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Regular Article

Associations between maternal postpartum depression and infant temperament in treatment-seeking mothers prior to and during the COVID-19 pandemic

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Abstract

It remains unclear how the COVID-19 pandemic has affected the mother–infant relationship and associations between maternal postpartum depression (PPD) and offspring temperament. This study examined the impact of the pandemic on these links and how maternal ratings of the mother–infant relationship mediated associations between PPD and infant temperament in a sample of treatment-seeking mothers in Ontario, Canada before and during the COVID-19 pandemic. Mothers with infants <12 months of age and Edinburgh Postnatal Depression Scale scores ≥10 enrolled in two separate randomized controlled trials of 1-day cognitive behavioral therapy-based workshops for PPD conducted before COVID-19 ($n = 392$) and during the pandemic ($n = 403$). Mothers reported on depressive symptomatology, infant temperament, and the mother–infant relationship. Maternal PPD was associated with more infant negative affectivity and mother–infant relationship difficulties. While associations between PPD and infant-focused anxiety were stronger during COVID-19, the pandemic did not otherwise affect associations between PPD and infant temperament. Mediation analyses suggested that aspects of the mother-infant relationship mediated associations between PPD and infant negative affectivity. Findings highlight the importance of detecting PPD and intervening to potentially improve outcomes for mothers and their children.

Keywords: COVID-19; mother-child relations; postpartum depression; temperament; mothers

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Background

Postpartum depression (PPD) affects up to one in five mothers in the first year after delivery (Shorey et al., 2018) and has been linked to an increased risk of future depressive episodes (Turkcapar et al., 2015), partner relationship problems (Odinka et al., 2018), and cognitive, social, emotional, and behavioral problems in offspring (Slomian et al., 2019). During the COVID-19 pandemic, mothers faced additional challenges to their mental health, including reduced social support (Spinola et al., 2020), a disruption of healthcare services (World Health Organization, 2020), and financial difficulties (Wilson et al., 2020). Mothers also experienced an expansion of roles (Andrew et al., 2020), where most had additional household responsibilities including having to provide care to their infants and toddlers, as well as educating their school-aged children. The threat of job losses, reduced income, and food insecurity also contributed to disrupted family routines and increased partner conflict. These factors and others have contributed to elevated rates of perinatal depression and anxiety during the pandemic (Davenport et al., 2020; Layton et al., 2021; Liang et al., 2020), with potential adverse effects for their infants in both the short and long term.

Infant temperament is consistently rated as more difficult or is marked by more negative affect in the first 12 months after delivery by mothers with PPD in both clinical and general population samples (Bridgett et al., 2009; Britton, 2011; Forman et al., 2007; Kerstis et al., 2013; McGrath et al., 2008). These early disruptions in development are important because these temperamental traits can predict elevated levels of internalizing and externalizing behaviors during both childhood and adolescence (Filippi et al., 2022; Gartstein et al., 2012; Lahey et al., 2008). Maternal PPD is associated with greater risk for suboptimal parenting and child-rearing practices (Slomian et al., 2019), which can negatively impact offspring brain development. Deficits in cognitive and emotional development associated with harsh parenting may explain why children exposed to PPD have more difficulties regulating their emotions and behaviors. Studies have also examined transactional influences between mothers and offspring, acknowledging that maternal moods and behavior can impact offspring, but that offspring can also affect their mothers (Sameroff, 2010). For instance, longitudinal studies have shown that while maternal depression and child behavioral difficulties (e.g., internalizing and externalizing behaviors) are associated during infancy and early childhood,

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these difficulties also predicted future symptoms of maternal depression (Baker et al., 2020; Curci et al., 2022; Roubinov et al., 2022). Despite the stresses imposed on parents and families by the pandemic, no studies have compared associations between PPD and infant temperament prior to and during the COVID-19 pandemic.

