**POSTPARTUM DEPRESSION AND INFANT EMOTION REGULATION**

**TASK-SHIFTING THE TREATMENT OF MATERNAL POSTPARTUM DEPRESSION TO TREAT MOTHERS WHILE MITIGATING NEGATIVE CONSEQUENCES ON INFANT EMOTION REGULATION**

**By BAHAR AMANI, HBSc., MA**

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AUTHOR: Bahar Amani, HBSc., MA. (McMaster University)

SUPERVISOR: Dr. Ryan J. Van Lieshout

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**Lay Abstract**

Postpartum depression (PPD) is common and has consequences for both mothers and their infants. The negative impact of PPD exposure on infant emotion regulation (ER) is especially harmful because of its association with later psychopathology. As a result, the objectives of the present thesis were to i) determine whether task-shifting the treatment of PPD is effective in treating mothers while ii) mitigating the potential negative effects of PPD exposure on infant ER. The results of this thesis indicate that a task-shifted,peer-delivered treatment is effective in treating mothers with PPD and that treating mothers with a task-shifted treatment may also lead to adaptive changes in infant ER. This thesis indicates that task-shifting the treatment of PPD may improve outcomes for mothers, prevent PPD-related consequences on infant ER development, and ultimately, improve future outcomes for their infants.

**Abstract**

**Objectives:** To determine whether task-shifting the treatment of Postpartum depression (PPD) is effective in both treating mothers and mitigating the potential negative effects of PPD exposure on infant emotion regulation (ER).

**Methods:** In Study 1, a randomized controlled trial (RCT) with a waitlist control group was used to examine whether a nine-week group Cognitive Behavioural Therapy (CBT) intervention delivered by peers can effectively treat PPD in mothers. Study 2 used data from this same RCT to determine if maternal PPD treatment with peer-delivered group CBT intervention would lead to adaptive change in markers of ER in their infants. Finally, Study 3 used data from a RCT with a treatment-as-usual control group to examine whether maternal treatment with a Public Health Nurse (PHN)-delivered group CBT intervention led to adaptive change in markers of infant ER. In both Studies 2 and 3, markers of infant ER included two neurophysiological measures and a maternal-report measure of infant temperament.

**Results:** Study 1 found that peer-delivered group CBT led to significant improvements in symptoms of depression and anxiety in mothers and reductions in symptoms remained stable six months after treatment initiation. Study 2 found evidence of change in two neurophysiological measures of infant ER following maternal treatment with peer-delivered intervention, but not in the maternal-report measure of infant temperament. Finally, Study 3 found evidence of change in a single neurophysiological marker of infant ER following maternal treatment with the PHN-delivered intervention, but found no change following maternal treatment in a second neurophysiological marker and maternal-report measure of infant ER.

**Conclusions:** The studies in this thesis highlight the potential of using task-shifting to fill a gap in the healthcare system’s treatment of PPD. This work suggests that interventions delivered by peers and PHNs may not only be effective in treating those with PPD, but may also benefit their infants by mitigating any PPD-related consequences on infant ER development. This thesis contributes to the evidence that suggests timely maternal treatment of PPD may disrupt the transmission of psychiatric risk from parent to infant.

**Keywords:** Emotion regulation, Neurophysiology, Infancy, Postpartum depression, Cognitive behavioural therapy

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None

**List of Abbreviations**

|  |  |
| --- | --- |
| ACC | Anterior Cingulate Cortex |
| ACE | Adverse Childhood Experience |
| ANS | Autonomic Nervous System |
| CAD | Canadian Dollar |
| CBT | Cognitive Behavioural Therapy |
| CI | Confidence Interval |
| CONSORT | Consolidated Standards of Reporting Trials |
| COVID-19 | Coronavirus Disease 2019 |
| CSV | Comma Separated Value |
| DSM-5 | The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition |
| ECG | Electrocardiography |
| EEG | Electroencephalography |
| EPDS | Edinburgh Postnatal Depression Scale |
| ER | Emotion Regulation |
| FAA | Frontal Alpha Asymmetry |
| FFSF | Face-to-Face Still Face Paradigm |
| FFT | Fast Fourier Transformation |
| fNIRS | Functional Near Infrared Spectroscopy |
| GAD-7 | Generalized Anxiety Disorder 7 - Item |
| HD-DOT-fNIRS | High-density Diffuse Optical Tomography Functional Near-infrared Spectroscopy |
| HF-HRV | High Frequency-Heart Rate Variability |
| HPA | Hypothalamic-pituitary-adrenal |
| IB | Impaired Bonding |
| IBQ-R | Infant Behaviour Questionnaire-Revised |
| IBQ-R-REG | Infant Behaviour Questionnaire-Revised, Orienting/Regulatory Capacity |
| ICC | Intraclass Correlations |
| IFA | Infant‐Focused Anxiety |
| IPT | Interpersonal Therapy |
| Lab-TAB | Laboratory Temperament Assessment Battery |
| LMM | Linear Mixed Effects Models |
| MDD | Major Depressive Disorder |
| MDE | Major Depressive Episode |
| MINI | Mini International Neuropsychiatric Interview |
| MPFC | Medial Prefrontal Cortex |
| MRM | Mutual Regulation Model |
| NICE | The National Institute for Health and Clinical Excellence |
| PBQ | Postpartum Bonding Questionnaire |
| PFC | Prefrontal Cortex |
| PHN | Public Health Nurse |
| PPD | Postpartum Depression |
| PSNS | Parasympathetic Nervous System |
| PSWQ | Penn State Worry Questionnaire |
| REDCAP | Research Electronic Data Capture |
| RCI | Reliable Change Index |
| RCT | Randomized Controlled Trial |
| RPA | Rejection and Pathological Anger |
| SES | Social Engagement System |
| SD | Standard Deviation |
| SMD | Standardized Mean Difference |
| SNS | Sympathetic Nervous System |
| SPS | Social Provisions Scale |
| SPSS | Statistical Package for the Social Sciences |
| TAU | Treatment as Usual |

