehara et al., 2018). Anxiety symptoms overlap with PPD, but they are distinct diagnostic entities; therefore, screening for the postpartum mental difficulties should include not only depression but also anxiety (Nakić Radoš et al., 2018). In addition, despite the inconsistency of the studies concerning the prevalence of anxiety during the postpartum period, some studies suggest that 20–25% of women have anxiety disorders during pregnancy, and 15–20% in the postpartum period. When anxiety symptoms in general are explored (trait anxiety), these rates increase to 25–33% during pregnancy, 17–22% in the postpartum period, and 15–33% in the late postpartum period (e.g., Grant et al., 2008; Dennis et al., 2013), highlighting the long-term duration of anxious symptoms. Despite the high prevalence of anxiety problems in the postpartum period, there is a lack of studies of this condition (Matthey et al., 2003; Wenzel et al., 2003; Tietz et al., 2014). The previous psychopathology, particularly the history of anxiety, might be highlighted as one of the most important postpartum anxiety risk factors, characterized by autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect (Lovibond and Lovibond, 1995). Matthey et al. (2003) found that a previous history of anxiety disorder posed a major risk factor for anxiety at 6 weeks postpartum.

Bonding is a complex phenomenon that represents numerous stages in the development of the relationship between mother and baby (Hill and Flanagan, 2020). Maternal bonding, which is believed to develop during pregnancy or immediately after childbirth as a dynamic construct (Bicking Kinsey and Hupcey, 2013) and continues to improve in the first months of the infant's life (Muzik et al., 2013), is defined as "an affective state of the mother," and corresponds to emotions and cognitions of a mother toward her baby (Billings, 1995; Klaus et al., 1995; Bicking Kinsey and Hupcey, 2013). A maternal bonding refers to the emotional messages and actions a mother displays to her baby, while attachment refers to the caregiver's closeness and commitment that enables a baby to form a positive connection with them (Goulet et al., 1997; Redshaw and Martin, 2013). Impaired mother–infant bonding includes delays in mothers' emotional responses toward their infant, anger, hostility, indifference, and rejection (Brockington et al., 2001, 2006). The mother–infant bond attracts a lot of attention, not only having an important role in the baby's wellbeing but also in the child's cognitive and emotional development (e.g., Tamis-LeMonda et al., 2001; Cirulli et al., 2003).

Considering the studies examining the relationship between mother–infant bonding problems and PPD and postpartum anxiety, it can be said that a poor parental mental health is one of the main risk factors for impaired parent–infant interactions that may lead to adverse effects on bonding (Reck et al., 2004; Parfitt and Ayers, 2009). Although disorders of mother–infant bonding are seen even in healthy postpartum mothers (Vengadavaradan et al., 2019), research on potential risk factors related to mother–infant bonding has focused on postpartum maternal mental health, in particular on PPD (Handelzalts et al., 2021). Research to date provides substantial evidence that both antenatal depressive symptoms (Kolk et al., 2021) and PPD measured early after childbirth could predict bonding difficulties until 1 year after childbirth (Brockington et al., 2006; Moehler et al., 2006; Muzik et al., 2013; Nonnenmacher et al., 2016; Tsuchida et al., 2019; Kasamatsu et al., 2020; Handelzalts et al., 2021). Depression in pregnancy and after birth could have an adverse impact on women, their children, and their relationships (World Health Organization, 2008). Other studies demonstrated that not only PPD but also depressive symptoms are related to impaired mother–infant bonding (Moehler et al., 2006; Edhborg et al., 2011; Hairston et al., 2011; Tietz et al.,

2014; Dubber et al., 2015; Garcia-Esteve et al., 2016; Kasamatsu et al., 2020; Nakić Radoš et al., 2020). According to some studies addressing multiple risk factors, both the history of depression (Nonnenmacher et al., 2016; Badr et al., 2018) and depression in pregnancy (Ohoka et al., 2014; Daglar and Nur, 2018) along with PPD, have been associated with impaired mother–infant bonding. Similarly, in one study, clinically defined maternal depressive disorder during pregnancy is shown to negatively impact maternal–fetal bonding (McFarland et al., 2011), suggesting that the basis for poor mother–infant bonding in PPD may have roots in pregnancy (Lefkovics et al., 2014). On the other hand, another study showed that the maternal depression during pregnancy was not significantly associated with mother–infant bonding (Brassel et al., 2020).

In addition to the symptoms of depression, anxiety-related problems also have effects on bonding. Several research projects have investigated the link between postpartum anxiety and mother–infant bonding (e.g., Edhborg et al., 2011; Tietz et al., 2014). Tietz et al. (2014) found that mothers with postpartum anxiety disorder reported significantly lower bonding than healthy mothers. Further analysis showed that it was not a diagnosis of anxiety disorder itself but concurrent subclinical depressive symptoms together with avoidance of anxiety-related situations, that predicted lower mother–infant bonding. Similarly, in rural Bangladesh, maternal anxiety symptoms were positively associated with mother's emotional bonding (Edhborg et al., 2011). In another study, the higher levels of postpartum-specific anxiety were related to impaired overall bonding scores, subscales of impaired general bond, rejection and anger, and infant-focused anxiety across the first 6-months of life (Fallon et al., 2021). Feldman et al. (1997) stated that an increased anxiety during prenatal and postnatal periods seem to interfere with the mother's ability to bond and interact sensitively with the child. In addition, several studies indicate the significance of maternal anxiety on mother–infant bonding behaviors, the mother–infant relationship, and mother–infant interaction (e.g., Manassis et al., 1994; Nicol-Harper et al., 2007; Feldman et al., 2009; Kaitz et al., 2010).

Self-criticism was also considered as a mediator in this study. Despite the increasing attention in literature, self-criticism has been scarcely studied in the context of adaptation and transition to motherhood but represents a promising mechanism to comprehend postpartum distress. Self-criticism refers to a persistent and intense form of internal dialogue that involves self-scrutiny and expression of hostility and contempt toward the self (Whelton and Greenberg, 2005; Kannan and Levitt, 2013). There are two different forms of self-criticism, known as the "hated-self" and the "inadequate self." The first one focuses on harsh self-loathing and the desire to remove unwanted aspects of the self with the function of self-persecution. The second one focuses on shortcomings or failures, with the function of self-correction (Gilbert et al., 2004). Referring to the relationship between self-criticism and history of depression and anxiety, both forms of self-criticism, but especially hated-self, have been consistently associated with psychopathology (Castilho et al., 2017; Kotera et al., 2021). For example, some studies showed that the high levels of self-criticism have been consistently shown to be a risk factor for the development of depression (e.g., Ehret et al., 2015; Zhang et al., 2019). Other research on female adolescents demonstrates that self-criticism successfully predicted the first onset of nearly all depressive and anxiety disorders (Kopala-Sibley et al., 2017). However, in their study on student samples, McIntyre et al. (2018) did not find that self-criticism predicted future levels of anxiety. On the other hand, self-reassurance (i.e., the ability to focus on one's positive aspects and be compassionate toward the self when things go wrong) functions as a buffer against self-criticism and therefore appears to be a protective factor against the development of psychopathology (Gilbert et al., 2004; Werner et al., 2019).

In the postpartum period, women seem to be particularly prone to self-criticism (Brassel et al., 2020), given the changes in maternal identity and the lack of control and autonomy accompanying motherhood (Priel and Besser, 1999; Brassel et al., 2020). Concerning the association between self-criticism and PPD and postpartum anxiety, such thinking style and emotions may heighten women's vulnerability to postpartum depression and anxiety symptoms. Although research on the effects of self-criticism on postpartum depression symptoms is still limited, existing studies have shown that postpartum depressed women presented higher levels of self-criticism compared to non-depressed women, and both depressed and non-depressed mothers' self-criticism was related to state anxiety (Vliegen and Luyten, 2009). In addition, self-criticism was strongly and positively associated with postpartum depressive symptoms (Vliegen et al., 2006; Besser et al., 2007). However, it is important to consider that self-criticism is described as a transdiagnostic factor, rather than a specific cognitive appraisal from depression, given that it seems prevalent in other psychological disorders (Luyten et al., 2007), such as anxiety disorders (Vliegen and Luyten, 2009; Castilho et al., 2014), stress (Luyten et al., 2011; Mandel et al., 2015), and social anxiety (Shahar et al., 2015; Lazarus and Shahar, 2018).

Self-criticism may also be associated with difficulties in mother–infant bonding. Beebe et al. (2007) found that at 4 months, self-critical mothers displayed less gaze and facial coordination with their infant and poorer infant attachment security at 20 months. Mothers may interpret infant signals and behavior as a reflection of their self-inadequacy and may therefore interact less with the child (Kaminer et al., 2007) or reduce their involvement in caregiving (Reizer and Mikulincer, 2007). In addition, self-critical mothers may project onto the infant feelings of resentment due to the loss of control and autonomy imposed by motherhood (Priel and Besser, 1999; Casalin et al., 2014; Brassel et al., 2020).

In summary, although there is evidence of the maternal history of depression and other forms of psychopathology as predictors of PPD and the quality of mother–infant bonding, studies have rarely included self-criticism as a mechanism explaining this link. Furthermore, although many studies have studied categorical diagnoses of PPD and anxiety disorders, they have not been able to capture the vast range of severity and intensity of depressive and anxious symptoms across the diverse stages of the postpartum period (Gorham, 2020). Furthermore, the history of maternal anxiety symptoms has been poorly

studied in the literature on postpartum (in)adaptation. As such, this study aimed to analyze the association between maternal history of depression and anxiety symptoms, and mother–infant bonding, through self-criticism and levels of depressive and anxiety symptoms. According to previous studies, we first hypothesized that having a history of depression symptoms would predict less mother–infant bonding through higher levels of self-criticism and higher PPD. Although anxiety has been less explored in literature, given its high prevalence in the postpartum period and its relation to self-criticism, we also hypothesized that the history of anxiety symptoms affects bonding, *via* self-criticism and postpartum anxiety.

MATERIALS AND METHODS

Participants

The sample included 550 Portuguese mothers, aged 18–48 years ($M = 32.76$, $SD = 5.06$). Most mothers had completed a university degree, were married/living with their partner, and were not currently on maternity leave. Concerning delivery mode, 63.7% reported giving birth vaginally and 36.3% giving birth through cesarean (programmed or emergency). The percentage of mothers who reported a chirurgical mode of delivery (planned or emergency cesarean section) is in line with the average of Portuguese national statistics for cesarean, that is, 36% (INE, 2021). Infants were aged between 2 weeks and 24 months ($M = 8.57$ months, $SD = 6.51$). The participants' demographic characteristics are shown in **Table 1**.

The inclusion criteria were as listed in the following: (a) To be a biological mother of one baby <24 months old, excluding twins; (b) to have conceived the baby in a context of a heterosexual relationship; (c) to have adequate knowledge of the Portuguese language to be able to complete questionnaires; and (d) to be 18 years and over. Mothers completed an online survey. Informed consent was obtained from all the women before they answered the protocol. Among the 556 mothers who participated, six questionnaires were excluded because one or more measures left more than 20% of the questions incomplete. In sum, 550 mothers were included in this study. Based on the cut-off points used by Lovibond and Lovibond (1995), mean scores indicated normal levels of depression and anxiety among participants.

TABLE 1 | Sociodemographic characteristics of the sample.

	***M* (*SD*)/*n* (%)**
Mothers' age (years)[a]	32.76 (5.06)
Mothers' education	
Basic/secondary education	206 (37.5%)
University degree	342 (62.1%)
Other	2 (0.4%)
Mothers' marital status	
Single	33 (6.0%)
Partnered without living together	12 (2.2%)
Married/partnered and living together	499 (90.7%)
Divorced/separated	6 (1.10%)
Household monthly income	
Less than €1583	283 (51.5%)
1€583 or above	267 (48.5%)
Gestational complications	
Yes (e.g., high-risk pregnancy, maternal health problems, fetus'/baby's health complications)	313 (56.9%)
No	237 (43.1%)
Mode of delivery	
Vaginal delivery	245 (44.5%)
Instrumental vaginal delivery	106 (19.2%)
Planned cesarean section	96 (17.5%)
Emergency cesarean section	103 (18.8%)
Gestational age	
Preterm childbirth (<37 weeks)	33 (6.0%)
Post-term childbirth (37 weeks or more)	517 (94.0%)
Currently in maternity leave	
Yes	237 (43.1%)
No	312 (56.9%)
Infants' age (months)[b]	8.57 (6.51)
Number of children	
1	349 (63.5%)
2	163 (29.6%)
3 or more	33 (6.4%)
Missings	3 (0.5%)

[a] *One participant did not report her age.*
[b] *Eight participants did not report the age of their infants.*

Measures

Sociodemographic and Clinical Background Questionnaire

Sociodemographic and clinical background questionnaire was applied to obtain information about the sociodemographic characteristics (e.g., age, relational status, academic degree, professional situation, cohabitation, number/ages of children, and type of delivery), pregnancy, breastfeeding, problems during and postpartum of the participants. This questionnaire also included several questions related to risk factors for PPD symptoms and (in)adaptation, such as maternal psychopathology; medical support during pregnancy, childbirth, and postpartum; childbirth experience; baby's temperament; distress during pregnancy; partner's distress during pregnancy/in the present; and body image. For this study, four items assessed the history of depression and anxiety symptoms, respectively ("Before pregnancy, did you feel sad or depressed often?" and "During pregnancy, did you feel sad or depressed often?" "Before pregnancy, did you feel anxious, nervous and/or tense often?" and "During pregnancy, did you feel anxious, nervous and/or tense often?"). The two items assessing the history of depression symptoms were aggregated and entered in the analyses as independent variables. The same procedure was repeated to obtain the score from history of anxiety symptoms. Each of these items were measured on a 5-point Likert scale, ranging from 1 ("I strongly disagree") to 5 ("I strongly agree"). The use of this scale was to capture a dimensional continuum rather than a simplistic and dichotomic answer (yes or no). Good correlations were found between the items that measured the history of

depression symptoms ($r = 0.60$, $p < 0.001$) and the history of anxiety symptoms ($r = 0.57$, $p < 0.001$).