Understanding how the COVID-19 pandemic affected the health and development of the offspring of mothers with PPD is important because rates of PPD appear to have increased during COVID-19, and it could reveal opportunities to reduce the impact of the pandemic and PPD on these infants. Stressful events, such as natural disasters, experienced perinatally have been shown to have a significant adverse impact on offspring. For example, pregnant women exposed to Hurricane Sandy had infants who smiled and laughed less frequently at 12 months of age (Pehme et al., 2018). Subjective maternal prenatal stress present during the 1998 ice storm in Quebec, Canada was also associated with more difficult temperament in infants at six months (Laplante et al., 2016). Infants conceived during the COVID-19 pandemic also exhibited lower regulatory capacity at three months of age (Provenzi et al., 2021). However, the findings of the only study to date that has examined the temperament of infants of mothers seeking treatment for PPD during the pandemic were mixed (Chang et al., 2021). Infants born to mothers with PPD during the pandemic may be in a particularly precarious situation. From birth, infants bond with their mothers through touch and facial expressions, which facilitate neurobehavioral development (Green et al., 2021). However, the regular wearing of face masks in concordance with public health measures, sometimes even in maternity wards (Talwar, 2021), may have hindered infants' ability to process maternal facial expressions and cues to self-regulate. Considering mothers with PPD and their infants often display gaze aversion or have reduced mutual gaze time (Granat et al., 2017), this additional barrier may have amplified disturbances in infant social and temperament development occurring in response to the stresses associated with the COVID-19 pandemic. Regardless, since the majority of the studies that have examined large-scale stressful events experienced perinatally were relatively small and lacked comparable predisaster comparison groups, more data are needed to determine how exposure to population-level postpartum stressors affect associations between PPD and infant temperament.

A number of biological and social factors have been hypothesized to mediate associations between maternal depression and infant temperament (Bates et al., 2020; Gustafsson et al., 2018; Räikkönen et al., 2015). For example, a study by Mason et al. (2011) noted that maternal feelings of poorer attachment mediated the association between PPD at two months and worse socio-emotional development at 6 months in their sample of 219 mother–infant dyads. In children, maternal responsiveness (Milgrom et al., 2004), intrusiveness (Hummel & Kiel, 2015), parenting (Tissot et al., 2016), and nutritional status (Avan et al., 2010) also have been explored as putative mediators of associations between PPD and temperamental/behavioral problems. However, there remains a surprising paucity of studies examining the role of the mother-infant relationship in mediating associations between PPD and infant temperament, which must be addressed to better understand the mechanisms by which PPD exerts its effects and to help identify potential targets for intervention.

Given the importance of the mother–infant relationship, the adverse effects of PPD on the mother–infant dyad, and how the pandemic may have placed even greater stress on mothers, it is imperative that we examine the role the mother–infant relationship plays in associations between maternal PPD and infant temperament. The few studies that have examined the mother–infant relationship in general population samples of postpartum mothers during COVID-19 suggest that this relationship has worsened (Fallon et al., 2021; Liu et al., 2021), but despite its importance to healthy infant and child development, no studies have assessed the role the mother-infant relationship plays in mediating associations between PPD and infant temperament.

The effects of the pandemic, including lockdowns, work-from-home, online schooling, and a lack of mental health resources may have exacerbated mental health problems, including anxiety and depression in caregivers (Russell et al., 2020), negatively impacting parenting, infant temperament, and the quality of mother-infant relationships. Given these realities, we sought to investigate whether the COVID-19 pandemic moderated associations between maternal PPD and infant temperament and the mother-infant relationship in two samples of treatment-seeking mothers with PPD prior to and during the pandemic. Secondly, due to the scant literature available on the mother–infant relationship as a potential mediator of associations between PPD and infant temperament, we also sought to examine the mediating effect of mother–infant relations on infant temperament in these samples.

Methods

Settings, participants, and ethical considerations

The present study utilized baseline (i.e., pre-intervention) maternal and infant data from two separate randomized controlled trials (RCTs) examining the impact of 1-day cognitive behavioral therapy-based workshops on mothers seeking treatment for PPD in the province of Ontario, Canada. The first (pre-COVID-19) RCT of 392 mothers involved in-person workshops and was conducted prior to COVID-19 between January 2018 and March 2020. The second (COVID-19) RCT recruited 403 mothers and was conducted during the COVID-19 pandemic from April to October 2020 (Van Lieshout et al., 2021). The eligibility criteria, measures, and workshops in the latter RCT were identical to the in-person study (except that the workshops were delivered online).

Each trial used the same inclusion/exclusion criteria and sampling frame. Women who met the following inclusion criteria were eligible to participate in their respective RCT: an Edinburgh Postnatal Depression Scale (EPDS) score $\geq$10, $\geq$18 years old, an infant <12 months of age at enrollment, and fluency in English. No other exclusionary criteria were applied. Mothers could self-refer or be referred by a healthcare provider. Both RCTs received ethics approval from the Hamilton Integrated Research Ethics Board (Project IDs #3816 and #11413) and were registered at ClinicalTrials.gov (NCT03654261 and NCT04485000). All participants provided written informed consent prior to joining the studies, and all study procedures were undertaken in accordance with the Declaration of Helsinki.