**Declaration of Academic Achievement**

I have written the initial draft of each of the following manuscripts and worked with the coauthors to complete the finalized versions included in this sandwich thesis. Below I describe my contributions and those of my coauthors.

**Study 1:** I conceptualized the objectives of this study, collected all data, conducted all data analyses, and prepared the initial manuscript. Dr. Van Lieshout assisted in the conception of the idea for this study and provided support on the data interpretation and provided critical feedback on the final manuscript. Dr. Mark Ferro and Calan Savoy provided support with the data analysis and interpretation of the data. Donya Merza, provided feedback on the initial and later drafts of the manuscript. Drs. Streiner and Bielings reviewed and provided feedback on the content of the manuscript.

**Study 2:** I conceived the objectives of this study, collected all data, conducted all data analyses, and prepared the initial manuscript. Dr. Van Lieshout helped conceptualize the study and interpret the data, provided critical feedback on the contents of the manuscript and on subsequent drafts. Calan Savoy provided feedback on data analysis and interpretation. Drs. Louis Schmidt and Krzeczkowskiprovided support on neurophysiological data collection and analyses and provided valuable feedback on the content of the manuscript.

**Study 3:** I assisted with data collection, conducted all data analyses, and prepared the initial manuscript. Dr. Van Lieshout helped conceptualize the study and interpret the data, provided critical feedback on the contents of the manuscript and on subsequent drafts. Drs. Louis Schmidt and Krzeczkowskiprovided support on neurophysiological data collection and analyses and provided valuable feedback on the content of the manuscript.

**Chapter 1. Background**

**1.1. Maternal Postpartum Depression: A Modifiable Risk Factor for Mental Illness in Offspring**

Over the past several decades, research in both human and animal models (Kalmakis & Chandler, 2015; McEwen, 2003) have highlighted the negative impact of exposure to adverse early life experiences (also known as adverse childhood experiences or ACEs). The most common ACEs include emotional, sexual, or physical abuse, neglect, other dysfunctional home environments, and exposure to parental mental illness (Felitti et al., 1998). As they threaten the foundations of stable relationships, cognitive development and emotion regulatory capacity, ACEs disrupt optimal emotional, cognitive, behavioural, social, and psychological development (Felitti et al., 1998; Weiss & Wagner, 1998). Adverse childhood experiences have even been found to lead to suboptimal development of the structure and function of the brain and increase the risk of developing a psychiatric disorder in adulthood (Anda et al., 2006; Edwards et al., 2003). The Centers for Disease Control and Prevention (2019) reports that rates of depression among adults can be reduced by up to 44% if efforts are made to reduce exposure to ACEs in the population.

Exposure to a parental mental illness is a common and deleterious form of ACE (Anda et al., 2006; Felitti et al., 1998). The offspring of depressed parents are three to four- times more likely to develop major depressive disorder (MDD) (Weissman et al., 2006), and are at elevated risk for anxiety disorders, substance dependence, and poorer functioning over the life course (Weissman et al., 2005). One study found that nearly 60% of the grandchildren of individuals with a depressive disorder eventually developed one themselves (Weissman et al., 2005).Offspring exposed to maternal postpartum depression (PPD) in particular, have a greater risk of experiencing depression in adolescence and adulthood (Halligan et al., 2007; Netsi et al., 2018; Sanger et al., 2015), highlighting the importance of the very early environment. As early as three to six -months of age, exposure to PPD has been associated with markers of future psychiatric disorder (Field et al., 1988; Field et al., 1995).