Forms of Self-Criticizing and Self-Reassuring Scale

The Portuguese version of the forms of self-criticizing and self-reassuring scale (FSCSRS) (Gilbert et al., 2004; Castilho et al., 2015) consisted of 21 items to assess how critical/attacking or how supportive and reassuring participants are when things go wrong. The scale has three subscales. The subscale of "Inadequate-self" (10 items) assesses the feeling of inadequacy of the self in the face of failures, obstacles, and mistakes ("I think I deserve my self-criticism"). The subscale of "Hated-self" (three items) evaluates a more destructive response, based on self-loathing, anger, and aversion to failure situations, characterized by a disliked relationship with the self and by a desire to hurt, chase, and assault the self ("I get so angry with myself that I want to hurt myself or harm myself"). The subscale of "Reassuring-self" (8 items) assesses a positive, warm, comforting, and compassionate attitude toward the self ("I still like who I am"). The FSCSRS starts with a first probe statement: "When things go wrong for me (…)." The participants respond on a 5-point scale (ranging from 0 = "not at all like me" to 4 = "extremely like me") on a series of questions (e.g., "I think I deserve my self-criticism," "There is a part of me that puts me down," and "I find it easy to forgive myself"). The statements of the FSCSRS were derived from clinical work with depressed people where Pinto–Gouveia had noted some typical thoughts depressed patients offered about their self-criticism and ability to self-reassure (Castilho et al., 2015). Higher mean scores reflect a greater sense of inadequacy, hated-self, and self-reassurance (scores 0–5). The internal reliability of "Inadequate-self" was $\alpha = 0.92$, of "Hated-self" was $\alpha = 0.74$, and of "Reassuring-self" was $\alpha = 0.92$.

Depression Anxiety Stress Scale

Depression, anxiety, and stress levels of participants were measured using the Portuguese version of depression anxiety stress scale (DASS-21) (Lovibond and Lovibond, 1995; Pais-Ribeiro et al., 2004). The DASS-21 is a self-report scale with 21 items, seven for each subscale (e.g., "I felt that life was meaningless," "I felt I was close to panic," and "I found it difficult to relax"). The "Depression scale" measures symptoms of dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, anhedonia, and inertia. The "Anxiety scale" measures autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. Finally, the "Stress scale" assesses difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive, and impatient. The participants rate the extent to which they have experienced each symptom over the past week, on a 4-point scale (0 = "did not apply to me at all" to 3 = "applied to me very much, or most of the time"). The sum scores for DASS dimensions were computed and, for comparison with the original DASS, scores were multiplied by two. Higher scores indicate more frequent anxiety, depression, and stress symptoms (scores 0–42). It must be highlighted that we intentionally used a dimensional score of depressive and anxious symptoms to capture symptoms in a continuum of severity, rather than a clinical diagnosis of PPD or anxiety disorders associated with postpartum. The structure of the Portuguese version of DASS-21 was identical to the original version, with the same items on the same scale. Good internal reliability was obtained for all subscales [depression ($\alpha = 0.87$), anxiety ($\alpha = 0.82$), and stress ($\alpha = 0.90$)].

Postpartum Bonding Questionnaire

Mother–infant bonding was assessed by the Portuguese short version of the postpartum bonding questionnaire (PBQ) (Brockington et al., 2001; Nazaré et al., 2012). The PBQ is a self-report, 12-item scale that assesses the mother's feelings or attitudes toward her baby (e.g., "I feel distant from my baby" and "I love to cuddle my baby"). The participants were asked to rate how often they agreed with these statements reflecting their experience on a 6-point scale ranging from 0 (always) to 5 (never), with reverse coding of positive statements. Higher mean scores indicate greater problems of mother–infant bonding. Through confirmatory factorial analysis the authors in the Portuguese version of the scale analyzed six models, which were based on previous PBQ studies (Nazaré et al., 2012). A 12-item structure that corresponded to the first factor of the original structure of the scale, named impaired mother–infant bonding (Brockington et al., 2001), was identified as having the best fit to their data, with good levels of internal as well as temporal consistency, along with adequate values of convergent and discriminant validity. In this study, a good internal reliability was obtained for the postpartum bonding scale ($\alpha = 0.75$).

Procedure

This study is part of a larger research project dedicated to risk and protective factors for (un)adjustment to motherhood. The study was previously approved by the Ethics and Deontology Committee of the School of Psychology and Life Sciences from University Lusofona. The data collection occurred between February and March of 2020. A non-probabilistic sampling was delivered based on a snow-ball method. The study comprised an online survey made in Typeform and was advertised in internet forums of mothers and on Facebook groups dedicated to maternal topics.

Statistical Analysis

Data analyses were performed using IBM SPSS (v. 28). Descriptive analyses were conducted for sociodemographic and study variables. Zero-order correlations between the study variables were computed. Effect sizes of correlations were based on Cohen's guidelines (1988; small: Pearson's $r = 0.10$; medium: $r = 0.30$; and strong: $r = 0.50$).

To test our hypotheses and examine whether the main effects of history of depression symptoms and anxiety symptoms on mother–infant bonding are mediated by self-criticism (inadequate, hated, and reassuring self), as well as postpartum negative affect (depression and anxiety symptoms), we tested two parallel and serial mediation models using PROCESS version 4.0 for IBM SPSS Statistics (Model 80; Hayes, 2018). In the models performed, history of depression and anxiety

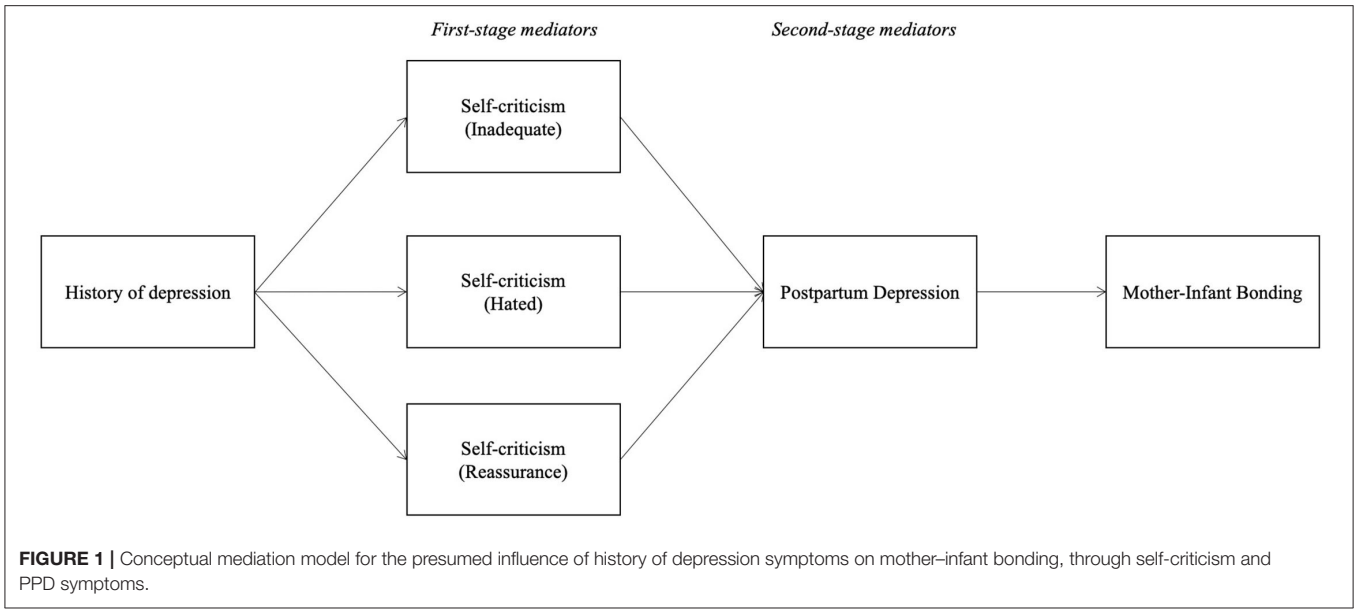

FIGURE 1 | Conceptual mediation model for the presumed influence of history of depression symptoms on mother–infant bonding, through self-criticism and PPD symptoms.

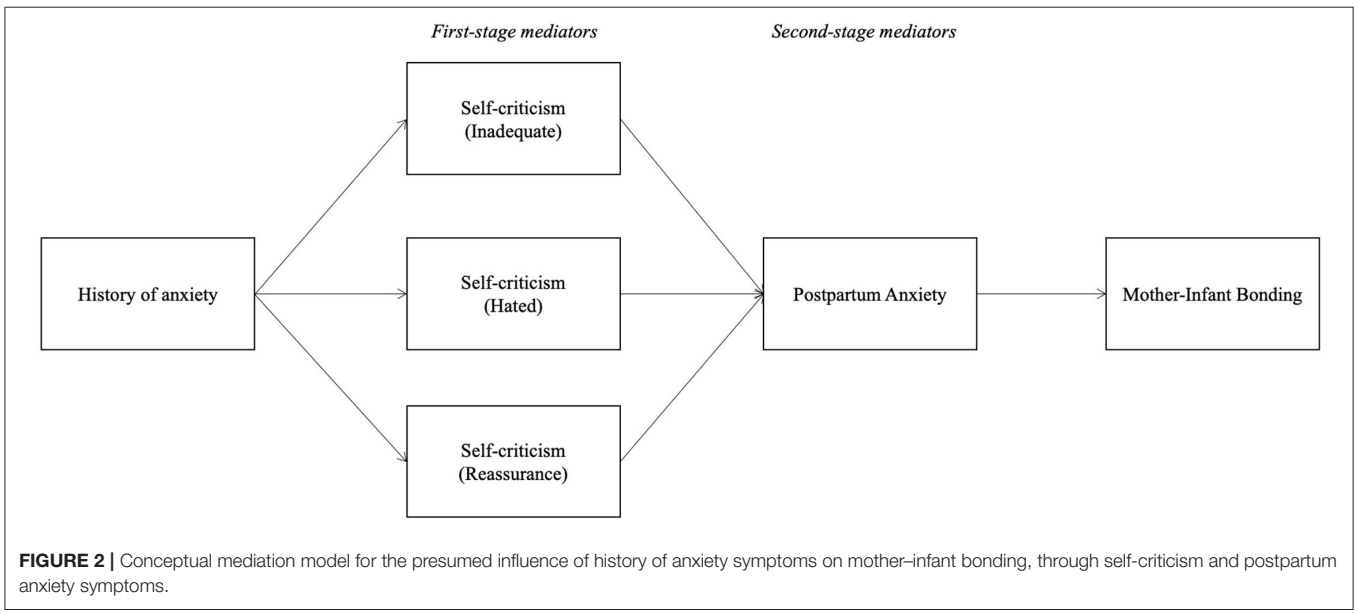

FIGURE 2 | Conceptual mediation model for the presumed influence of history of anxiety symptoms on mother–infant bonding, through self-criticism and postpartum anxiety symptoms.

symptoms were entered as independent variables (each tested independently), self-criticism dimensions were the parallel first step mediators, postpartum negative affect (depression or anxiety) was the serial second step mediator and bonding the dependent variable. Accordingly, the first tested model evaluated the indirect effect of the history of depression symptoms (before and during pregnancy) on mother–infant bonding through the three dimensions of self-criticism (as first step mediators), and PPD symptoms (as a second step mediator; see **Figure 1**). The second tested model checked the indirect effect of the history of anxiety symptoms (before and during pregnancy) on mother–infant bonding through the three dimensions of self-criticism (as first step mediators) and postpartum anxiety symptoms (as second step mediator; see **Figure 2**). Given that comorbidity between depression and anxiety is common (Kalin, 2020), to control for these overlapping symptoms and consider the variability caused by the history of depression and anxiety symptoms before and during pregnancy, we included these variables as covariates in the analysis. As such, in Model 1, we controlled for the effect of history of anxiety symptoms and in Model 2, we controlled for the effect of history of depression symptoms. Additionally, we controlled for the effect of infants' age, mothers' age, income, and gestational complications. Indirect effects were tested through a bootstrapping procedure, including 5,000 bootstrap and 95% bias-corrected, and accelerated confidence intervals. Indirect effects were considered significant when zero was not included in the bootstrap 95% Confidence Interval.

TABLE 2 | Correlations and descriptive statistics of history of depression and anxiety symptoms, self-criticism, postpartum negative affect, and mother–infant bonding.