Measures

Sociodemographic characteristics

At baseline in both RCTs, mothers reported their age, ethnicity, parity, marital status, years of education, pre-pandemic household income, prior use of mental health counseling, current psychotropic medication use, and their infant's age.

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Maternal PPD: The EPDS is a self-reported 10-item gold-standard questionnaire rating the experience of symptoms over the past week, with each question being scored on a 0–3 point scale. The total scale scores, which vary from 0-to-30 points (Cox et al., 1987), are utilized in this study. EPDS scores ≥10 are suggestive of an elevated risk for PPD. The internal consistency (Cronbach's alpha) of the EPDS is good (α = .87) (Long et al., 2020), which was reflected within both of our pre-COVID-19 (α = .83) and COVID-19 (α = .80) groups.

Infant temperament: Mothers also completed the Infant Behavior Questionnaire-Revised Very Short Form (IBQ-R VSF), a measure that contains 37 items, each scored on a 7-point scale (1–7) (Putnam et al., 2014). Scores on this scale are calculated for three domains: Positive Affectivity/Surgency (PAS), Negative Affectivity (NEG), and Orienting/Regulatory Capacity (ORC). PAS is related to the personality trait of extraversion, NEG is comparable to neuroticism, and ORC is associated with better orienting and soothability (Putnam et al., 2014). Higher scores on PAS and ORC are more adaptive, whereas higher scores on NEG are generally believed to be maladaptive. The three domains have shown acceptable internal consistencies (α's ≥ .75) (Putnam et al., 2014). For the pre-COVID-19 group, internal consistency was good for the IBQ-R VSF PAS (α = .82) and acceptable for the NEG (α = .78) and ORC (α = .75) subscales. Similar inter-item consistency was observed in the COVID-19 group (PAS: α = .81, NEG: α = .80, and ORC: α = .75).

Mother-infant relationship: The Postpartum Bonding Questionnaire (PBQ) is intended to detect relationship problems in the mother-infant dyad and is a 0-to-125-point self-administered survey with 25 items answered on a 6-point scale (0–5) (Brockington et al., 2006). Higher scores are suggestive of more problems in the mother-infant relationship. The PBQ is comprised of four subscales: Impaired Bonding (IB), Rejection and Pathological Anger (RPA), Infant-Focused Anxiety (IFA), and Incipient Abuse (IA). IA is not included in this report owing to its less reliable psychometric properties (Brockington et al., 2006; Wittkowski et al., 2007). In other samples, the internal consistencies of the IB, RPA, and IFA subscales have had mixed α values varying from .63 to .79 (Wittkowski et al., 2007). In the pre-COVID-19 group, the PBQ IB (α = .84), RPA (α = .82), and IFA (α = .69) subscales had good internal consistency. Likewise, the COVID-19 group also reported similar consistencies (IB: α = .86, RPA: α = .84, and IFA: α = .72). The PBQ was also examined in this study as a mediating variable between PPD and infant temperament because it assesses multiple facets of the mother-infant relationship, including loss of maternal emotional response, rejection, and anxiety directed at the infant, all of which may be important in understanding how PPD could affect infant temperament.

Statistical Analyses

Demographic data were summarized and potential differences between pre-COVID-19 (in-person) and COVID-19 (online) groups were assessed via *t-tests* for continuous data and chi-squared tests for categorical data. To investigate associations between PPD (continuous EPDS scores) and offspring outcomes, linear regression models were constructed for the pre-COVID-19 and COVID-19 samples separately. To investigate differences in the strength of these associations between pre-COVID-19 and COVID-19 samples, moderation analyses were then performed by combining study samples and introducing a multiplicative group × EPDS score interaction term into the regression models.