**1.2 Maternal Postpartum Depression**

Over the last three decades, mental health research has focused heavily on the consequences of postpartum depression (PPD) on both mother and infant (Brummelte & Galea, 2016; Duffett-Leger et al., 2012; Letourneau et al., 2017). About one in five mothers and birthing parents will suffer from PPD (Gaynes et al., 2005). An even greater proportion, as many as one in three, will experience at least subclinical levels of depression (Meaney, 2018). Postpartum depression typically occurs in the first four to 12 weeks after childbirth and can persist for 12 months (O’Hara, 2009; Wisner et al., 2002), or even longer in some cases (Goodman, 2004b). Symptoms of PPD are those of DSM-5 major depressive disorder (MDD), including depressed mood, loss of interest and pleasure in activities, loss of energy, sleep and appetite disturbance, difficulty concentrating, irritability, and suicidal ideation (American Psychiatric Association, 2022). In addition to these symptoms, PPD frequently involves feelings of inadequacy as a mother, loneliness and emptiness, and feelings of the loss of control (Beck & Gable, 2000; Jolley & Betrus, 2007). Along with these symptoms, many individuals struggle with the stereotype that the early periods of motherhood are blissful and easy (Lee, 1997). Qualitative studies of those with PPD report that they feel fear and shame, and struggle with the thoughts that they are not meeting their infant’s needs (Coates et al., 2014). Unsurprisingly, these factors can keep many from disclosing their symptoms to healthcare providers and seeking timely treatment.

If left untreated, PPD can increase the risk of future depression (Woolhouse et al., 2015), substantially affecting the quality of their overall wellbeing in the long-term. The presence of PPD in a family increases the risk of relationship problems within marriages and familial conflict and disharmony (Goodman, 2004a). In fact, maternal PPD has been found to be the strongest predictor of paternal depression throughout the postpartum period (Goodman, 2004a). The incidence of paternal depression increases from 10%, to nearly 50% in the presence of maternal PPD (Goodman, 2004a). The presence of maternal PPD in a family can also significantly impact the development of both newborn infants and other children in a family. Studies investigating the long-term effects of PPD (Halligan et al., 2007; Murray et al., 2011; Netsi et al., 2018; Sanger et al., 2015) highlight the devastating and long-lasting implications that untreated PPD can have on mothers and their infants.

In addition to the overwhelming symptoms it imposes on mothers and birthing parents, PPD can adversely affect the mother-infant relationship and parenting (Barry et al., 2015; Brummelte & Galea, 2016; Burke, 2003), and the development and health of their offspring (Barry et al., 2015; Burke, 2003; Lovejoy et al., 2000; Murray et al., 2015; O’Hara & McCabe, 2013; Paulus et al., 1996). Individuals with PPD have been found to be more likely to be less empathetic, sensitive, and responsive to their infants’ needs (Field, 2010; Stein et al., 2014). They also tend to breastfeed their infants less often (Dias & Figueiredo, 2015), and report having a harder time connecting with their newborns (Coates et al., 2014). Not only are those with PPD more likely to be irritable, hostile, towards their infants, less warm and practice harsh parenting behaviours (Lovejoy et al., 2000), they are also less likely to engage positively during face-to-face interactions with their infant or display nurturing behaviours (Field, 2010; Field et al., 2006). Given these challenges, it is not surprising that maternal PPD can have severe developmental consequences for newborns in the short and long-term.

**1.3 Transmission of Psychiatric Disorder from Mothers to Infants**

Extensive research has demonstrated that maternal PPD is a risk factor for later mental health problems in their offspring (Halligan et al., 2007; Netsi et al., 2018; Sanger et al., 2015). However, it remains unclear to what extent the transmission of depression risk from mother to offspring is a result of heritability, environmental factors, or a combination of the two. Although research in genetics has been unable to identify a single gene related to risk, over a hundred gene variants believed to increase depression risk have been identified (Lohoff, 2010). A growing consensus in the field of developmental psychology is that individuals inherit genetic vulnerabilities to traits that place them at risk of later problems like depression (e.g., neuroticism), as opposed to inheriting depression itself (Shadrina et al., 2018). Therefore, when depression or other psychiatric disorders do occur, it is likely due to a combination of genetic predisposition to certain traits and environmental risk factors as opposed to a single candidate gene.

There are a number of environmental risk factors in early life that contribute to the risk of developing emotional and/or behavioural problems following exposure to maternal PPD.Some of these factors include excess stress exposure in utero and/or postnatally, suboptimal mother-infant relationship and exposure to maternal and familial stressors.

*Prenatal Stress Exposure*

Fetal exposure to maternal depression and/or stress in utero has been identified as a potential risk factor for later psychiatric disorder in offspring (Kinsella & Monk, 2009). Unfortunately, many with PPD likely experienced prenatal depression or at least elevated symptoms of depression at that time. Prenatal depression is often accompanied by other life stressors like lower socioeconomic status, single parenthood, and lower social support (Goyal et al., 2010), adding further to fetal stress exposure in utero. Cortisol levels in mothers prenatally have even been found to predict their infant’s levels of cortisol (O’Connor et al., 2013). Exposure to excess cortisol in utero is known to affect the development of the key physiological systems involved stress regulation, particularly the hypothalamic-pituitary-adrenal (HPA) axis (Kinsella & Monk, 2009). Extensive research has reported that suboptimal development of the HPA axis and poorer stress regulation capacity is a potent risk factor for depression (Heim et al., 2008; Herman et al., 2016).