Study variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	*M (SD)*
1. History of depression symptoms	–										2.44 (1.05)
2. History of anxiety symptoms	0.75***	–									2.27 (1.03)
3. Self-criticism (inadequate-self)	0.37***	0.39***	–								1.24 (0.89)
4. Self-criticism (hated-self)	0.30***	0.32***	0.60***	–							0.29 (0.60)
5. Self-criticism (reassuring self)	−0.40***	−0.40***	−0.49***	−0.41***	–						1.89 (0.92)
6. PPD symptoms	0.38***	0.38***	0.60***	0.61***	−0.44***	–					4.82 (6.54)
7. Postpartum anxiety symptoms	0.36***	0.42***	0.40***	0.44***	−0.36***	0.67***	–				3.82 (5.55)
8. Mother–infant bonding	0.22***	0.23***	0.30***	0.22***	−0.18**	0.34***	0.25***	–			0.37 (0.34)
9. Infants' age (months)	−0.02	0.01	−0.01	−0.03	0.02	0.05	0.09*	0.12**	–		8.57 (6.51)
10. Mothers' age (years)	−0.09*	−0.09*	−0.05	−0.10*	0.08	−0.09*	−0.09*	−0.07	0.11*	–	32.71 (5.19)

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

RESULTS

Correlations between study variables are shown in **Table 2**. All study variables were significantly correlated with each other. Results show a high association between having a history of depression and anxiety symptoms, before and during pregnancy. History of depression and anxiety symptoms were positively correlated with the dimensions of self-criticism inadequate-self and hated-self, but negatively with reassuring self. High inadequate-self and hated-self and lower reassuring self-criticism was associated with higher levels of PPD and anxiety symptoms. Moreover, higher levels of self-criticism (hated and inadequate) were associated with higher problems in bonding. In the opposite direction, reassuring-self was negatively associated with bonding problems. Depression symptoms before and after partum, and anxiety symptoms before and after partum, were positively related to problems in mother–infant bonding.

History of Depression and Mother–Infant Bonding

In mediational analyses, findings (**Table 3**) show that having a history of depression symptoms influences the dimensions of self-criticism as it increases mothers' sense of inadequate-self and hated-self, while it reduces the levels of reassuring-self. Both harsh self-criticism dimensions, inadequate-self and hated-self, are associated with increased PPD symptoms. Reassuring-self is associated with decreased PPD symptoms. Finally, when controlling for all the variables in the model, PPD symptoms are positively associated with impaired mother–infant bonding, and the direct effect of history of depression symptoms on mother-infant bonding decreases and becomes non-significant.

The model testing the indirect effect of the history of depression symptoms on mother–infant bonding (**Figure 3**) showed significant indirect effects through the chain of mediators considered (see **Table 4**). As such, we found the following indirect effects of the serial mediation models. (1) First, through the self-criticism dimension of inadequate-self and through PPD symptoms; (2) second, through the self-criticism dimension of hated-self, and through PPD symptoms; and (3) finally through the self-criticism dimension of reassuring-self followed by PPD symptoms.

History of Anxiety and Mother–Infant Bonding

Results (**Table 5**) show a significant effect of mother's history of anxiety symptoms on the three dimensions of self-criticism, as it increases mother's sense of inadequate-self and hated-self, while it reduces the levels of reassuring self-criticism. Different from Model 1, in Model 2, only the self-criticism dimensions of the hated-self and the reassuring-self are significantly associated with postpartum anxiety symptoms, although in different directions. Accordingly, the greater the feelings of hated self, the greater the postpartum anxiety, while greater levels of mother's reassurance are associated with lower levels of postpartum anxiety symptoms. Finally, regarding the second-step mediator, postpartum anxiety is positively associated with impaired mother–infant bonding. When controlling for all the mediators in the model, in relation to the total effect, the direct effect of the history of anxiety symptoms on mother–infant bonding decreases and becomes non-significant. Also, when testing the indirect effects of the history of anxiety symptoms on mother–infant bonding (**Figure 4**) through the overall chain of mediators, there are no significant indirect effects (see **Table 6**). Results show that inadequate-self is, alone, a significant mediator of the relation between history of anxiety symptoms and infant–mother bonding.

DISCUSSION

This study analyzed if maternal history of depression symptoms predicted mother–infant bonding and if this relation was mediated sequentially by mother's self-criticism and present symptoms of depression. The same model was explored for anxiety, including history of anxiety symptoms as a predictor and present symptoms as mediator.

The results evidenced a high association between having a history of depression and anxiety symptoms, before and during pregnancy, which is in line with the vast literature that describes the overlapping and comorbid relations between these two frequent psychological conditions. Similarly, the positive associations were found between the history of depression symptoms and the PPD symptoms, and between

TABLE 3 | Standardized regression coefficients (β), unstandardized regression coefficients (b), standard errors (SE), and model summary information for the tested serial–parallel mediation Model 1.

	Inadequate-self				**Hated-self**				**Reassuring-self**				**PPD symptoms**				**Mother–infant bonding**				**Mother–infant bonding**			
																	(Total effect model)				**(Serial–parallel mediation model)**			
Antecedent	***β***	***b***	***SE***	***P***	***β***	***b***	***SE***	***P***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***
History of depression symptoms (IV)	0.19	0.17	0.05	0.001	0.134	0.08	0.04	0.029	−0.23	−0.20	0.05	0.000	0.09	0.29	0.15	0.058	0.15	0.05	0.20	0.018	0.08	0.03	0.02	0.204
Inadequate-self (M1)	–	–	–	–	–	–	–	–	–	–	–	–	0.26	0.94	0.16	0.000	–	–	–	–	0.12	0.05	0.02	0.032
Hated-self (M2)	–	–	–	–	–	–	–	–	–	–	–	–	0.37	1.99	0.22	0.000	–	–	–	–	−0.02	−0.01	0.03	0.770
Reassuring-self (M3)	–	–	–	–	–	–	–	–	–	–	–	–	−0.10	−0.36	0.13	0.008	–	–	–	–	0.02	0.01	0.02	0.706
PPD symptoms (M4)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.25	0.03	0.01	0.000
Constant	–	0.40	0.26	0.120	–	−0.20	0.18	0.261	–	2.50	0.26	0.000	–	0.77	0.83	0.354	–	−0.13	0.10	0.216	–	−0.17	0.11	0.107
History of anxiety symptoms (cov)	0.25	0.22	0.05	0.000	0.20	0.12	0.04	0.001	−0.22	−0.19	0.05	0.000	0.05	0.14	0.15	0.351	0.14	0.05	0.02	0.025	0.07	0.02	0.02	0.282
Mothers' age (cov)	−0.02	−0.004	0.01	0.617	−0.05	−0.01	0.00	0.214	0.02	0.00	0.01	0.624	−0.02	−0.01	0.02	0.552	0.06	0.04	0.00	0.153	0.07	0.00	0.00	0.073
Infants' age (cov)	−0.01	−0.001	0.01	0.802	−0.02	0.00	0.00	0.618	0.01	0.00	0.01	0.825	0.07	0.04	0.02	0.020	0.11	0.01	0.00	0.010	0.09	0.00	0.00	0.021
Gestational complications (cov)	0.01	0.02	0.07	0.837	0.00	0.00	0.05	0.931	−0.01	−0.01	0.07	0.865	0.01	0.09	0.21	0.665	−0.03	−0.02	0.03	0.446	−0.04	−0.02	0.03	0.362
Income (cov)	0.03	0.02	0.02	0.478	−0.09	−0.03	0.02	0.040	0.08	0.04	0.02	0.042	−0.05	−0.10	0.06	0.135	0.12	0.02	0.01	0.005	0.14	0.03	0.01	0.001
	$R^2 = 0.17$				$R^2 = 0.12$				$R^2 = 0.19$				$R^2 = 0.48$				$R^2 = 0.10$				$R^2 = 0.17$			
	$F_{(6,535)} = 18.59, p < 0.001$				$F_{(6,535)} = 12.23, p < 0.001$				$F_{(6,535)} = 21.14, p < 0.001$				$F_{(9,532)} = 54.88, p < 0.001$				$F_{(6,535)} = 9.44, p < 0.001$				$F\ (10,531) = 11.19, p < 0.001$			

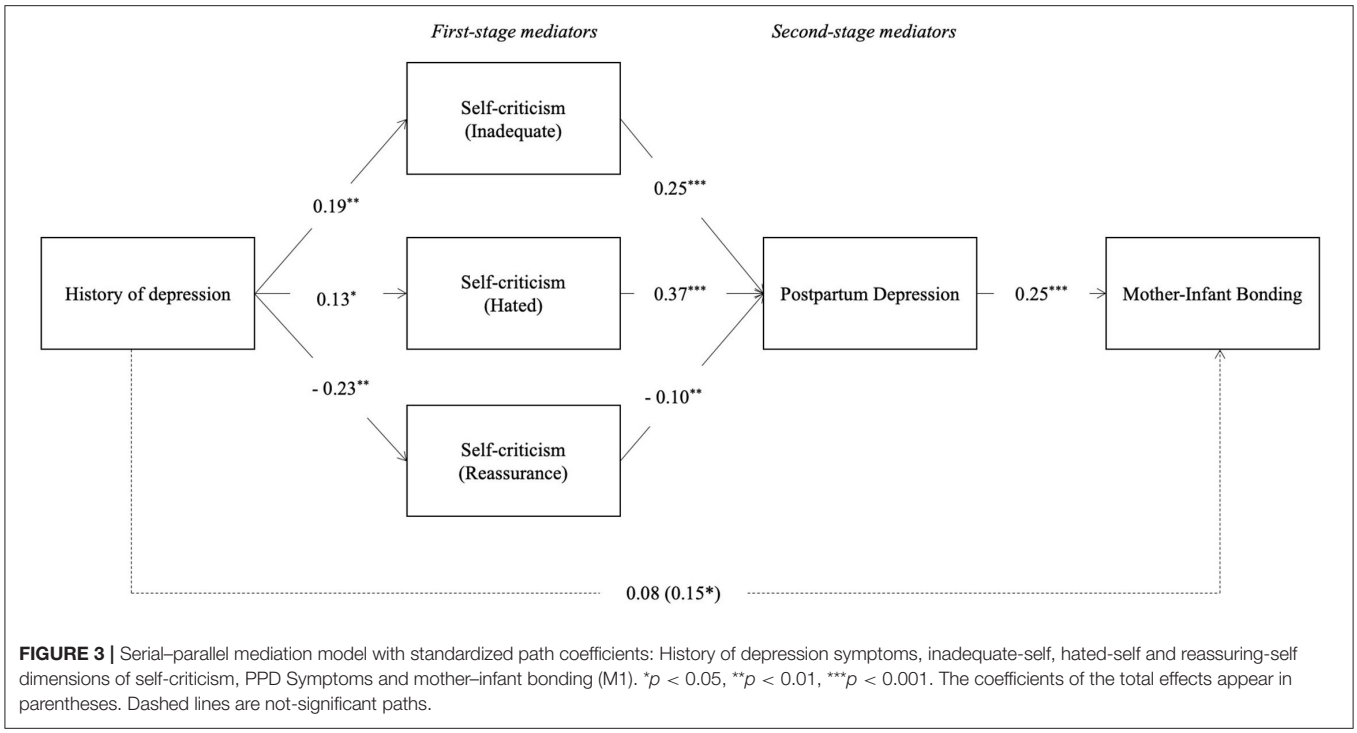

FIGURE 3 | Serial–parallel mediation model with standardized path coefficients: History of depression symptoms, inadequate-self, hated-self and reassuring-self dimensions of self-criticism, PPD Symptoms and mother–infant bonding (M1). $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. The coefficients of the total effects appear in parentheses. Dashed lines are not-significant paths.

TABLE 4 | Standardized coefficients (β), unstandardized coefficients (b), unstandardized boot standard errors, and boot 95% confidence intervals of the unstandardized indirect effects of history of depression symptoms on mother–infant bonding, through inadequate-self, hated-self, reassuring-self, PPD symptoms (Model 1).

Specific indirect effect (mediators)	β	*b*	Boot SE	Boot 95% CI
History of depression symptoms → Inadequate-self → Mother–infant bonding	0.023	0.008	0.006	[−0.001, 0.020]
History of depression symptoms → Hated-self → Mother–infant bonding	−0.002	−0.001	0.003	[−0.007, 0.008]
History of depression symptoms → Reassuring-self → Mother–infant bonding	−0.004	−0.001	0.003	[−0.008, 0.005]
History of depression symptoms → PPD symptoms → Mother–infant bonding	0.023	0.007	0.005	[−0.0001, 0.018]
History of depression symptoms → Inadequate-self → PPD symptoms → Mother–infant bonding	0.012	0.004	0.002	[0.001, 0.009]
History of depression symptoms → Hated-self → PPD symptoms → Mother–infant bonding	0.012	0.004	0.003	[0.0002, 0.010]
History of depression symptoms → Reassuring-self → PPD symptoms → Mother–infant bonding	0.006	0.002	0.001	[0.0003, 0.005]

the history of anxiety symptoms and postpartum anxiety symptoms, highlighting the continuity of these risk factors during the peripartum period. These findings were in line with previous studies that showed the co-occurrence and the positive association between anxiety and depressive symptoms during PPD (e.g., Heron et al., 2004).

As for the first model of our study, the results have demonstrated that the history of depression symptoms showed significant indirect effects on mother–infant bonding through the chain of mediators, in line with the studies showing that mothers with a psychiatric history are at a higher risk of PPD symptoms and bonding problems (Lefkowitz et al., 2010; de Kruijff et al., 2019; Nakić Radoš et al., 2020; Tolja et al., 2020).

In addition, findings show that having a history of depression symptoms is associated with higher levels of inadequate-self and hated-self, and lower levels of self-reassurance, which is consistent with previous studies showing positive associations of inadequate-self and hated-self with psychopathology (Castilho et al., 2017) and a negative association of self-reassurance with psychopathology (Gilbert et al., 2004; Werner et al., 2019). The relationship between the inadequate self, hated-self and reassuring self, and PPD symptoms showed a similar pattern. This is consistent with the existing research that showed that the self-criticism had a negative effect on PPD symptoms (e.g., Vliegen and Luyten, 2009) and on those feelings of self-inadequacy mediated the stress-depression relationship (e.g., Kotera et al., 2021). Also, a stronger positive relationship between hated-self and depression was found, which is consistent with evidence showing hated-self to be consistently more highly associated with psychopathology than the inadequate self (Gilbert et al., 2004; Castilho et al., 2017; Werner et al., 2019).