Mediation analyses were conducted to compare the magnitude of the indirect effect of parenting behavior (assessed via the PBQ) relative to the direct effect of EPDS upon infant outcomes in both RCTs together (i.e., the combined sample). These mediation analyses utilized the products of coefficients method described by MacKinnon (2000). This approach has been found to have greater statistical power than the more conservative causal steps methodology used by Baron and Kenny (MacKinnon et al., 2002). In this study, the b and asymmetric confidence intervals of the indirect effect (A * B path) were also calculated. Sobel's test was next applied to assess whether the difference in effect between 1) the main effect between predictor and outcome is significantly greater than 2) the direct effect controlling for the presence of the mediator. Finally, because Sobel's test is not easily interpretable in isolation, the percentage of effect accounted for by indirect path alone was also computed as described by MacKinnon et al. (2002). Statistical analyses were performed using SPSS Statistics 23 (IBM Corporation) and in R (RMediation package) (Tofighi & MacKinnon, 2011), and statistically significant results were defined as $p < .05$ (two-tailed).

Results

The sociodemographic characteristics of pre-COVID-19 and COVID-19 study samples are summarized in Table 1. A total of 795 mothers contributed data, 392 and 403 from the pre-COVID-19 and COVID-19 groups, respectively. Mothers in the pre-COVID-19 group were less often White, slightly older (32.9 versus 31.8), and had fewer children (1.5 versus 1.8) than those in the COVID-19 group. No other demographic characteristics (e.g., infant age, marital status, years of education) differed between groups.

Mean EPDS, IBQ-R VSF ORC, and PBQ-IFA scores were rated as higher in the COVID-19 group. The remaining IBQ-R VSF subscale scores (PAS and NEG) and PBQ subscale scores were comparable between groups (see Table 2).

Pre-COVID-19 and COVID-19 samples were first merged to examine the impact of the COVID-19 pandemic on the strength of these associations, and an EPDS × pre-COVID-19/COVID-19 interaction term was introduced into the model (Table 3). For all outcomes, this interaction term was not statistically significant with one exception: the infant-focused anxiety subscale of the PBQ (B = −0.16, SE = 0.05, $p < .01$). After stratifying the data into pre-COVID-19 and COVID-19 sample for this outcome, EPDS scores were found to be a statistically significant predictor of PBQ-IFA scores in the COVID-19 sample (B = 0.20, SE = 0.04, $p < .01$) but not in the pre-COVID-19 group (B = 0.04, SE = 0.03, $p = .21$), suggesting that PPD was more strongly associated with infant-focused anxiety during the pandemic.

Given the relative similarity of the two samples and the lack of a statistically significant EPDS by COVID-19 group interaction, data from the pre-COVID-19 and COVID-19 samples were pooled to examine associations between maternal EPDS scores and offspring outcomes. Maternal EPDS scores were associated with higher IBQ-R VSF NEG (β = 0.12, SE = 0.01, $p < .01$) scale scores in infants. The EPDS also predicted aspects of the mother-infant relationship, as the IB (β = 0.28, SE = 0.06, $p < .01$), RPA (β = 0.25, SE = 0.04, $p < .01$), and IFA (β = 0.22, SE = 0.03, $p < .01$) subscales of the PBQ showed statistically significant associations with the EPDS. The complete results of these analyses are summarized in Table 4.

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Table 1. Baseline characteristics of pre-COVID-19 (in-person) and COVID-19 (online) participants

	Pre-COVID-19 ($n = 392$)	COVID-19 ($n = 403$)
Ethnicity, *n*/total *n* (% White)	248/381 (65%)*	294/396 (74%)*
Maternal age, years: mean (SD)	32.9 (5.0)*	31.8 (4.5)*
Infant age, months: mean (SD)	5.3 (3.8)	5.3 (3.4)
Number of children: mean (SD)	1.5 (0.9)*	1.8 (1.2)*
Marital Status, *n*/total *n* (% Married/Common law)	344/375 (91%)	371/396 (94%)
Years of Education: mean (SD)	16.4 (1.5)	16.5 (1.4)
Mean Household Income 2019, CAD (SD)	77,148 (47,908)	83,835 (46,672)
Prior use of counseling, *n*/total *n* (% Yes)	157/375 (42%)	167/395 (42%)
Current use of medication, *n*/total *n* (% Yes)	236/374 (63%)	247/396 (62%)

Abbreviation: CAD, Canadian Dollars.
*$p < .05$.