*Postnatal Stress Exposure*

Postnatally, exposure to excessive stress due to maternal PPD can also have a programming effect on the HPA axis and subsequent stress regulation (Barry et al., 2015). Infants of postnatally depressed mothers have been found to exhibit higher baseline levels of cortisol (Brennan et al., 2008), and in one study, adult offspring exposed to PPD in infancy demonstrated higher baseline cortisol and cortisol reactivity to a social stressor task when compared to adults not exposed to PPD (Barry et al., 2015). The stress-diathesis model highlights that in addition to a range of vulnerabilities (e.g., genetic predisposition, behavioural, socio-emotional, contextual) exposure to excessive stress may be a key deciding factor in the development of depression (Colodro-Conde et al., 2018).

*The Mother-Infant Relationship*

Given that mothers and birthing parents with PPD struggle with parenting, research in developmental psychology has implicated exposure to these parenting practices as a potential risk factor for later depression. Observational studies have reported that mothers with PPD display more hostility and are more anxious during interactions with their infants (Diego et al., 2006; Field, 2010; Lovejoy et al., 2000). They are also less responsive and sensitive during interactions with their infants, and often fail to meet their infant’s socio-emotional needs. One study found that mothers who scored at least 13 on the Edinburgh Postnatal Depression Scale (EPDS) were five times more likely to have poorer infant bonding than women who scored below this threshold (O’Higgins et al., 2013). Exposure to insensitive parenting during infancy is associated with a risk of developing disorganized attachment and a subsequent risk of psychopathology (e.g., externalizing behaviour; Groh et al., 2017). Postpartum depression has also been associated with higher rates of unhealthy parenting practices towards infants including poorer feeding behaviours and sleep practices (McLearn et al., 2006a, 2006b).

*Other Maternal and Familial Stressors*

Lastly, given that PPD often occurs in the context of other life challenges, there are a number of stressors that infants are often exposed to in addition to PPD itself. Factors like lower socioeconomic status, single parenthood, and lack of a social support network often precede the development of PPD (Goyal et al., 2010). Maternal PPD is also commonly accompanied by familial discord, including marital problems and poorer parenting towards newborns and other children (Apter-Levi et al., 2016; Burke, 2003; Goodman, 2004a)*.*One longitudinal study found familial discord to be associated with a greater risk of developing depression in adolescence and young adulthood (Nomura et al., 2002). The presence of parental depression has been associated with higher rates of child abuse and intra-family violence (Berger, 2005), all factors that may contribute to future depression risk in offspring.

**1.4 Emotion Regulation**

Although it appears that multiple exposures converge to increase the risk of depression in the offspring of those with PPD, suboptimal development of offspring emotion regulation (ER) appears to be a potent mediator. As young as three to six -month old infants exposed to PPD exhibit difficulty with ER measured with behavioural and neurophysiological markers (Field et al., 1988; Field et al., 1995). Given that difficulty with ER is one of the traits that may make someone more susceptible to depression, and its development has been found to be affected by multiple risk factors (e.g., prenatal and postnatal stress exposure, and suboptimal mother-infant relationship), focusing on infant ER may be key to preventing future psychiatric disorder.

Emotion regulation (ER) is the process by which an individual appraises and then modifies their emotions in the service of a future goal (Thompson, 1994). Emotion regulatory capacity refers to the level of control an individual has over the positive and negative emotions they experience, as well as when and how they occur. Individuals with strong ER capacity can better refrain from impulsive and less appropriate behaviours, control their bodily arousal, and refocus their attention when experiencing strong negative or positive emotions (Thompson, 1994).

Brain-imaging studies have uncovered that ER involves the activity of complex brain networks that span cortical (e.g., prefrontal cortex (PFC), anterior insula (AI) and anterior cingulate cortex (ACC)) and subcortical regions (e.g., amygdala, ventral striatum and periaqueductal grey (PAG; Kohn et al., 2014; Morawetz et al., 2017). While the dorsolateral PFC appears to be involved in cognitive processes and governs executive functions involved in ER such as motivation and attention, the ventrolateral PFC appears to signal the dorsolateral PFC once an emotion is perceived. Kohn and colleagues (2014) identified a region in the ACC positioned to allow connections to and from subcortical and cortical regions. However, since infants have yet to develop higher order cortical processes involved in ER and the prefrontal cortical (e.g., dorsolateral PFC, ventrolateral PFC) connections that govern ER mature much more slowly than subcortical regions, individuals are left to rely heavily on their caregivers to regulate their emotional and internal physiological states during infancy (Porges & Furman, 2011).