Finally, higher levels of postpartum depressive symptoms were associated with higher problems in bonding, which confirms previous evidence from other studies (Edhborg et al., 2011; Dubber et al., 2015; Nakić Radoš et al., 2020; Tolja et al., 2020; Handelzalts et al., 2021). This finding is important since

TABLE 5 | Standardized regression coefficients (β), unstandardized regression coefficients (b), standard errors (SE), and model summary information for the tested serial–parallel mediation Model 2.

	Inadequate-self				**Hated-self**				**Reassuring-self**				**Postpartum Anxiety**				**Mother–infant bonding**				**Mother–infant bonding**			
																	(Total effect model)				**(Serial–parallel mediation model)**			
Antecedent	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***	***β***	***b***	***SE***	***p***
History of anxiety symptoms (IV)	0.25	0.22	0.05	0.00	0.20	0.12	0.04	0.001	−0.22	−0.19	0.05	0.000	0.221	0.60	0.15	0.00	0.14	0.05	0.02	0.025	0.050	0.02	0.02	0.43
Inadequate-self (M1)	–	–	–	–	–	–	–	–	–	–	–	–	0.096	0.30	0.15	0.05	–	–	–	–	0.172	0.06	0.02	0.00
Hated-self (M2)	–	–	–	–	–	–	–	–	–	–	–	–	0.262	1.21	0.21	0.00	–	–	–	–	0.043	0.02	0.03	0.41
Reassuring-self (M3)	–	–	–	–	–	–	–	–	–	–	–	–	−0.096	−0.29	0.13	0.28	–	–	–	–	0.005	0.00	0.02	0.92
Postpartum anxiety symptoms (M4)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.121	0.01	0.01	0.01
Constant	–	0.40	0.26	0.12	–	0.20	0.18	0.261	–	2.50	0.26	0.000	–	0.49	0.80	0.54	–	0.13	0.10	0.216	–	−0.16	0.11	0.14
History of depression symptoms (cov)	0.19	0.17	0.05	0.00	0.13	0.08	0.04	0.029	−0.23	−0.20	0.05	0.000	0.033	0.09	0.15	0.54	0.15	0.05	0.02	0.018	0.096	0.03	0.02	0.11
Mothers' age (cov)	−0.02	0.00	0.01	0.62	−0.05	−0.01	0.00	0.214	0.02	0.00	0.01	0.624	−0.058	−0.03	0.02	0.11	0.06	0.00	0.00	0.153	0.076	0.01	0.00	0.07
Infants' age (cov)	−0.01	0.00	0.01	0.80	−0.02	0.00	0.00	0.618	0.01	0.00	0.01	0.825	0.115	0.05	0.02	0.00	0.11	0.01	0.00	0.010	0.097	0.01	0.00	0.02
Gestational complications (cov)	0.01	0.01	0.07	0.84	0.00	0.00	0.05	0.931	−0.01	−0.01	0.07	0.865	0.104	0.59	0.20	0.00	−0.02	−0.02	0.03	0.446	−0.046	−0.03	0.03	0.26
Income (cov)	0.03	0.02	0.02	0.48	−0.09	−0.03	0.02	0.040	0.08	0.04	0.02	0.042	−0.011	−0.02	0.06	0.78	0.12	0.02	0.01	0.005	0.125	0.02	0.01	0.00
	$R^2 = 0.17$				$R^2 = 0.12$				$R^2 = 0.19$				$R^2 = 0.33$				$R^2 = 0.10$				$R^2 = 0.15$			
	$F_{(6,535)} = 18.59, p < 0.001$				$F_{(6,535)} = 12.23, p < 0.001$				$F_{(6,535)} = 21.14, p < 0.001$				$F_{(9,532)} = 28.56, p < 0.001$				$F_{(6,535)} = 9.44, p < 0.001$				$F\ (10,531) = 9.53, p < 0.001$			

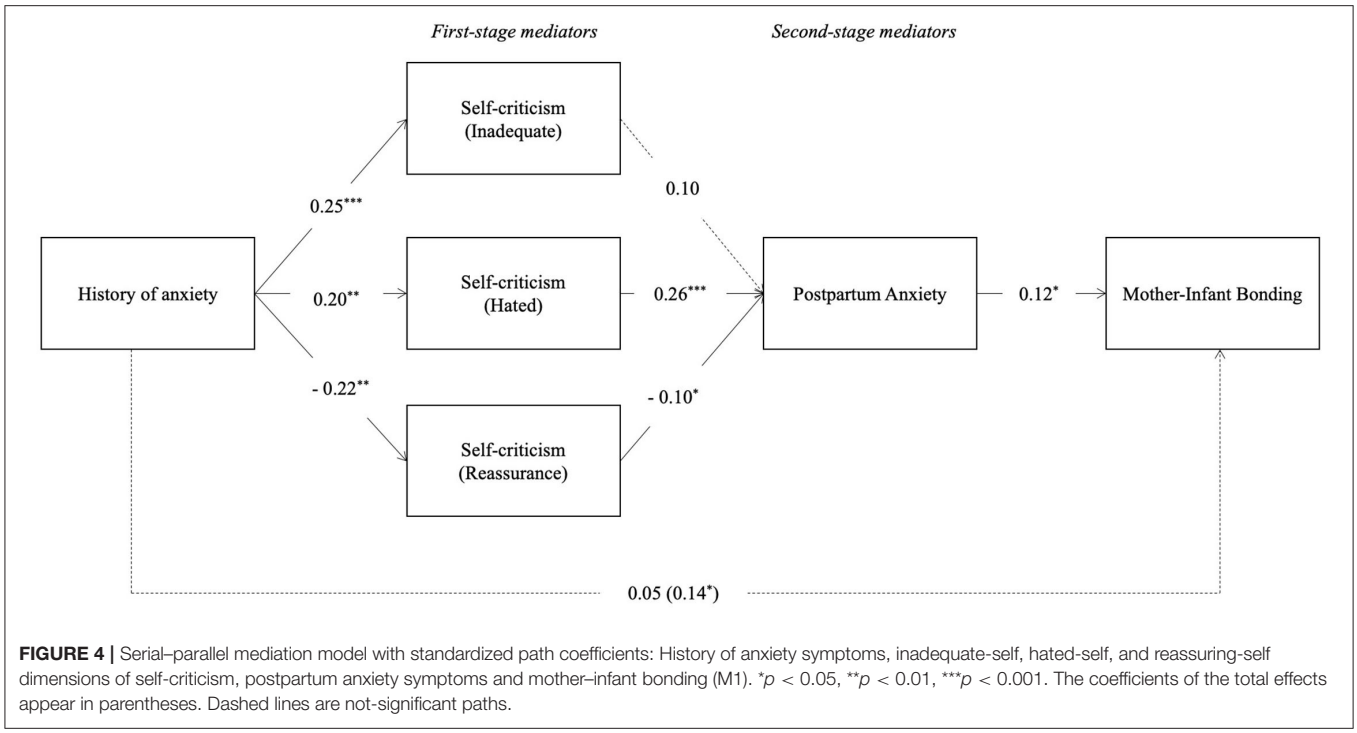

FIGURE 4 | Serial–parallel mediation model with standardized path coefficients: History of anxiety symptoms, inadequate-self, hated-self, and reassuring-self dimensions of self-criticism, postpartum anxiety symptoms and mother–infant bonding (M1). $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. The coefficients of the total effects appear in parentheses. Dashed lines are not-significant paths.

TABLE 6 | Standardized coefficients (β), unstandardized coefficients (b), unstandardized boot standard errors, and boot 95% confidence intervals of the unstandardized indirect effects history of anxiety symptoms on mother–infant bonding, through inadequate-self, hated-self, reassuring-self, postpartum anxiety symptoms (Model 2).

Specific indirect effect (mediators)	β	b	Boot SE	Boot 95% CI
History of anxiety symptoms → Inadequate-self → Mother–infant bonding	0.041	0.014	0.007	[0.003, 0.030]
History of anxiety symptoms → Hated-self → Mother–infant bonding	0.009	0.003	0.005	[−0.007, 0.012]
History of anxiety symptoms → Reassuring-self → Mother–infant bonding	−0.001	−0.001	0.003	[−0.007, 0.007]
History of anxiety symptoms → Postpartum anxiety symptoms → Mother–infant bonding	0.027	0.009	0.006	[−0.0002, 0.023]
History of anxiety symptoms→ Inadequate-self → Postpartum anxiety symptoms → Mother–infant bonding	0.003	0.001	0.001	[−0.0004, 0.003]
History of anxiety symptoms → Hated-self → Postpartum anxiety symptoms → Mother–infant bonding	0.006	0.002	0.002	[−0.0001, 0.006]
History of anxiety symptoms → Reassuring-self → Postpartum anxiety symptoms → Mother–infant bonding	0.003	0.001	0.001	[−0.0000, 0.003]

it facilitates understanding of how maternal depression might impact bonding and further outcomes on infant health. Maternal depression might affect maternal bonding (Noorlander et al., 2008) and might lead to an insensitive caretaking environment (Nicol-Harper et al., 2007; Kaitz et al., 2010; Müller et al., 2016). Insensitive caretaking which can be seen in PPD symptoms might be affecting the difficulties in self-regulation of the infant (Manian and Bornstein, 2009).

As for the second model of our study, history of anxiety symptoms showed no significant indirect effects on mother–infant bonding through the overall chain of mediators. Furthermore, in our study, the direct effect of history of anxiety symptoms decreases and becomes non-significant on mother–infant bonding. Considering that there are very few studies examining the relationship between postpartum anxiety symptoms and bonding, and studies examining the relationship between the history of anxiety symptoms and bonding are even rarer and have heterogeneous results (Dubber et al., 2015; Göbel et al., 2018), this finding can be considered as a reflection of another aspect of maternal feelings on bonding before and during pregnancy. It can be evaluated that anxiety before and during pregnancy might be somehow functional in terms of bonding during the transition to parenthood (e.g., serving to protect the baby) (Figueiredo and Conde, 2011). Therefore, this finding between the history of anxiety and bonding may have been obtained. With respect to the link between postpartum anxiety symptoms and bonding, as expected, higher levels of postpartum anxiety symptoms were associated with higher problems in bonding, which confirms previous evidence from other studies (Edhborg et al., 2011; Tietz et al., 2014; Dubber et al., 2015). Mothers experiencing anxiety might show more difficulty in self-regulating, and in interacting sensitively and regulating the child (Feldman et al., 1997; Tietz et al., 2014).

In addition, consistent with previous studies on the links between self-criticism and psychopathology (Gilbert et al.,

2004; Castilho et al., 2017; Werner et al., 2019), having a history of anxiety symptoms was associated with higher levels of inadequate-self and hated-self, and lower levels of self-reassurance. The same was true with regards to the relationship between the inadequate self and reassuring self, and postpartum anxiety symptoms, which is in line with previous studies showing a negative effect of self-criticism in anxiety in the postpartum period (e.g., Vliegen and Luyten, 2009; Kotera et al., 2021). Therefore, individual attempts to cope with one's feelings of inadequacy can play an important role in the experience of anxiety in the postpartum period. Furthermore, no relationship regarding hated-self and anxiety was found. This is somewhat surprising, given evidence showing that the hated-self is more detrimental to mental health than the inadequate self (Gilbert et al., 2004; Castilho et al., 2017; Werner et al., 2019). Studies investigating the association between self-criticism and psychopathology have mostly used clinical samples (McIntyre et al., 2018; Werner et al., 2019); therefore, the fact that we used a community sample might contribute to explaining these unexpected findings regarding anxiety. Further studies that are conducted with non-clinical samples that explore the relationship between self-criticism and anxiety postpartum are needed.

Limitations and Recommendations for Future Studies

The studies presented several limitations that must be addressed. First, since this was a cross-sectional study, no causality could be inferred based on the analyses performed. Also, although the participants were instructed the exact time point to answer, the collection of data in one point could be considered as a limitation in terms of observer bias, perhaps calling into question if perhaps maternal perceptions of their previous mood as well as cognitions about the self and bonding with their child are not a function of their mood at the time of data collection. Therefore, some caution is needed when interpreting our findings. Future studies should include longitudinal designs to overcome this limitation. For instance, self-criticism, postpartum negative symptoms, and perception of infant–mother bonding of mothers with negative symptoms before and during pregnancy should be assessed 3–9 months after childbirth and, ideally, 1–2 years after childbirth to infer the possible causality and the identification of trajectories related to the impact of the history of depression and anxiety symptoms across diverse phases of postpartum period. Second, our non-probabilistic sampling procedures (i.e., convenience and snowball techniques and data collection based on social application's advertisements) might have influenced the characteristics of the sample and attracted mothers more motivated to respond to this large protocol, more digitally proficient, and with less particular impairments (psychical or neuropsychological). Also, the discrepancy between Cronbach α between the hated-self (0.74) and the inadequate self (0.92) should be noted, even though it is coherent with previous studies (e.g., Castilho et al., 2015).

Third, although the literature has highlighted the existence of high comorbidity between PPD and anxiety symptoms, our results are only focused on symptoms of PPD and anxiety, separately. Future studies could consider testing similar models with symptoms of anxiety and depression together. Moreover, self-report measures might be biased by social desirability, especially concerning mother–infant bonding.

Fourth, certain key variables are highly correlated as given in the following: History of depression symptoms and history of anxiety symptoms; PPD and postpartum anxiety symptoms; PPD symptoms and hated-self; PPD symptoms and inadequate-self. Also, although the participants were instructed the exact time point to answer, the collection of data in one point can be considered as a limitation in terms of observer bias, perhaps calling into question if perhaps maternal perceptions of their previous mood as well as cognitions about the self and bonding with their child are not a function of their mood at the time of data collection. Therefore, some cautions are needed when interpreting our findings.