Table 2. Depression, infant temperament, and mother–infant bonding among pre-COVID-19 (in-person) and COVID-19 (online) participants

	Pre-COVID-19 ($n = 392$)	COVID-19 ($n = 403$)
EPDS, mean (SD)	15.5 (4.5)*	16.1 (4.3)*
IBQ-R VSF, mean (SD)		
Positive Affectivity/Surgency	4.3 (1.2)	4.3 (1.2)
Negative Emotionality	3.8 (1.1)	3.9 (1.2)
Orienting/Regulatory Capacity	5.2 (0.9)*	5.3 (0.8)*
PBQ, mean (SD)		
Impaired Bonding	12.0 (7.2)	12.9 (7.8)
Rejection and Pathological Anger	6.3 (4.8)	6.7 (5.2)
Infant-Focused Anxiety	3.5 (2.5)*	5.3 (3.3)*

Abbreviations: EPDS, Edinburgh Postnatal Depression Scale; IBQ-R VSF, Infant Behavior Questionnaire-Revised Very Short Form; PBQ, Postpartum Bonding Questionnaire.
*$p < .05$.

Since COVID-19 pandemic exposure did not affect most associations between maternal EPDS scores and infant outcomes, we used our pooled sample and the products of coefficients method to investigate the mediating effect of the mother–infant relationship on statistically significant associations between maternal EPDS and IBQ-R VSF NEG scores (Figure 1). PBQ-IB scores were a statistically significant mediator of the association between EPDS and IBQ-R VSF NEG scores, accounting for 72% of the observed association ($B_{indirect\ effect} = 0.02$, 95% CI: 0.01–0.04, Sobel's $t = 6.27$, SE = 0.01, $p < .01$). The PBQ-RPA score was also a statistically significant mediator of the association between PPD and IBQ-R VSF NEG, with the indirect effect accounting for 58% of the observed association ($B_{indirect\ effect} = 0.02$, 95% CI: 0.01–0.03, Sobel's $t = 5.28$, SE = 0.01, $p < .01$). Finally, PBQ-IFA also mediated the association between EPDS and IBQ-R VSF NEG ($B_{indirect\ effect} = 0.01$, 95% CI: 0.01–0.02, Sobel's $t = 4.28$, SE = 0.02, $p < .01$), though the percent mediation accounted for just 4% of the association.

Table 3. Moderating effect of the COVID-19 pandemic on associations between EPDS scores and outcomes

Outcome	B	Std. Error	t	*p*-value	95% CI		Partial Eta^2
IBQ-R VSF PAS	0.01	0.02	0.53	0.59	−0.03	0.05	0.00
IBQ-R VSF NEG	−0.01	0.02	−0.49	0.63	−0.04	0.03	0.00
IBQ-R VSF ORC	0.00	0.01	0.02	0.99	−0.03	0.03	0.00
PBQ-IB	−0.14	0.12	−1.19	0.23	−0.37	0.09	0.00
PBQ-RPA	−0.13	0.08	−1.63	0.10	−0.28	0.03	0.00
PBQ-IFA	−0.16	0.05	−3.18	<0.01*	−0.26	−0.06	0.01

Abbreviations: EPDS, Edinburgh Postnatal Depression Scale; IBQ-R VSF, Infant Behavior Questionnaire-Revised Very Short Form; PAS, Positive Affectivity/Surgency; NEG, Negative Affectivity; ORC, Orienting/Regulatory Capacity; PBQ, Postpartum Bonding Questionnaire; IB, Impaired Bonding; RPA, Rejection and Pathological Anger; IFA, Infant-Focused Anxiety.

Table 4. Associations between EPDS scores and mother and infant health and behavior scales among pre-COVID-19 (in-person) and COVID-19 (online) participants

Outcome	β	B	Std. Error	*p*-value	95% CI		Partial Eta^2
IBQ-R VSF PAS	0.03	0.01	0.01	0.15	−0.01	0.03	0.00
IBQ-R VSF NEG	0.12	0.03	0.01	<0.01*	0.02	0.05	0.02
IBQ-R VSF ORC	−0.04	−0.01	0.01	0.43	−0.02	0.01	0.00
PBQ-IB	0.28	0.48	0.06	<0.01*	0.37	0.59	0.08
PBQ-RPA	0.25	0.30	0.04	<0.01*	0.23	0.38	0.07
PBQ-IFA	0.22	0.15	0.03	<0.01*	0.10	0.20	0.04

Abbreviations: EPDS, Edinburgh Postnatal Depression Scale; IBQ-R VSF, Infant Behavior Questionnaire-Revised Very Short Form; PAS, Positive Affectivity/Surgency; NEG, Negative Affectivity; ORC, Orienting/Regulatory Capacity; PBQ, Postpartum Bonding Questionnaire; IB, Impaired Bonding; RPA, Rejection and Pathological Anger; IFA, Infant-Focused Anxiety.