**1.5 Development of Emotion Regulation is Dependent on Early Experiences with Caregivers**

In his seminal piece on the origins of ER, Fox (1994) explains that ER development does not occur in a “vacuum”. Instead, its development is influenced by the infant’s early environment and their interactions with their caregivers. In the early postnatal period, infants depend heavily on continuous “give and take” exchanges with their caregivers to regulate their emotional distress. Tronick’s mutual regulation model (MRM) outlines the importance of early mother-infant interactions in forming a dyadic regulatory system (Gianino & Tronick, 1988; Tronick & Beeghly, 2011). Infants may use vocal cues (e.g., babbling), facial expressions, and physical gestures to communicate with their caregivers, and to express their socioemotional and homeostatic needs. In turn, mothers help to regulate their infants by responding to infants attempts at interaction. During optimal interactions, mothers recognize their infant’s cues and respond in a timely and appropriate manner. This “give and take” between mothers and infants helps infants to develop the foundation of their future self-regulatory capacity beyond infancy (Tronick & Beeghly, 2011).

Sensitive mothers can identify their infant’s distress and provide immediate regulatory support, thereby helping the infant return to a calm state. Infants with sensitive mothers have been found to have more secure attachment (Ainsworth, 1979) and demonstrate greater behavioural and cognitive development in childhood (Belsky & Fearon, 2002; Ding et al., 2014). Given that one of the common consequences of maternal PPD is reduced sensitivity to newborns and caregiving behaviours (Brummelte & Galea, 2016; Field, 1992; Slomian et al., 2019), infants exposed to PPD may receive less of the regulatory support that they require and so they learn that their caregiver may not be able to effectively support them (Feldman, 2007b). This leads to a dysfunctional dyadic regulatory system that may have consequences beyond an infant’s current emotional distress not being immediately addressed, including behavioural and socio-emotional problems, and an increased risk of psychiatric disorder.

The process of dyadic regulation through mother-infant interaction occurs both at the behavioural and physiological level (Feldman, 2007b). In fact, interactions with mothers in the early postnatal period are supported by the coordinated activity of the neurophysiological systems (e.g., corticolimbic and autonomic nervous systems) that underlie attachment and socioemotional functioning (Atzil et al., 2011, 2014; Feldman, 2007a, 2016). These systems provide a mechanism through which interactions with mothers and maternal socioemotional input can shape infant ER development. As early as three months old, mothers and infants demonstrate rhythmic coordination of their behaviours and physiology (Feldman, 2007b). Feldman coined the term “biobehavioural synchrony” to describe this process (Feldman, 2007b). Early non-human animal work by Hofer showed that maternal interactions regulated the affective state and physiology (e.g., heart rate, sleep-wake patterns) of rat pups shortly after birth (Hofer, 1994). Following this work, researchers began to report that synchrony in infant physiology and behaviour, and maternal physiology (e.g., heart rate) and behaviour (e.g., touch, vocalizations) is key to the development of an optimal dyadic regulatory system.

Following Hofer’s research, Feldman examined the effects of maternal touch and contact on infant autonomic reactivity (Feldman et al., 2014). Feldman and colleagues (2014) found that mothers who provided daily skin-to-skin contact to their preterm neonates had children with higher baseline vagal tone to emotional stressors ten years later. Vagal tone, a measure of the flexibility of the parasympathetic nervous system (PSNS) to adapt to the environment (Propper & Moore, 2006), is a key marker of ER ability (Porges, 2007; Thayer et al., 2009). Feldman’s important work highlighted the lasting impact of maternal physical contact on infant physiology. Later, Feldman and colleagues examined dyadic synchrony by studying the face-to-face interactions of mothers and infants while recording cardiac output, and behavioural interactions like gaze, affect, and vocalizations (Feldman et al., 2011). They found that dyads synchronized their heart rhythms with less than one second lags, and when they displayed vocal or affective synchrony, synchrony in the dyad’s heart rhythms increased even further.

Recently, Krzeczkowski and colleagues examined the way in which maternal regulatory inputs may be transmitted to infants at a moment-to-moment basis (Krzeczkowski et al., 2022). They found that increases in maternal High Frequency -Heart Rate Variability (HF-HRV), a measure of vagal tone, influenced subsequent decreases in infant HF-HRV during distress. Decreases in infant HF-HRV during distress is thought to indicate a better ability in using their socioemotional environment to regulate their physiological states (Porges & Furman, 2011). Among mother-infant dyads where mothers had PPD, this level of synchrony was only found after mothers had their PPD treated. This work highlighted the possibility that the PSNS of mothers and their infants may coordinate to ensure adaptive functioning of the dyadic regulatory system at times of infant distress. Given that maternal regulation of infant distress is crucial to the development of infant’s ability to eventually regulate their own emotions, this study highlights the potential for maternal treatment of PPD to possible mitigate at least some issues with dyadic regulation and mitigating possible long-term consequences for infants.

**1.6 Measurement of Emotion Regulation in Infants**

Given that ER occurs across multiple domains in infants (e.g., behavioural, physiological), both observational measurements of infant behaviour and measurements of neurophysiological activity (e.g., electroencephalography (EEG) and electrocardiography (ECG)) have been used to assess its functioning (Field et al., 2002; Fox, 1991; Lusby et al., 2014, 2016; Porges, 2007; Thayer et al., 2009).