Fifth, the factors concerning the context (e.g., partner's, family's or professional's support, and infant temperament and characteristics) were left out of the analyses. Future research must include their possible impact on maternal negative affect and on mother–infant bonding during the postpartum period. In addition, only intrapersonal variables are considered in the models, neither contextual nor "child" variables are included. Future research should take this into account and have more information about and from other informants and sources.

Also, the future research should test whether the proposed models apply to both common and clinically significant levels of anxiety and depression. Furthermore, the symptoms across the postpartum period, limited data exist about the stability and specific trajectories of these symptoms, and even less about the evolution of anxiety symptoms during postpartum. For that reason, the wide range of infants' ages requires caution in the interpretation of the results. Future research should consider a limited range of age, but also should characterize the pathways associated with emotional symptomatology across the postpartum period.

Finally, our study focused on depressive and anxious symptoms and on different types of self-criticism as mediating mechanisms. As such, our results should explore the cognitions, the coping mechanisms, and the emotions, associated with self-criticism, that are more prevalent in women with both depression and anxiety symptoms, and the differences among them. Moreover, the role of self-reassuring styles and self-compassion should be studied as possible protective factors for anxiety and depression in postpartum, and for the quality of mother–child bonding. Further exploration on the mechanisms through which self-critical thinking might impact psychopathology in postpartum would be important, especially regarding anxiety in which knowledge is still limited.

Strengths and Implications

This study adds to the existing research by examining both retrospectively self-reported levels of depression and anxiety symptoms before and during pregnancy, and the current (postpartum) levels of depression and anxiety symptoms in a large community sample in Portugal. The previous studies of self-criticism have been implicated in a range of

psychopathologies (McIntyre et al., 2018). Similarly, our findings also evidence the possible transdiagnostic role of self-criticism in the comprehension and maintenance of anxiety and depression during postpartum and bonding. Furthermore, we controlled the effect of depression and anxiety on each model, evidencing the differential contribution of anxiety and depression to bonding problems. Thus, they should be addressed as comorbid, despite being distinct phenotypic conditions.

The results from this study have important specific clinical implications. Given that the history of both depression and anxiety symptoms have predicted negative affect and bonding, concrete screening assessment delivered on mental care and general health institutions during pregnancy should address the existence of depressive and anxious symptoms prior and during pregnancy to help women at risk of postpartum distress and provide specific interventions. Furthermore, our findings suggest that decreasing maternal self-criticism should be targeted in preventive and therapeutic psychological interventions, and self-reassurance, which represents a self-compassionate attitude, should be promoted as a buffer mechanism to reduce the incidence of negative symptoms and bonding problems during the postpartum period. In this way, cultivating a self-accepting, mindful and non-judgmental mindset might help future and recent new mothers to adapt to changes and difficulties from this period with lower levels of self-criticism and less negative affect. Feeling less depressed and anxious might prevent bonding difficulties and less risk factors for mental health and wellbeing in mothers and children.

CONCLUSIONS

Maternal depression and other psychological problems have been described in literature as having considerable consequences on bonding during the postpartum period and afterward. This study added new insights on this previous evidence, revealing that the quality of mother–infant bonding in postpartum might be affected by the history of depression symptoms in mothers, but especially, that self-criticism and consequently the depressive symptoms might play a role in this relation. Further, the history of anxiety symptoms also has an impact on bonding but only is mediated by hated-self and, in an opposite way, by reassuring self. Our results highlight the importance of assessing previous history of maternal psychological symptoms and psychopathology, as they might represent an important risk factor for bonding in the postpartum period. Further, interventions might need to promote more self-compassionate attitudes in mothers to prevent maladaptation after the birth of a child.

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 Ethical and Deontological Committee for Scientific Research of the School of Psychology and Life Sciences (CEDIC). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AB and LC contributed to the conception and design of the study. AB, SA, and LC organized the database. LC and ÁS performed the statistical analysis and wrote sections of the manuscript. AB, SA, and BK wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Prospective Associations of Lifetime Post-traumatic Stress Disorder and Birth-Related Traumatization With Maternal and Infant Outcomes

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Objective: Many women experience traumatic events already prior to or during pregnancy, and delivery of a child may also be perceived as a traumatic event, especially in women with prior post-traumatic stress disorder (PTSD). Birth-related PTSD might be unique in several ways, and it seems important to distinguish between lifetime PTSD and birth-related traumatization in order to examine specific consequences for mother and child. This *post-hoc* analysis aims to prospectively examine the relation of both, lifetime PTSD (with/without interpersonal trauma) and birth-related traumatization (with/without postpartum depression) with specific maternal and infant outcomes.

Methods: In the prospective-longitudinal Maternal in Relation to Infants' Development (MARI) study, $N = 306$ women were repeatedly assessed across the peripartum period. Maternal lifetime PTSD and birth-related traumatization were assessed with the Composite International Diagnostic Interview for women. Maternal health during the peripartum period (incl. birth experience, breastfeeding, anxiety, and depression) and infant outcomes (e.g., gestational age, birth weight, neuropsychological development, and regulatory disorders) were assessed *via* standardized diagnostic interviews, questionnaires, medical records, and standardized observations.

Results: A history of lifetime PTSD prior to or during pregnancy was reported by 25 women who indicated a less favorable psycho-social situation (lower educational level, less social support, a higher rate of nicotine consumption during pregnancy). Lifetime PTSD was associated with pregnancy-related anxieties, traumatic birth experience, and anxiety and depressive disorders after delivery (and in case of interpersonal trauma additionally associated with infant feeding disorder). Compared to the reference group,

women with birth-related traumatization ($N = 35$) indicated numerous adverse maternal and infant outcomes (e.g., child-related fears, sexual problems, impaired bonding). Birth-related traumatization and postpartum depression was additionally associated with infant feeding and sleeping problems.

Conclusion: Findings suggest that both lifetime PTSD and birth-related traumatization are important for maternal and infant health outcomes across the peripartum period. Larger prospective studies are warranted.

Implications: Women with lifetime PTSD and/or birth related traumatization should be closely monitored and supported. They may benefit from early targeted interventions to prevent traumatic birth experience, an escalation of psychopathology during the peripartum period, and adverse infant outcomes, which in turn may prevent transgenerational transmission of trauma in the long term.

Keywords: lifetime PTSD, birth-related traumatization, pregnancy, postpartum, infant outcomes

INTRODUCTION

Many women experience traumatic events already prior to or during pregnancy, and delivery of a child may also be perceived as a traumatic event, especially in women with prior post-traumatic stress disorder (PTSD). PTSD is one of the most debilitating mental disorders and the 12-month prevalence in the German general population is 2.3% (95%CI: 1.8–2.9) (1). Women are more often affected by PTSD than men (12 month-rate in women and men: 3.6%; 95%CI: 2.8–4.7; and 0.9%, 95%CI: 0.6–1.5) and most of them experience traumatic events already prior to pregnancy (1). Still, the peripartum period is considered to be a vulnerable time frame for the onset, recurrence, and exacerbation of PTSD symptoms and other mental disorders in women (e.g., peripartum anxiety and depressive disorders) (2). Due to traumatic experiences prior to or during pregnancy about 3.3% of pregnant women suffer from PTSD and prevalence rates in risk populations (e.g., history of intimate partner violence) are even higher (about 18%) (3). In addition, up to one-third of women who have recently given birth describe their birth experience as traumatic (4), up to 10% suffer from clinically relevant posttraumatic stress symptoms during the first weeks thereafter (5–8), and up to 4% develop the full clinical picture of PTSD (3, 7, 9, 10). The prevalence of postpartum PTSD is even higher in at-risk populations (e.g., up to 19% after preterm delivery, emergency cesarean section, or still birth) (3, 7, 9, 10).

Birth-related PTSD might be unique in several ways, and it seems important to distinguish between lifetime PTSD and birth-related traumatization. Birth experience may become traumatic if the birth involves actual or threatened death or an injury for a woman or for the infant (2, 11, 12). Birth-related traumatization affects the mother-child-dyad and childcare of the baby might trigger maternal traumatic memories of birth. Given that childcare is usually associated with an increased vigilance, the hyperarousal criteria should be considered with caution. Risk factors of birth-related traumatization are a history of sexual trauma and intimate partner violence, depression or anxiety in pregnancy, fear of childbirth, complications during pregnancy, obstetric interventions/ operative delivery, peripartum infant complications, a subjective negative birth experience, and perception of inadequate intrapartum care or lack of social support (5, 11–14).

Both, lifetime PTSD and birth-related traumatization may be associated with postpartum depressive and anxiety disorders, whereas the relation to pregnancy- and child-related fears is less studied (5, 15–17). Moreover, PTSD in the context of pregnancy and childbirth might affect the partnership (e.g., sexual problems) and the mother-child-dyad (e.g., bonding) (16, 18, 19). For instance, traumatic memories or re-experiencing of the childbirth might reduce emotional availability of the mother to the infant, especially if the infant serves as a trigger of the event. This, in turn, could be crucial for the type of attachment the infant develops to the mother. Mother-child dyads may be further fragiled by the numbness affected women are likely to perceive (20). Some studies showed that birth-related PTSD symptoms are associated with bonding and breastfeeding difficulties that may have long-term health implications for infants (21, 22). In addition, symptoms of hyperarousal and intrusion might lead to impaired childcare and interaction with the child (e.g., angry or intrusive interaction) (19, 23, 24) and comorbid maternal depression might contribute additionally to parenting impairment (25, 26). A review by Christie et al. (27) found that parental PTSD was associated with impaired functioning across various parenting domains and less optimal parent-child relationships (27). The Perinatal Interactional Model of Intergenerational transmission of traumatization proposes that maternal PTSD leads to suboptimal caregiving behavior and parent-child interactions, which undermine child regulatory capacity and increase distress leading to poorer social-emotional outcomes for offspring of parents with PTSD (28). Moreover, Pat-Horenczyk et al. (29) suggested the idea of relational emotional regulation in which difficulties with emotion regulation pass from mother faced with trauma to the child (29). In line with this, Davies and colleagues showed that women with postpartum PTSD symptoms following childbirth and postpartum depression perceive their attachment relationships to be less optimal and

rated their infants as being temperamentally more difficult and less easy to soothe as compared to non-symptomatic women (9). Moreover, some prospective studies found maternal postpartum PTSD to be associated with difficult temperament and/ or poorer cognitive and social-emotional development in infants up to 2 years (19, 30). Especially interpersonal trauma might be crucial for the relation between mother and child and for early child development (e.g., neuropsychological development) (2, 31, 32).

Aims of the Study

In sum there is evidence that PTSD prior to and during pregnancy as well as birth-related traumatization are associated with adverse maternal and infant outcomes. As it has been argued that birth-related PTSD might be unique in several ways it seems important to distinguish between lifetime PTSD and birth-related traumatization in order to examine specific consequences for the mother and child (31, 33, 34). A *post-hoc* analysis of the data of the *Ma*ternal *A*nxiety in *R*elation to *I*nfant Development (MARI) study was conducted to examine specific associations of lifetime PTSD and birth-related traumatization with the above mentioned outcomes. In the prospective-longitudinal MARI study (35, 36) women were recruited already during early pregnancy and reported their lifetime diagnostic status prior to pregnancy. Participants were followed up three times during pregnancy and three times after delivery within this multi-wave and multi-method study. Given that anxiety and depressive disorders occur frequently in expectant mothers and may be also relevant for the considered outcomes, we chose expectant mothers with no anxiety and/or depressive disorders prior to or during pregnancy as reference group. This allows the examination of specific associations of lifetime PTSD and birth-related traumatization with the specific outcomes.

Using the data of the MARI study we were able to examine (1) whether women with PTSD prior to or during pregnancy were at higher risk for poor maternal health during the peripartum period (e.g., pregnancy-related fears, maternal anxiety and depressive disorder, operative delivery), for a traumatic birth experience, and adverse gestational and infant outcomes (e.g., regulatory disorders, attachment, neuropsychological development) as compared to women with neither anxiety nor depressive disorder until third trimester of pregnancy. Further, we examined (2) whether women suffering from birth-related traumatization were at higher risk for adverse maternal and infant outcomes (e.g., child-related fears, maternal anxiety and depressive disorder, maternal sexual problems, infant regulatory disorders) as compared to women with no anxiety or depressive disorder prior to delivery and no birth-related traumatization. Here we additionally investigated the role of postpartum depression at 2, 4 or 16 month postpartum (25).

METHODS

Procedure

The prospective-longitudinal MARI Study was conducted among $N = 306$ expectant mothers, sampled from the community in gynecological outpatient settings in Dresden, Germany (study period: 01/2009 – 09/2012). Participating pregnant women (and their infants) completed up to seven assessments: T1 (baseline): week 10 to 12 of gestation; T2: week 22 to 24 of gestation; T3: week 35 to 37 of gestation; T4: 10 days postpartum; T5: 2 months postpartum; T6: 4 months postpartum; T7: 16 months postpartum (36).

Informed consent was obtained from all participants and all legal guardians of the infants. The MARI Study was carried out in accordance with the Helsinki Declaration (2013) and was reviewed by the Ethics Committee of the Technische Universität Dresden (No: EK 94042007). More detailed information including objectives, methods, design, and a detailed study flow chart has been published elsewhere (35, 36).