Discussion

This study suggests that maternal PPD is associated with more infant negative affectivity and more problems with the mother-infant relationship. However, the strength of these associations did not appear to be meaningfully influenced by the pandemic in most cases. The lone exception was infant-focused anxiety, which was more strongly associated with PPD during the pandemic. Meanwhile, all PBQ subscales appeared to mediate associations between EPDS scores and infant negative affectivity in our pooled pre-COVID-19 and COVID-19 sample.

In the COVID-19 group, EPDS, IBQ-R VSF Orienting/Regulatory Capacity, and infant-focused anxiety (PBQ-IFA) scores were higher, although the difference in EPDS and Orienting/Regulatory Capacity scores was not clinically significant (Matthey, 2004). During the pandemic, a stronger association between EPDS scores and PBQ-IFA may have been contributed to by an increase in stressors, including a fear of infants and other family members contracting COVID-19, social isolation and loneliness, and increased difficulties with finances and accessing healthcare (Spinola et al., 2020; Wang et al., 2020; Wilson et al.,

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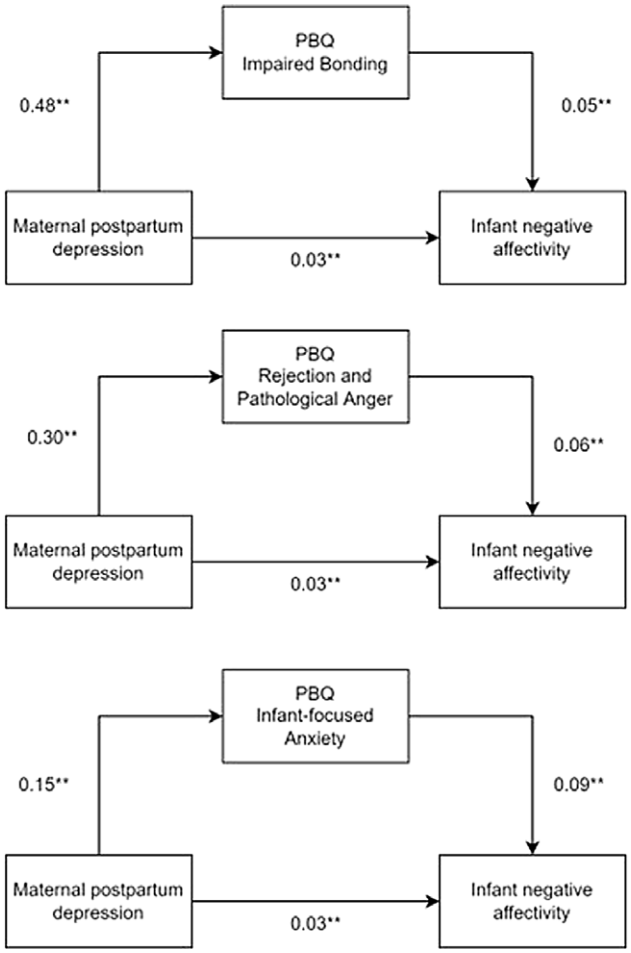

Figure 1. Mediation of associations between maternal postpartum depression (Edinburgh Postnatal Depression Scale) and infant negative affectivity (Infant Behavior Questionnaire-Revised Very Short Form) via Postpartum Bonding Questionnaire (PBQ) subscales. Unstandardized beta values are reported for each regression pathway. $^{**}p < 0.05$.

2020). These factors may have increased mothers' anxiety specifically related to their competence and ability to take care of their infants, which could have manifested as increased levels of infant-focused anxiety. Furthermore, mothers could also have been experiencing elevated levels of postpartum anxiety, which is frequently comorbid with PPD (Falah-Hassani et al., 2016; Radoš et al., 2018), and may have contributed to heightened anxiety directed at their infants. Other mother–infant relationship problems, such as impaired bonding or rejection and pathological anger, may not have worsened compared to previous studies with general population samples since the current study utilized a sample of treatment-seeking mothers (Fallon et al., 2021; Liu et al., 2021). Perhaps mothers in the current study were already experiencing impairments in these areas of the dyadic relationship, and so they could not worsen further (i.e., a ceiling effect may have existed; Layton et al., 2021).