Using EEG, infant corticolimbic brain activity can be measured to quantify patterns of resting frontal alpha asymmetry (FAA), the relative activity of the right and left frontal hemisphere of the brain. This pattern of activity is believed to be indicative of an individual’s approach-withdrawal motivations (Harmon-Jones & Gable, 2017). While approach motivations are connected to positive emotionality, withdrawal motivations are linked to avoidance and negative emotionality. Individuals who display greater right FAA are thought to have a more dominant withdrawal motivation which may place them at a greater risk of poor ER and psychopathology (Harmon-Jones & Allen, 1997).

In section 1.4, the role of subcortical regions in ER and their key role in emotion processing was highlighted. The amygdala has connections to two cortical regions involved in the identification of the level of threat (e.g., anterior insula (AI) and dorsolateral ACC; Seeley et al., 2007), as well as subcortical regions responsible for initiating a bodily response following stimulus detection (e.g., hypothalamus, periaqueductal grey (PAG; Rodrigues et al., 2009)). Approach-avoidance motivations involve the regulation of the amygdala by the PFC (Kaldewaij et al., 2016), and given the role of the early socioemotional environment on approach-avoidance motivation development, PPD-related deficits in the quality of mother-infant socio-emotional interactions may alter the activity of the infant amygdala and its connection to the PFC. With this as rationale, maternal treatment for PPD may improve an infant’s socioemotional environment, alter infant amygdala activity and lead to more approach behaviours, and greater left FAA.

Heart rate variability (HRV), the variation in time between each heartbeat, is another neurophysiological marker of infant ER as it measures the activity of the parasympathetic nervous system (PSNS) within the Autonomic nervous system (ANS). The ANS’s key role is in regulating the body’s different physiological processes (e.g., heart rate, respiration, digestion) to ensure that the body remains in homeostasis (Berntson et al., 1993).

The two branches of the ANS, the sympathetic nervous system (SNS) and PSNS actively operate to counteract one another. While the SNS mobilizes the body’s physiological systems to react to stress, the PSNS promotes bodily relaxation. A key component of the PSNS, the vagus nerve, innervates the heart and controls the cardiovascular system, and works to inhibit the activity of the SNS on the cardiac system (Thayer & Brosschot, 2005). But, in stressful situations, vagal activity is supressed and the SNS takes over to allow for stress reactions. This “withdrawal of vagal activity” can be quantified to represent PSNS control and provides a measurement of how individuals respond physiologically to stressors (Propper & Moore, 2006). Heart rate variability at the frequency of respiration (HF-HRV) can be used to quantify vagal tone. In infants, this frequency is typically between 0.24 to 1.04 Hz (Laborde et al., 2017). Greater ER is represented by an increase in HF-HRV at rest as it indicates optimal activity of the PSNS in flexibly adapting to the environment (Propper & Moore, 2006).

Lastly, infant ER is also commonly measured using informant-reports of infant temperament. Rothbart explained that temperament is indicative of differences in individual behaviour based on individual psychobiology (Rothbart, 2007). Parental reports of infant temperament have been found to represent stable, trait-related differences in ER capacity and provide an indication of the way infants interact with their environments. Individuals are thought to be born with an innate disposition and ways in which they react behaviourally and emotionally to stimuli in their environment (Rothbart, 2007). This individual, natural disposition is referred to as their temperament. The Infant Behaviour Questionnaire -Revised (IBQR) is a widely-used, and validated informant-report measure of infant regulatory temperament (Putnam et al., 2014).The regulatory capacity/orienting domain of the IBQR in particular, is a reliable indicator of infant ER and has been used in studies of maternal intervention to assess the effect of PPD treatment on infant ER (Krzeczkowski et al., 2021a; Putnam et al., 2008).

**1.7 Consequences of PPD on Infant Emotion Regulation Development**

As PPD can affect the quality of mother-infant interactions, it can interfere with the ability of mothers to identify and respond to their infant’s cues in an optimal manner (Feldman, 2007a). Mothers who fail to respond to infant cues and regulate their infants’ emotional states, can impede the development of infant ER (Feldman, 2007a). This disruption in optimal ER development may have a programming effect on the sensitive neuronal circuits that rapidly develop during the early postnatal period (Van den Bergh, 2011). Infants exposed to PPD have displayed both functional and morphometric changes in brain regions key to emotion regulation. Morphometrically, increased amygdala volume has been found in a longitudinally- followed group of children exposed to maternal depression early in life (Lupien et al., 2011). Functionally, infants exposed to PPD display brain activity indicative of a tendency towards negative emotionality (right FAA) and less flexibility of the autonomic nervous system (lower levels of HF-HRV; Field & Diego, 2008; Lusby et al., 2014a).

Optimal ER capacity is vital to healthy cognitive, socioemotional, and behavioural functioning (Calkins et al., 2021). Consequently, problems with ER are predictive of future behavioural problems and conduct disorder in adolescence (Beauchaine et al., 2007). Difficulties with ER during infancy can have profound long-term consequences such as a greater risk of criminal convictions and substance abuse (Moffitt et al., 2011) and psychiatric disorder later in life (Netsi et al., 2018). Fortunately, if mothers are treated while their infants are still in a period of enhanced neuroplasticity, we may be able to mitigate any serious developmental consequences before they occur.