Participants

Overall, $N = 533$ pregnant women were approached by the study team in gynecological outpatient settings in Dresden (Germany) and screened for inclusion and exclusion criteria. Fifty women were excluded based on the exclusion criteria, which were as follows: gestational age >12 weeks ($n = 8$), younger than 18 or older than 40 years ($n = 8$), multiple pregnancy ($n = 2$), history of more than three spontaneous abortions/(induced) terminations of pregnancy/stillbirths or infant impairment ($n = 2$), invasive fertility treatment ($n = 9$), severe physical disease/microsomnia/skeletal malformation ($n = 6$), substance abuse or heroin substitution during the past 6 months ($n = 0$), severe psychiatric illness ($n = 2$), expectation to leave the area of Dresden ($n = 6$), and insufficient mastery of German language ($n = 7$). Additional 9 women did not participate due to spontaneous abortion before the baseline interview (T1), 10 due to lacking consent of the father of the infant, 154 due to lack of time, and 4 due to unknown reasons (36).

Overall, data of 306 women were eligible for the MARI study. Due to spontaneous abortion/induced termination of pregnancy, the participation of $n = 8$ women ended after T1. During the study, $n = 3$ women moved away, $n = 5$ women could not be reached any more by phone, postal, or personal contact, $n = 9$ women reported lack of time or interest for further participation, and $n = 7$ women refused contact for follow-up assessment. Overall, retention rate until 16 months after delivery (T7) was 89.5% ($n = 274$). Some women did not participate at single assessments, e.g. due to preterm delivery, own/infant sickness, or lack of time (T2: $n = 0$, T3: $n = 10$, T4: $n = 2$, T5: $n = 5$, T6: $n = 1$, T7: $n = 7$) (a detailed flow chart of the MARI study was presented by Martini et al. (36).

Measures and Procedures

Figure 1 presents the assessment points of the MARI study and predictors and outcomes of the present analyses. A Computer-Assisted Personal Interview (CAPI) version of the Composite International Diagnostic Interview for Women (CIDI-V) (37) was applied at each assessment wave except for T4 (10 days postpartum). Due to the special situation after delivery, questionnaires were used at T4 instead of the diagnostic interview to assess mode of delivery, birth experience, neonatal outcomes, and postpartum adjustment.

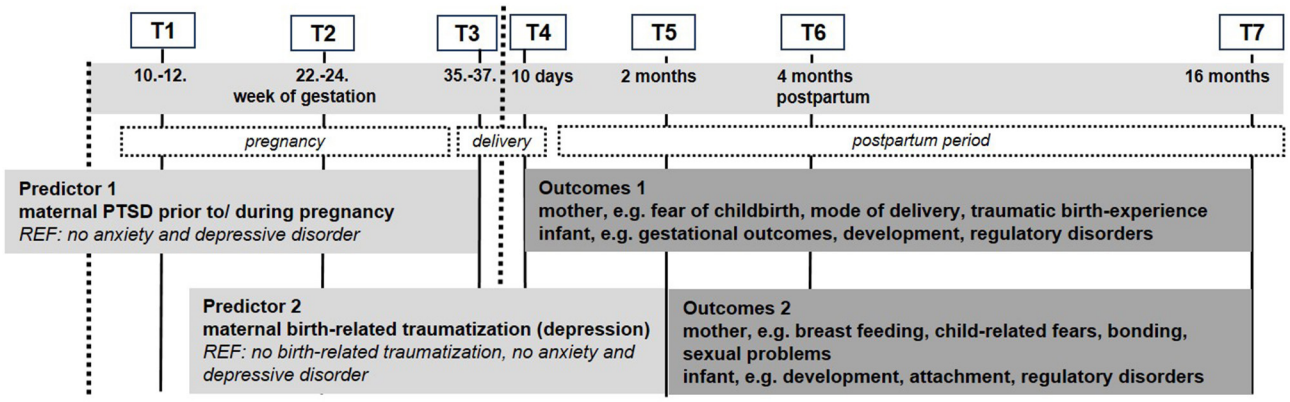

FIGURE 1 | Assessment waves, measures and outcomes for the *post-hoc* analyses of lifetime PTSD and birth-related traumatization with maternal and infant outcomes.

Predictors: PTSD Prior to or During Pregnancy and Birth-Related Traumatization

Maternal post-traumatic stress disorder as well as anxiety and depressive disorder were assessed using the CIDI lifetime version at baseline (T1) and the CIDI interval version at follow-up (T2, T3, T5, T6, T7). The CIDI-V is a modified version of the World Health Organization CIDI (WHO-CIDI) (38) that allows for a fully standardized assessment of DSM-IV-TR mental disorders in women (with specifying ICD-10 codes). Psychometric properties of the CIDI were modest to very good (39, 40). Diagnostic interviews were conducted by psychologists having received 1 week of intensive training and conducting a series of supervised interviews. Interviewers were closely monitored throughout the field period by experienced supervisors (clinical psychologists) (36).

Lifetime PTSD was assessed at Baseline (T1) and in Follow-up (T2, T3, T5, T6, and T7) interviews using the questions of the CIDI-V (Section N). Overall, $n = 25$ participants suffered from PTSD prior to or during pregnancy (35).

Birth-related traumatization was assessed at T5, T6, and T7 using adapted questions and lists of section N relating to the birth. It was defined as traumatic birth experience (A1: delivery as traumatic event or A2: intense fear, helplessness, or horror) AND hyperarousal or re-experiencing delivery or avoidance at T5, T6, or T7. Birth-related traumatization was indicated by $N = 35$ women. Of those women, $N = 19$ additionally indicated postpartum depression.

Since only $N = 4$ women indicated both PTSD prior to or during pregnancy and birth-related traumatization, this small group could not be analyzed in more detail.

Maternal and Infant Outcomes

Fear of childbirth during pregnancy and experience of childbirth was measured based on the German version of the Wijma Delivery Expectancy/ Experience Questionnaire (W-DEQ, Version A, Version B) (41–43). The W-DEQ is a reliable and valid 33-item questionnaire, with scores ranging from 'not at all' (0) to 'extremely' (5), yielding a minimum score of 0 and a maximum score of 165 (some items have to be reversed and a higher score indicates more intense fear of childbirth) (44, 45).

Maternal pregnancy- and child related fears were assessed at the end of the CIDI-V section on anxiety disorders with embedded questions and lists (37). During the assessments in pregnancy (T1–T3) the participants were instructed to read a list with pregnancy-related fears (e.g., rumination about current pregnancy, fear of labor pain, fear of vaginal delivery) and at T6 and T7 a list with child-related fears was provided (e.g., fear of mistakes concerning child care, fear of financial problems, fear of age-inappropriate development). The participants were asked "Have you ever ("Since the last interview, have you…") had a strong fear or avoidance of any of the situations/things in the list?" If the participants indicated one or more of these fears, they were asked whether the fear was excessive or stronger compared to other women and to evaluate the burden of the reported fears. Further questions on the presentation of associated anxiety symptoms (e.g., racing heart, sweating, trembling/shaking, dry mouth, difficult breathing, sensation of choking), frequency (sometimes or most of the time vs. only once), and interference with daily live (not at all or somewhat vs. a lot or very much) were asked.

Information on *gestational age*, *preterm delivery* (<37 + 0 week of gestation), *infant birth weight*, and *mode of delivery* was collected via medical records (46).

Sexual problems were assessed at T7 using the German version of the Massachusetts General Hospital Sexual Function Questionnaire (MGH) (47, 48). The MGH is a five-item screening instrument that assesses sexual problems with respect to sexual interest, arousal, orgasm, lubrication, and overall sexual satisfaction: (i) "How has your interest in sex been over the past month?"; (ii) "How has your ability to become sexually aroused or excited been over the past month?"; (iii) "How has your ability to achieve orgasm been over the past month?"; (iv) "How has your ability to become or remain lubricated been over the past month?"; (v) "How would you rate your overall sexual satisfaction over the past month?". Items are labeled: 1: greater than normal; 2: normal; 3: minimally diminished; 4: moderately diminished; 5: markedly diminished; and 6: totally absent. Based

on previous studies (47), a cutoff score of three was used to differentiate normal sexual functioning (≤3) from putative sexual problems or dysfunctions (>3) on each item. Concurrent and predictive validity (with respect to sexual functioning and sexual dysfunctions assessed by other self-reports and diagnostic instruments) of the MGH have been shown to be high (47, 49).

Duration of breastfeeding and *infant regulatory disorders* were assessed with a structured diagnostic interview (Baby-DIPS) at T5, T6, and T7 (50). *Excessive infant crying* was defined according to the "rule of three" by Wessel et al. (51) as crying for ≥3 h per day on ≥3 days per week for ≥3 weeks (51). *Feeding problems* were defined as any feeding problem (from a list of 16 feeding problems), failure-to-thrive, or mothers worrying (a lot or very much) about infant growth over a period of at least 4 weeks. *Sleeping problems* were defined as difficulties in initiating or maintaining sleep for ≥3 nights per week for ≥3 months while the mother was somewhat, a lot, or very much impaired by her infant's sleeping difficulties between 6 and 16 months (52). Cases that were attributable to a concurrent medical condition were excluded. The Baby-DIPS comprises good to excellent inter-rater reliability as well as high acceptance rates for interviewers and participants (53). Rates and co-occurrence of regulatory problems in the MARI sample were comparable to rates reported by others (52, 54).

Maternal bonding was assessed with the German Version of the Postpartum Bonding Instrument (PBQ) at T5 (55). This self-report questionnaire consists of 25 items assessing impaired bonding, rejection and anger, anxiety about care, and risk of abuse (42, 56). The very good psychometric properties were confirmed for the German Version (55). For this analysis, the scales impaired bonding as well as rejection and anger were relevant.

Observations of the mothers and their infants were conducted using standardized observation paradigms to assess infants' temperament (57), neuropsychological development (58), and the quality of infant attachment (59). Standardized observations were conducted by two female psychologists who were blinded to the diagnosis of the mother and had received 2 weeks of training. All observations were recorded by three cameras and supervised to ensure a high assessment quality. Video coding was conducted with the software "Interact" (Mangold).

Neuropsychological development was assessed at T6 and T7 with the standardized procedure by Petermann and Renziehausen (58). The tasks allow for an assessment of developmental deficits in different areas (movement control, fine motor skills, visual perception, exploration behavior, receptive and expressive language, cognitive performance). Coding was conducted by graduate and postgraduate psychology students according to the manual guidelines (58).

Temperament was measured with the procedures developed by Kagan et al. (60). For the assessment of *infant's reactivity* at T6, the infants sat in a reclining cushioned seat and heard some taped sentences, saw three different colorful mobiles move back and forth, had a cotton swab dipped in dilute butyl alcohol placed under the nostrils, heard a female voice speaking different syllables, and saw a colored umbrella spread out. During these procedures the mother was out of view of the infant. Videotapes were coded for high motor activity (multiple arm, leg, and back movements) and crying (high percentage of time spent crying) in response to the stimuli. Infants were classified as "highly reactive" (high motor activity and crying), "low reactive" (low motor activity and crying), or neither (either high motor activity and low crying amount or the opposite). The assessment of *behavioral inhibition* at T7 involved the presentation of inanimate stimuli to the child (a spinning bingo wheel with noisy objects inside, rotating toys, a puppet show, and sweet and sour tastes). Moreover, strangers (a woman dressed in a white laboratory coat and surgical face mask and a woman with a black cloth over her head and shoulders) attempted to interact with the child. Video coding was conducted by graduate and postgraduate psychology students who were blinded and had received a training of 2 weeks for coding the infant's reactivity and behavioral inhibition (60). The average coding time was 45 min for reactivity and behavioral inhibition. At least 10 videos were coded during training sessions to yield an adequate observer agreement (kappa >0.8) and about 10% of all videos were randomly selected and re-analyzed for quality check to ensure observer agreement with satisfying results (61).

Attachment: At T7 mother-infant-dyads participated in the Strange Situation Procedure (59), which consisted of eight episodes, including two brief separations and reunions of the infant from/with the mother. Following the procedures described by Ainsworth et al. (59) and Main and Solomon (62), the attachment group classification was based primarily on the infant's reactions to the mother's return (59, 62). Infants who actively greeted and/or sought contact with the mother upon reunion and returned to exploration within 3 min were classified as secure (Typ B: secure). Infants who actively averted gaze or avoided or ignored the mother immediately upon reunion (Typ A: avoidant) and infants who sought to reunite with the mother but displayed ineffective proximity and contact-seeking behavior, showing anger and active resistance to contact or prolonged fussiness and persistent low-level distress (Typ C: ambivalent/resistant) were classified as insecure. Video coding was conducted by graduate and postgraduate psychology students who were blinded and had received the coding training. The average coding time for attachment videos was 60 min. Cohen's kappa coefficient for the secure and insecure (avoidant and resistant) attachment classifications was based on 20% of randomly selected and independently scored videotapes of the Strange Situation Test (63). Interrater reliability was conducted on 20% of the sample ($\kappa = 1.00$ for ABC classification). Final scores for difficult tapes and coder disagreements were based on consensus [for more information see (64)].

Statistical Analyses

All analyses were performed using STATA version 14 (65). For research question (1) linear and logistic regression analyses were conducted to examine concurrent and prospective associations (Beta, ß and odds ratios, OR) of maternal PTSD prior to or during pregnancy with and without interpersonal trauma with maternal and infant health outcomes (reference: women with neither anxiety nor depressive disorder until T3). For research question (2) linear and logistic regression analyses were conducted to examine betas/ORs including 95% confidence intervals (CI) of maternal birth-related traumatization (with and

TABLE 1 | Sociodemographic and gynecological characteristics of women with any PTSD until T3 (with/without interpersonal trauma) ($N = 25$) as compared to women with neither anxiety nor depressive disorder until T3 ($N = 100$).