With the exception of PBQ-IFA, the strength of associations between EPDS scores and maternal and offspring outcomes were not different from those enrolled during the pre-pandemic period, highlighting the robustness of these associations. One reason for this finding may be because from June to October 2020 in Ontario, social gathering restrictions were eased (Government of Ontario, 2020), allowing mothers to maintain social support from friends and family, which may have played a role in preventing deterioration in mental health since social support is a protective factor against PPD (Reid & Taylor, 2015; Yim et al., 2015). Mothers may also have received additional support from their partners who were working remotely at home or from online communities. Additionally, our sample of treatment-seeking mothers could have been hopeful and optimistic due to anticipation of treatment in the context of their RCT (both studies involved waitlist control groups), which may have served to bolster their resilience.

Overall, the associations observed between PPD and offspring temperament are generally consistent with previous research which has reported links between depressive symptoms and maternal reports of infant negative affect (Bridgett et al., 2009; Forman et al., 2007; McGrath et al., 2008) and mother-infant relationship difficulties (Liu et al., 2021; O'Higgins et al., 2013). Statistically significant associations between PPD and infant negative affectivity highlight that PPD can exert adverse effects on infants. It may be that PPD disrupts the mother–infant relationship (see mediation findings below). Since PPD is often characterized by fatigue and anhedonia (Pearlstein et al., 2009), these symptoms could hinder maternal interactions with the infant and may explain the more negative maternally-rated perceptions of infant temperament. Associations between PPD and infant negative affectivity may also be contributed to by difficulties with parenting, which are more common when parents are depressed (Slomian et al., 2019). Mothers with PPD may have been less engaged with their offspring, felt a lower sense of parenting competence, or relied more on harsher parenting practices, all of which would have negatively impacted their children.

Our findings also suggest that difficulties in the mother-infant relationship mediate associations between PPD and infant negative affectivity and are consistent with the findings of previous research. For example, in one prior study, maternal feelings of attachment mediated associations between PPD at two months and poorer infant socioemotional development at six months (Mason et al., 2011). Maternal PPD is associated with a climate of elevated negative affect, which is characterized by more affective mismatches and fewer repairs in mother-infant emotions during interactions (Tronick & Reck, 2009). As a result, infants learn that these mismatches are not easily repaired, and interactions become increasingly rigid, thus further entrenching negative affectivity in infants. This mechanism may explain why when aspects of the mother-infant relationship were impaired in this study, infant negative affectivity increased. It is also hypothesized that maternal care facilitates infant social development and emotion regulation in an on-going, moment-to-moment fashion via synchronized emotions and behavior within mother-infant dyads (Atzil et al., 2018). An impaired mother-infant bond could impede this process, which can prolong levels of negative affectivity in infants, particularly within moments when infants become distressed. Another potential mechanism may be that mothers with PPD and a poorer relationship with their infant may be ineffective at regulating their infants during moments of distress. When distress is not regulated by the caregiver, it can prolong negative affectivity (Esposito et al., 2017). However, our results were not consistent with the work of Milgrom et al. (2004), which showed that maternal responsiveness was not a mediator of associations between PPD at four months and child temperament at 42 months. Differences between our findings and those of Milgrom et al., could be due to the older age of children assessed in their study, their use of a recorded play task to assess maternal responsiveness, or differences between maternal responsiveness and our construct of the mother-infant

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relationship. Moreover, their small sample size may have limited their ability to detect statistically significant associations. While we hypothesized that maternal PPD could influence infant temperament via the mother-infant relationship, in keeping with transactional models, it is important to acknowledge that infant temperament also has the potential to alter maternal emotions and behavior. Multiple studies suggest that infant exposure to maternal negative affect within the first year of life can have an effect on shaping infant emotional and behavioral development (see Atzil et al., 2018 for a review; Feldman et al., 2009; Granat et al., 2017). For instance, a previous study tested transactional models through simultaneously assessed neurophysiological activity in mothers and their infants and observed that neurophysiological activity in mothers high in negative affect influenced similar neurobehavioral patterns in their infants, but that infant neurophysiology did not impact their mothers (Krzeczkowski et al., 2022). However, it is also important to note that other studies have shown poorer infant emotion regulation predicts greater PPD symptoms (Luecken et al., 2019; Somers et al., 2019). Future studies should use longitudinal models to explicitly examine the strength and direction of these transactional associations in the context of PPD. Regardless, the findings of the current study add to the literature on potential mediators of the association between PPD and infant negative affectivity by examining the mother-infant relationship, which has not been previously explored in this capacity.