Although the research that has identified PPD as being responsible for a number of developmental consequences in offspring is robust, the studies that have attempted to assess whether maternal intervention can mitigate these consequences are relatively sparse. For example, just one study appears to have assessed whether maternal treatment of PPD can elicit change in neurophysiological and behavioural markers of infant ER (Krzeczkowski et al., 2021b). In their observational study, Krzeczkowski and colleagues reported adaptive changes in two neurophysiological markers of ER (FAA, HF-HRV) as well as a behavioural measure of ER (orienting/regulatory capacity domain of the IBQR) in the infants of mothers who received a 9-week intervention. However, while this work added invaluable insights, there are a number of limitations in the PPD intervention that limit its ability to treat a large population of mothers and birthing parents. In this study, the PPD intervention was delivered by expert therapists in a specialized perinatal psychiatric clinic. Given the knowledge that PPD exposure is associated with suboptimal ER, and impairments in infant ER are linked to a host of negative consequences, focusing on increasing access to maternal PPD treatment may be an important step toward reducing the rates of psychiatric disorder in the population.

**2. Developing Scalable, Evidence-Based Mental Health Interventions**

**2.1 Access to Treatment during the Postpartum Period**

Untreated PPD can significantly affect the long-term physical and mental well-being of mothers and birthing parents with PPD. If left untreated, PPD can develop into persistent major depression (Horowitz & Goodman, 2004) and can increase the risk of several other difficulties including alcohol and recreational substance misuse (Chapman & Wu, 2013), and weight problems (Milgrom et al., 2012). However, treating maternal PPD early appears to circumvent future physical and mental health problems. Early intervention therefore may be key to drastically improving long-term outcomes in mothers and may be capable of mitigating negative effects that longer-term exposure to maternal depression could have on infants.

Despite the well-known burden of PPD and the potential for its treatment to benefit both women and their infants, it remains undertreated. Even in the presence of effective screening measures, just one in four mothers and birthing parents with PPD are detected (Coates et al., 2004). Of those detected, just 30% seek treatment (Reay et al., 2011). This is largely due to the many barriers to treatment that exist in the present health care system that prevent these individuals from both seeking and receiving evidence-based treatment. As a result, as few as one in ten receive evidence-based care for PPD (Cox et al., 2016).

The National Institute for Health and Clinical Excellence (NICE) clinical guidelines for antenatal and postnatal mental health from the UK recommend evidence-based psychological interventions such as cognitive behavioural therapy (CBT) or interpersonal therapy (IPT) as first-line treatments for women with PPD (NICE, 2007). Past randomized controlled trials (RCT) have highlighted the effectiveness of structured therapies like CBT (Sockol, 2015) and IPT (Sockol, 2018) in treating maternal PPD. Although antidepressants also appear to be effective (Butler et al., 2006) individuals with PPD are reluctant to use medication out of fear of exposing their newborns to medication through breast milk (MacQueen et al., 2016). Additionally, the NICE guidelines (2015) recommend that a greater threshold be used when resorting to psychopharmacological treatment for mild to moderate depression, and that efforts be made to make psychological treatments more readily available.

The guideline recommends a raised

threshold for using psychotropic drugs for some disorders (such

as mild or moderate depression or anxiety) and more emphasis

on providing psychological therapies. This requires greater and

faster availability of psychological interventions that meet the

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Unfortunately, at present the traditional health care system is ill-equipped to deal with common, time-sensitive conditions that require psychological treatment like PPD. As a result, even when PPD is detected, women rarely have access to evidence-based psychotherapies or are faced with long wait times and expensive private services (Bina, 2020; Boyd et al., 2011; Edge & MacKian, 2010). Additionally, most individuals with PPD are primarily treated by their family physicians who often lack the specialized training and the time to provide psychotherapy. These factors, along with the stigma surrounding PPD and reluctance to openly disclose their mental health difficulties out of fear that they will be reported to child protective services keep many from disclosing their symptoms (Byatt et al., 2013; Edwards & Timmons, 2005; Hadfield & Wittkowski, 2017; Heneghan et al., 2004; Prevatt et al., 2018; Santoro & Peabody, 2010; Thomas et al., 2014). As many mothers find it difficult to speak to their physician or other healthcare professionals, they are also unable to obtain the referrals needed to access mental health services. Treatment options that can address these barriers, encourage more women to seek treatment, and can ensure the timely treatment of PPD are needed to mitigate the burden of PPD on women and their infants.

**2.2 Social Support an Important Factor during the Postpartum Period**

Not only do mothers report experiencing a lack of social support during the postnatal period (Negron et al., 2013), but social isolation has been found to be a predictor of PPD development (Nielsen et al., 2000). Research that has sought to identify protective factors for PPD has highlighted the importance of a strong social support and community (Slomian et al., 2019). As mothers with PPD are riddled with feelings of guilt and shame about their ability as a mother, group interventions with other mothers may be especially beneficial to their treatment success. In fact, group interventions in informal community settings may especially encourage more women to seek and participate in treatment all while providing them with the opportunity to build strong networks of support within their communities.