	Women with neither anxiety nor depressive disorder until T3 ($N = 100$)	PTSD prior to or during pregnancy with/without interpersonal trauma ($N = 25$)	Significant group differences
	N, % or M, SD	*N*, % or M, SD	
Age (M, SD)	27.9 (4.6)	27.1 (3.7)	
Educational status (*n*, %)			
Lower education (≤10 years)	25 (25.0)	**13 (52.0)**	**Chi²=6.891, $p = 0.009$**
Higher education (>10 years)	75 (75.0)	**12 (48.0)**	
Marital status (*n*, %)			
Not married	64 (64.0)	18 (72.0)	
Married	36 (36.0)	7 (28.0)	
Cohabitation (*n*, %)			
Not living together	6 (6.0)	0 (0.0)	
Living together	94 (94.0)	25 (100.0)	
Working time at baseline (*n*, %)			
Full-time job	37 (37.0)	8 (32.0)	
Part-time job	26 (26.0)	4 (16.0)	
Currently not working	37 (37.0)	13 (52.0)	
Monthly household income after taxes (*n*, %)			
< 500€	9 (9.0)	1 (4.0)	
500–1,500€	34 (34.0)	11 (44.0)	
1,500–2,500€	27 (27.0)	9 (36.0)	
2,500–3,500€	19 (19.0)	2 (8.0)	
3,500–4,500€	8 (8.0)	2 (8.0)	
>4,500€	3 (3.0)	0 (0.0)	
Parity (*n*, %)			
Primipara	60 (60.0)	11 (44.0)	
Multipara	40 (40.0)	14 (56.0)	
Pregnancy planned/ desired: yes (*n*, %)	86 (94.5)	22 (95.7)	
Prior spontaneous abortions (*n*, %)			
No	79 (79.0)	16 (64.0)	
Yes	21 (21.0)	9 (36.0)	
Any nicotine consumption during pregnancy (*n*, %)	3 (3.0)	**4 (16.0)**	**Chi²=6.394, $p = 0.011$**
Any alcohol consumption during pregnancy (*n*, %)	31 (31.0)	7 (28.0)	
Social support during pregnancy (F-SozU, T2) (M, SD)	4.5 (0.4)	**4.1 (0.7)**	**$t = 3.122$, $p > 0.001$**
Partnership quality during pregnancy (PFB, T2) (M, SD)	72.8 (10.5)	68.5 (18.1)	

T3, MARI assessment during third trimester of pregnancy; REF, reference; PTSD, post-traumatic stress disorder; n, number; %, percentage; M, mean; SD, standard deviation; Chi², Chi-squared test; t, t-test; p, p-value. Bold: significant group differences.

without depression) with maternal and infant health outcomes (reference: neither anxiety nor depressive disorder prior to or during pregnancy and no birth-related traumatization). Separate analyses were conducted for each outcome and no adjustment for multiple testing was applied, because the individual tests were related to individual hypotheses. Statistical significance was evaluated two-sided at the 5% level ($p < 0.05$).

RESULTS

To investigate research question 1, analyses were based on the following three diagnostic groups:

- Reference: neither anxiety nor depressive disorder prior to or during pregnancy (until T3) ($N = 100$)
- PTSD prior to or during pregnancy (cumulative lifetime diagnosis until T3) ($N = 25$)
- PTSD prior to or during pregnancy with interpersonal traumata (cumulative lifetime diagnosis until T3) ($N = 17$)

Women with PTSD prior to or during pregnancy were characterized by a lower educational level (education: ≤10 years: reference: 25.0%, PTSD prior to or during pregnancy: 52.0%; Chi²=6.891, $p = 0.009$) compared to women with neither anxiety nor depressive disorder until delivery (**Table 1**). Moreover, women with PTSD prior to or during pregnancy

TABLE 2 | Maternal and infant outcomes in women with PTSD prior to or during pregnancy (with interpersonal trauma) compared to women with neither anxiety nor depressive disorder until T3.

	Reference group: Neither anxiety nor depressive disorder prior to or during pregnancy (until T3) (*N* = 100)	**PTSD prior to or during pregnancy (w/wo interpersonal trauma) (*N* = 25)**		**PTSD prior to or during pregnancy with interpersonal traumata (until T3) (*N* = 17)**	
	***N*, % or M, SD**	***N,* % or M, SD**	**OR (95%CI) or ß (95%CI)**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**
Maternal health during pregnancy and birth experience					
Fear of childbirth (W-DEQ-A, T3) (M, SD)	57.9 (21.5)	**69.3 (22.1)**	**ß = 11.40 (1.21–21.59)**	**69.7 (19.0)**	**ß = 11.80 (0.08–23.51)**
Birth experience (W-DEQ-B, T4) (M, SD)	62.8 (21.8)	67.3 (18.2)		65.8 (18.8)	
Pregnancy-related anxiety (*n*, %)					
Fear of labor pain	19 (19.0)	8 (32.0)		5 (29.4)	
Fear of vaginal delivery	26 (26.0)	10 (40.0)		8 (47.1)	
Fear of perineal rupture/episiotomy	27 (27.0)	6 (24.0)		5 (29.4)	
Fear of epidural anesthesia	8 (8.0)	**10 (40.0)**	**OR = 7.67 (2.61–22.53)**	**7 (41.2)**	**OR = 8.05 (2.41–26.89)**
Excessive pregnancy-related fear	7 (7.0)	*5 (20.0)*		3 (17.7)	
Presentation of anxiety symptoms	8 (8.0)	4 (16.0)		3 (17.7)	
Interference with daily live	3 (3.0)	**6 (24.0)**	**OR = 10.21 (2.35–44.43)**	**3 (17.7)**	**OR = 6.93 (1.27–37.76)**
Evaluation of fears as frequent	9 (9.0)	4 (16.0)		3 (17.7)	
Mode of delivery (*n*, %)					
Spontaneous delivery	78 (85.7)	20 (87.0)		14 (87.5)	
C-section/ Operative vaginal delivery	13 (14.3)	3 (13.4)		2 (12.5)	
Support and control during delivery (M, SD)					
Internal control (SCIB)	32.2 (8.1)	28.7 (9.2)		27.9 (9.4)	
External control (SCIB)	38.1 (8.9)	38.0 (8.2)		38.4 (8.7)	
Support (SCIB)	46.9 (8.6)	46.7 (11.3)		44.6 (12.0)	
DSM-VI criteria for traumatic birth experience (*n*, %)					
A1: delivery as traumatic event	11 (12.1)	**9 (42.9)**	**OR = 5.45 (1.87–15.90)**	**6 (42.9)**	**OR = 5.45 (1.59–18.70)**
A2: intense fear, helplessness, or horror	15 (16.5)	**8 (38.1)**	**OR = 3.12 (1.10–8.82)**	**6 (42.9)**	**OR = 3.80 (1.15–12.55)**
B: re–experiencing delivery	1 (1.0)	**4 (16.0)**	**OR = 18.85 (2.00–177.37)**	**2 (11.8)**	**OR = 13.20 (1.13–154.68)**
C: avoidance of recollection due to delivery	0 (0.0)	0 (0.0)	omitted	0 (0.0)	omitted
E: alterations in arousal following delivery	6 (6.0)	2 (8.0)		0 (0.0)	omitted
Any postpartum anxiety disorder (*n*, %)	8 (8.8)	**11 (47.8)**	**OR = 9.51 (3.19–28.39)**	**7 (43.8)**	**OR = 8.07 (2.37–27.49)**
Postpartum depression (*n*, %)	0 (0.0)	7 (30.4)	omitted	5 (31.3)	omitted
Infant health outcomes					
Gestational age (M, SD)	39.5 (1.5)	39.4 (1.2)		39.4 (1.2)	
Birth weight (M, SD)	3,403.2 (58.1)	3.510.7 (440.7)		3,494.1 (440.6)	
Excessive crying (*n*, %)	6/91 (6.6)	3/23 (13.0)		2/16 (12.5)	
Feeding problems (*n*, %)	24/91 (26.4)	10/23 (43.5)		**9/16 (56.3)**	**OR = 3.59 (1.20–10.70)**
Sleeping problems (*n*, %)	9/91 (9.9)	4/23 (17.4)		4/16 (25.0)	

(Continued)

TABLE 2 | Continued

	Reference group: Neither anxiety nor depressive disorder prior to or during pregnancy (until T3) (*N* = 100)	**PTSD prior to or during pregnancy (w/wo interpersonal trauma) (*N* = 25)**		**PTSD prior to or during pregnancy with interpersonal traumata (until T3) (*N* = 17)**	
	***N*, % or M, SD**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**
Neuropsychological development (T6) (M, SD)	11.6 (0.8)	11.6 (0.6)		11.6 (0.6)	
Neuropsychological development (T7) (M, SD)	13.3 (1.8)	13.6 (1.6)		13.1 (1.7)	
Temperament: highly reactive (T6) (*n*, %)	9/83 (10.8)	5/22 (22.7)		4/15 (26.7)	
Temperament: Behavioral Inhibition (T7) (*n*, %)	38/84 (45.2)	5/20 (25.0)		5/13 (38.5)	
Insecure attachment (Strange Situation) (T7) (*n*, %)	29/82 (35.4)	7/20 (35.0)		4/13 (30.8)	

T3, 3rd assessment during third trimester of pregnancy; T5, 5th assessment 2 months postpartum; T6, 6th assessment 4 months postpartum; T7, 7th assessment 16 months postpartum; REF, reference; Any PTSD until T3, women with any PTSD until T3, Any PTSD + man-made trauma until T3, women with any PTSD with manmade trauma until T3, W-DEQ, Wijma Delivery Expectancy/Experience Questionnaire; PBQ, Postpartum Bonding Questionnaire; N, number; %, percentage; M, mean; SD, standard deviation; OR, odds ratio; 95%CI, 95% confidence interval. Bold: significant group differences.

reported more often nicotine consumption during pregnancy (16.0% vs. 3.0%; Chi^2=6.394, $p = 0.001$) and lower social support during pregnancy (F-Sozu: M=4.1, SD=0.7 vs. M=4.5, SD=0.4; $t = 3.122$, $p > 0.001$) as compared to the reference group. There were no significant differences between the groups with regard to age, marital status, and monthly household income (**Table 1**).

Table 2 shows maternal and infant outcomes in women with PTSD prior to or during pregnancy compared with or without interpersonal trauma ($N = 25$) to women with neither anxiety nor depressive disorder until T3 ($N = 100$). Women with history of PTSD reported more fear of childbirth and fear of epidural anesthesia and perceived delivery more often as traumatic (including re-experiencing delivery later on). Moreover, infants of women with PTSD prior to delivery and interpersonal trauma ($N = 17$) were at higher risk for feeding problems.

To investigate research question 2, analyses were based on the following three diagnostic groups:

- Reference: neither anxiety nor depressive disorder prior to or during pregnancy (until T3) and no birth-related traumatization (traumatic birth experience (A1 or A2) AND no hyperarousal/ re-experiencing/ avoidance) ($N = 70$)
- birth-related traumatization (traumatic birth experience (A1 or A2) AND hyperarousal or re-experiencing or avoidance) ($N = 35$)
- birth-related traumatization (traumatic birth experience (A1 or A2) AND hyperarousal or re-experiencing or avoidance) AND depression ($N = 19$)

Table 3 shows maternal and infant outcomes in women with birth-related traumatization compared to women with neither anxiety nor depressive disorder until T3 and no birth-related traumatization. A higher risk for child-related fears, postpartum anxiety disorders, and sexual problems was reported by women with birth-related traumatization. Moreover, infants of mothers with birth-related traumatization and postpartum depression were at higher risk for feeding and sleeping problems.

DISCUSSION

This prospective longitudinal study demonstrated that (1) women with PTSD prior to or during pregnancy presented with a disadvantageous psycho-social situation, reported more pronounced fear of childbirth, and indicated more often a traumatic birth experience compared to women without anxiety and depressive disorder prior to delivery. Moreover, infants of women with PTSD and interpersonal trauma, had a higher risk for feeding problems. (2) Women with birth-related traumatization indicated numerous adverse outcomes (e.g., postpartum anxiety and depression, child-related fears, sexual problems), and in case of additional postpartum depression, the infants were more often affected by feeding and sleeping problems.

The first research question examined the associations of PTSD prior to or during pregnancy with specific maternal and infant outcomes. As expected and in line with previous research, women with PTSD prior to or during pregnancy reported more often pregnancy- and child-related fears and they were further at higher risk for a traumatic birth experience compared to women without anxiety and depressive disorder prior to delivery (12). Moreover, those women presented with a disadvantageous psycho-social situation (lower educational level, less social support) and indicated more often nicotine consumption during pregnancy (66, 67). These factors can be associated with a cascade of behavioral health and neuroendocrine changes that

TABLE 3 | Maternal and infant outcomes in women with birth-related traumatization (and depression) after delivery compared to women with neither anxiety nor depressive disorder until T3 and no birth-related traumatization.