Mother-infant bonding refers to the process of developing an emotional tie within the dyad which shapes physical, cognitive, and psychosocial outcomes (Klier, 2006). However, PPD leads to a consistent negative internal mental state in mothers leading to problems with mother-infant interactions, such as delayed, ambivalent, or decreased emotional responses to infants, diminished contact due to anxiety, or anger towards offspring. These outcomes could explain how the effects of PPD can shape offspring negative affectivity. Furthermore, bonding problems may also reflect difficulties repairing affective mismatches which extends infant experiences of negative states. Bonding problems occurring from mismatches may also be particularly detrimental during moments when infants become distressed, given that mothers with PPD may struggle with helping their infant navigate through these moments (Esposito et al., 2017). These results reinforce the negative impact maternal PPD has on infant outcomes and highlight an impaired mother-infant relationship as a risk factor for poor developmental trajectories. The nature of environmental experience is a key consideration in developmental psychopathology (Cicchetti & Toth, 2009). The COVID-19 pandemic provided a novel opportunity to examine theories of developmental psychopathology in new contexts.

The ecological transactional model core to developmental psychopathology posits that proximal and distal environmental factors interact to influence outcomes in individuals (Cicchetti & Toth, 1998). In this study, the effects of PPD on infant temperament may have been contributed to by both poor maternal interactions with offspring (proximal influence) and socioenvironmental conditions created by the pandemic (distal influence). These influences likely played a particular role in heightening infant-focused anxiety in mothers through, for example, the loss of social connections during periods of lockdown to job loss and fear of COVID-19 infection.

This study has several strengths but also some limitations. Data were obtained before and during the COVID-19 pandemic in comparable samples in an identical geographic region, allowing for an examination of the effects of the pandemic on our associations of interest. Our sample of nearly 800 treatment-seeking mothers is larger than many previous studies of associations between PPD and infant temperament. Furthermore, our use of the PBQ, which assesses multiple facets of the mother–infant relationship, allowed for a thorough investigation of how this construct affects links between PPD and infant temperament. However, our use of cross-sectional data affected our ability to clearly delineate the direction of associations. For example, while PPD can negatively impact infant temperament and vice-versa, we are unable to definitively determine which contributes more to our current findings. A cross-sectional design may have also restricted our ability to fully model complex familial interactions, which may be better represented when assessed over time. While we hypothesized that frequent mother–infant affective and behavioral mismatches may be core to our reported problems with the mother–infant relationship, we were unable to explicitly test this phenomenon. Moreover, the present sample was limited to mothers seeking treatment for PPD in a setting where healthcare is universally available and those with elevated levels of symptoms of PPD, but not necessarily DSM-5-diagnosed major depressive disorder. Consequently, our results may not be applicable to postpartum mothers in all settings. However, PPD severity exists on a spectrum, and upwards of 30% of recently delivered mothers will experience elevated levels of depressive symptoms on the order of which determined eligibility for our RCTs (Meaney, 2018). It is also important to note that our use of maternally reported measures without partner reports or observed measures of the mother-infant relationship is a limitation. Additionally, the mothers in this study were more frequently White, middle class, and married. This study was also not able to examine other mediators or pregnancy exposures, which may have impeded our understanding of all of the factors that might mediate associations between PPD and offspring outcomes.

Conclusion

The present study suggests that PPD is associated with elevated levels of negative affectivity in infants as well as more problems with the mother-infant relationship, and that these links are largely unaffected by the COVID-19 pandemic (with the exception of infant-focused anxiety). Moreover, the mother–infant relationship appears to mediate associations between PPD and infant negative affectivity. These results further highlight the importance of detecting and intervening on PPD and impairments in the mother–infant relationship to optimize the temperament of offspring during the pandemic and beyond.

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Conflicts of Interest. None.

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Trial Registration. 1-Day CBT Workshops for PPD; https://clinicaltrials.gov; NCT03654261. Online 1-Day CBT-Based Workshops for PPD; https://clinicaltrials.gov; NCT04485000

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