	Reference group: Neither anxiety nor depressive disorder until T3 and no birth-related traumatization (*N* = 70)	**Birth-related traumatization: Traumatic birth experience (A1/ A2) + (hyperarousal/ re-experiencing/ avoidance) (*N* = 35)**		**Birth-related traumatization: Traumatic birth experience (A1/ A2) + (hyperarousal/ re-experiencing/ avoidance) + depression (*N* = 19)**	
	***N*, % or M, SD**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**
Maternal health during postpartum period					
Duration of breastfeeding (M, SD)	9.4 (4.6)	9.6 (4.5)		8.8 (4.7)	
Maternal impaired bonding (T5) (PBQ) (M,SD)	4.3 (4.1)	5.3 (4.3)		5.5 (4.1)	
Maternal rejection and anger (T5) (PBQ) (M,SD)	1.5 (2.0)	1.7 (2.2)		1.8 (1.9)	
Child-related fears/ anxiety (*n*, %)					
Fear of mistakes concerning child care	9 (12.9)	**11 (31.4)**	**OR = 3.11 (1.14–8.44)**	6 (31.6)	
Fear of mistakes concerning child feeding	12 (17.1)	**14 (40.0)**	**OR = 3.22 (1.29–8.07)**	7 (36.8)	
Fear of financial problems	2 (2.9)	2 (5.7)		2 (10.5)	
Fear of mistakes concerning child rearing	3 (4.3)	**10 (28.6)**	**OR = 8.93 (2.27–35.14)**	**6 (31.6)**	**OR = 10.31 (2.28–46.56)**
Fear concerning quality of day care*	7 (10.3)	8 (23.5)		3 (16.7)	
Fear that child suffers from familial conflicts*	0 (0.0)	4 (11.8)	omitted	1 (5.6)	omitted
Fear of separation from child	3 (4.4)	**7 (20.6)**	**OR = 5.62 (1.35–23.36)**	3 (16.7)	
Fear of age-inappropriate infant development	5 (7.1)	5 (14.3)		**5 (26.3)**	**OR = 4.64 (1.18–18.23)**
Fear of viral or other infection/ disease	8 (11.4)	8 (22.9)		4 (21.1)	
Fear of infant injury	11 (15.7)	9 (25.7)		3 (15.8)	
Fear of infant death	13 (18.6)	**16 (45.7)**	**OR = 3.69 (1.51–9.06)**	**9 (47.4)**	**OR = 3.95 (1.34–11.66)**
Evaluation of fear as excessive	30 (42.9)	**23 (65.7)**	**OR = 2.56 (1.10–5.94)**	13 (68.4)	
Presentation of anxiety symptoms	7 (10.0)	**10 (28.6)**	**OR = 3.60 (1.23–10.51)**	5 (26.3)	
Evaluation of fears as frequent	6 (8.6)	**9 (25.7)**	**OR = 3.69 (1.19–11.42)**	4 (21.1)	
Interference with daily life	2 (2.86)	**5 (14.3)**	**OR = 5.67 (1.04–30.87)**	**4 (21.1)**	**OR = 9.07 (1.52–54.15)**
Any anxiety disorder postpartum	6 (8.6)	**14 (40.0)**	**OR = 7.11 (2.43–20.86)**	**8 (42.1)**	**OR = 7.76 (2.25–26.72)**
Postpartum depression	0 (0.0)	19 (54.3)	omitted	*19 (100.0)*	*group definition*
Sexual problems (T7) (M, SD)					
Sexual interest	3.2 (1.4)	**3.9 (1.3)**	**ß = 0.76 (0.18–1.33)**	**4.2 (1.2)**	**ß = 1.02 (0.30–1.75)**
Sexual arousal	2.8 (1.4)	**3.4 (1.4)**	**ß = 0.60 (0.02–1.19)**	3.5 (1.4)	
Orgasm	2.7 (1.4)	**3.6 (1.7)**	**ß = 0.90 (0.26–1.53)**	**3.8 (1.8)**	**ß = 1.10 (0.29–1.91)**
Lubrication	2.3 (0.9)	**3.0 (1.4)**	**ß = 0.76 (0.28–1.24)**	**2.9 (1.4)**	**ß = 0.67 (0.09–1.25)**
Overall sexual satisfaction	2.8 (1.3)	**3.9 (1.5)**	**ß = 1.1 (0.50–1.67)**	**4.4 (1.5)**	**ß = 1.57 (0.84–2.29)**
Infant Health and infant outcomes					
Excessive crying (*n*, %)	5/70 (7.1)	4/35 (11.4)		3/19 (15.8)	
Feeding problems (*n*, %)	17/70 (24.3)	15/35 (42.9)		**12/19 (63.2)**	**OR = 5.34 (1.81–15.74)**
Sleeping problems (*n*, %)	8/70 (11.4)	9/35 (25.7)		**8/19 (42.1)**	**OR = 5.64 (1.75–18.18)**
Neuropsychological development (T6) (M, SD)	11.4 (0.9)	11.6 (0.8)		11.7 (0.8)	
Neuropsychological development (T7) (M, SD)	13.3 (1.9)	13.1 (2.0)		12.9 (2.3)	

(Continued)

TABLE 3 | Continued

	Reference group: Neither anxiety nor depressive disorder until T3 and no birth-related traumatization (*N* = 70)	**Birth-related traumatization: Traumatic birth experience (A1/ A2) + (hyperarousal/ re-experiencing/ avoidance) (*N* = 35)**		**Birth-related traumatization: Traumatic birth experience (A1/ A2) + (hyperarousal/ re-experiencing/ avoidance) + depression (*N* = 19)**	
	***N*, % or M, SD**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**	***N*, % or M, SD**	**OR (95%CI) or ß (95%CI)**
Temperament: highly reactive (T6) (*n*, %)	7/63 (11.1)	5/32 (15.6)		2/17 (11.8)	
Temperament: behavioral Inhibition (T7) (*n*, %)	32/66 (48.5)	14/31 (45.2)		7/16 (43.8)	
Insecure attachment (Strange Situation) (T7) (*n*, %)	26/65 (40.0)	15/31 (48.4)		8/16 (50.0)	

*T5, 5th assessment 2 months postpartum; T6, 6th assessment 4 months postpartum; T7, 7th assessment 16 months postpartum; REF, reference; A1, DSM–IV PTSD criteria A1; A2, DSM–IV PTSD criteria A2; PBQ, Postpartum Bonding Questionnaire; N, number; %, percentage; M, mean; SD, standard deviation; OR, odds ratio; ß, Beta-coefficient; 95%CI, 95% confidence interval; * Data of N = 267 participants available only. Bold: significant group differences.*

may not only have negative consequences for the affected women, but also for the infants (68, 69). Regarding the current discussion on intergenerational transmission of trauma effects it is particularly interesting that women with lifetime PTSD reported more pronounced pregnancy-related fears (70). Yehuda and Lehrner recently highlighted that preconception trauma in parents might be associated with epigenetic changes and developmentally programmed effects that can result from offspring's early environmental in utero and postnatal exposures leading to an increased susceptibility of the infant to later environmental distress (70, 71). We found a higher risk for infant regulatory disorders (feeding problems) in mothers with PTSD prior to or during pregnancy and interpersonal traumata (2, 28, 29, 31, 32). However, no significant associations were seen for e.g., temperament, neuropsychological development, or bonding. One explanation could be that lifetime PTSD was not present anymore during the perinatal period in some of the women due to recovery or successful therapy. However, it still seems to be relevant for the development of infant feeding problems in case of interpersonal trauma. Another explanation might be the limited statistical power to detect differences between the respective groups (see limitations section).

The second research question pertains to birth-related traumatization. As expected, women with birth-related traumatization reported more often sexual problems as compared to the reference group (12). Given that sexual problems impede the partnership or interfere with further family planning, affected women might profit from targeted early interventions supporting them and their partners to successfully cope with sexual dysfunctions and associated problems (18, 72). In line with previous evidence, women with birth-related traumatization reported more often postpartum anxiety and depressive disorders as compared to the reference group (12). This is important to note, since traumatic birth experience might change the way affected mothers interact with their infants, especially if postpartum depression is also present (e.g., avoiding contact with or being emotionally unavailable for the infant) (73, 74). Moreover, we saw a higher risk for infant regulatory disorders (sleeping and feeding problems) in mothers with birth-related traumatization and postpartum depression. This was in line with the results by Garthus-Niegel and colleagues who reported an association of PTSD and impaired child sleep (75). However, no significant associations were seen for e.g., temperament, neuropsychological development, or bonding. This was surprising since other prospective studies found maternal postpartum PTSD to be associated with poorer cognitive and social-emotional development in infants up to 2 years (19, 30). However, Garthus-Niegel et al. (19) did not find significant associations with other domains of child development (fine/gross motor or communication development) which was also not seen in our sample (19).

Taken together, our findings highlight the importance of early targeted prevention and intervention for affected women (20) and the peripartum period represents an opportunity to interrupt the pattern of intergenerational transmission of trauma. Knowledge of PTSD prior to or during pregnancy that is also associated with a higher risk of traumatic birth experience (e.g., experience of fear, helplessness or horror, or re-experiencing delivery) is crucial for health-care providers to be alert of when they treat these high-risk women (20, 76). Moreover, trauma-informed interventions should be developed and tested especially for women with PTSD and a history of interpersonal trauma or comorbid depression (74, 77). Targets that should be addressed are prevention of re-traumatization during delivery, improvement of maternal partnership problems and social support, and sensitivity training to encourage mother-child-interaction and bonding/ attachment (78–80). First evidence shows that cognitive behavioral therapy (81) and Eye Movement

Desensitization and Reprocessing approaches (82–84) may improve PTSD status but require investigation in randomized controlled trials (85). Debriefing may only be successful if women are requesting it themselves (86). Since PTSD can also affect the developing relationship with the child, mother-infant bonding problems should also be addressed (20, 23). For some mothers, their infants are a reminder of their traumatic birth and may therefore trigger avoidance behaviors (i.e., non-initiation of breastfeeding) (21). Here, Mother Baby Connections, a program involving interaction therapy, has brought first promising results (87).

Strengths and Limitations

A particular feature of this investigation was the recruitment already during early pregnancy and the consideration of lifetime diagnostic status. To our knowledge this is the first study investigating both, lifetime PTSD and birth-related traumatization, with associated maternal and infant outcomes. Strengths of this study include the prospective multi-wave design and the long follow-up period. Findings are limited by small cell sizes in some clinical groups. This limits power to detect differences between the respective groups. Thus, the absence of significant differences between infants of mothers with no anxiety and depressive disorder as compared to mothers with lifetime PTSD or birth-related traumatization regarding, e.g., temperament, neuropsychological development, or bonding, should not be interpreted as indicative of negative results. It was also not possible to explore the putative cumulative risk of lifetime PTSD and birth-related traumatization on maternal and infant outcomes. Moreover, sample size prohibited examination of third variables that might also be relevant (e.g., income, education, birth outcomes) (88).

CONCLUSION

The study shows that PTSD is a highly debilitating disorder and affected (expectant) mothers might profit from early interventions already during pregnancy and the initial postpartum period (89). Our results highlight the crucial role of early identification and treatment of affected women. Women's health care providers should screen for PTSD and subsyndromal posttraumatic stress symptoms in routine assessments during and after pregnancy, especially in women with a reported history of trauma. Such screening will allow women to receive needed treatment and referrals and mitigate the potentially negative sequelae of PTSD (14). However, screening without sufficient services is not helpful and could be triggering for both professionals and families. Thus, a fully trauma informed perinatal system and effective trauma specific interventions during pregnancy and immediately after traumatic births is warranted to ensure that the families receive help for parenting and early bonding (77).

Finally, this *post-hoc* analysis was conducted with the aim of generating hypotheses for future research. Larger prospective studies are warranted to examine why interpersonal trauma is especially harmful for perinatal outcomes, and to disentangle whether this is driven by the interpersonal trauma in general, or trauma related to mothers' own childhood attachment relationships. It will be important to examine the role of hormonal alterations and other biological or psychosocial factors in the context of perinatal PTSD and to include a comprehensive assessment on psychotherapeutic and pharmacological treatments. Finally, it is important to note, that paternal PTSD after childbirth is a highly understudied and unrecognized problem that should receive more attention.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because after consulting the Ethics Committee and due to the sensitive nature of the questions asked in this study, participants were assured that all raw data would remain confidential and would not be shared. Therefore, no openly assessable data files are attached. Further information on the data can be obtained from the corresponding author (JM, email: julia.martini@tu-dresden.de), the Ethics Committee of the Medical Faculty of the Technische Universität Dresden (email: ethikkommission@mailbox.tu-dresden.de), and the Institute of Clinical Psychology and Psychotherapy of the Technische Universität Dresden.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Technische Universität Dresden (No: EK 94042007). Written informed consent to participate in this study was provided by the participants' legal guardian.

AUTHOR CONTRIBUTIONS

JM conceptualized and designed the study, designed the data collection instruments, collected data for the study, carried out the statistical analyses and the interpretation of the data, drafted the initial manuscript, and approved the final manuscript as submitted. EA, SK, KW, JR, and SG-N critically reviewed the manuscript and approved the final manuscript as submitted. All authors contributed to the article and approved the submitted version.

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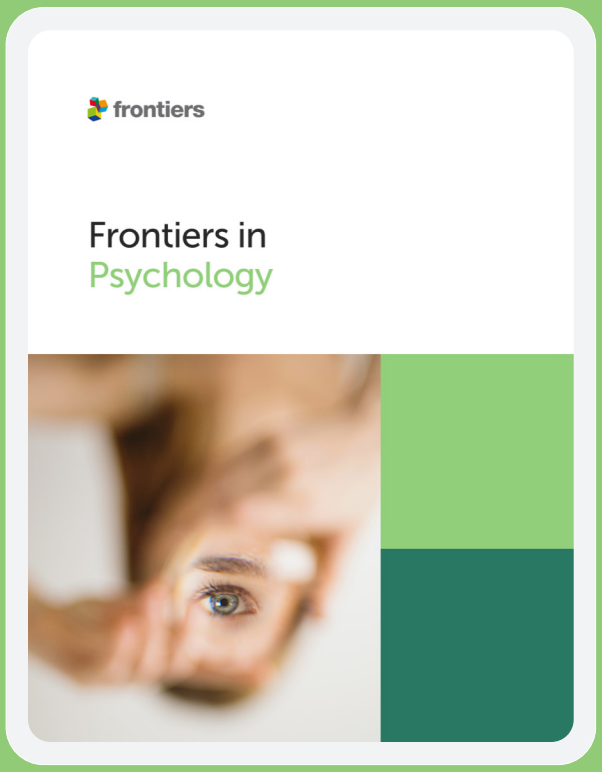

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