**2.3 Potential for Group CBT to Target Barriers to PPD Treatment**

Presently, existing healthcare systems in Canada are unable to meet the needs of women and individuals with PPD and just one out of every ten women will receive evidence-based care (Cox et al., 2016). As such, innovative methods of treating PPD are needed that are designed to reduce barriers to access, while being potentially amenable to widespread dissemination. Although evidence-based psychotherapeutic interventions like CBT are preferred by those with PPD (MacQueen et al., 2016) and are recommended by clinical practice guidelines (NICE, 2007), access to individual psychotherapy is limited and there are many barriers to its receipt. These barriers include, but are not limited to time constraints, excessive cost, and a lack of available services (Mohr et al., 2010). Group delivery may be one solution to increasing the number of women able to receive psychotherapy. Group CBT appears to be effective in treating PPD (Honey et al., 2002; Milgrom et al., 2005), and is preferred as many individuals with PPD value the support and normalization of symptoms (Dennis & Chung-Lee, 2006; Lavender et al., 2016).

Cognitive behavioural therapy (CBT) is ideal for group delivery because its content allows participants to discuss scenarios, work together to problem solve, and allows participants to learn from other members in their group. Because group CBT allows for more individuals to receive treatment at one time, this format of therapy also has the potential to reduce treatment costs and reduce waitlists.

This treatment modality may also encourage more mothers and birthing parents to seek out treatment. Since social isolation is a common symptom of PPD (Dennis, 2014; Mills et al., 1995), having the opportunity to connect with a group of individuals experiencing the same challenges, may be especially encouraging. Taken together, a group CBT intervention may be an efficacious and cost-effective solution to timely PPD treatment, that may encourage more mothers to seek treatment, while directly addressing their social needs.

**2.4 Task-Shifting the Treatment of PPD**

CBT is traditionally delivered by licensed mental health practitioners with formal training in medical settings, creating further hurdles for women hoping to access treatment. For most mothers and birthing parents, accessing even group CBT is unrealistic as the cost of care is too high, medical professionals are seen as too intimidating and the availability for these forms of treatment are low and so wait lists are long (Bina, 2020; Boyd et al., 2011; Edge & MacKian, 2010).

Task-shifting, the redistribution of tasks from specialized experts to those with less training has become increasingly popular in mental health care service delivery over the last two decades (Fuhr et al., 2019; Rahman et al., 2016; Sikander et al., 2015; Singla et al., 2020; Van Lieshout et al., 2022). Moreover, since a key barrier to up-scaling mental health treatments is the scarcity of skilled human resources, task-shifting the treatment of PPD will allow for those with formal psychiatric training to focus on more severe psychiatric disorders and potentially reduce the overall burden on the healthcare system.

Task-shifting has largely been used in low and middle-income countries (e.g., Pakistan, Zimbabwe) to increase healthcare access in rural communities that have few health care resources available (Chibanda et al., 2014; Rahman et al., 2016). A review of evidence-based psychological treatments delivered by lay people have highlighted the effectiveness of these treatments (Singla et al., 2017). In India, Patel and colleagues (2017) had non-specialist lay counsellors deliver a psychological treatment using the principles of behavioural activation to individuals with moderate to severe depression. Their task-shifted intervention significantly improved symptoms of depression in its participants and nearly two-thirds of participants experienced remission. In this study, the lay people delivering treatment were mostly community health workers or individuals with an existing relationship with others in the community. Although we cannot say for certain, the familiarity of the participants with the individuals delivering the treatment may have contributed to the treatment success.

In Zimbabwe, Chibanda and colleagues had trained peer counselors use problem solving therapy to treat mothers with PPD (Chibanda et al., 2014). Like Patel and colleagues, they found their task-shifted intervention to be effective in reducing morbidity among their study participants. These studies suggest that task-shifting to lay persons may be a key strategy in reducing disparities in receipt of psychological evidence-based treatments. Given the significant burden that PPD places on mothers and birthing parents, and the future health of their infants, finding scalable, evidence-based methods of treating PPD that are engaging to women and easy for them to access is of utmost importance.

**2.5 Task-Shifting PPD Treatment to Public Health Nurses**

Public Health Nurses (PHNs) are a frequent, first point of contact for many mothers in the postpartum period, as they already have an existing role in the screening for PPD. As part of their existing roles in postpartum care, PHNs often provide mothers with support, despite not having the psychiatric training to offer formal psychotherapies. In a qualitative study, PHNs reported that they believe that their roles should involve the management of PPD and the delivery of psychotherapy (Segre et al., 2010). However, lack of formal training is a key barrier (Higgins et al., 2018). Given PHNs’ existing skills in providing women in the postpartum period with care, if given the opportunity to take part in formal training, they could play a key role in increasing treatment access. In fact, a recent study reported that most women with PPD felt that nurses were the optimal non-specialist provider of psychotherapeutic interventions (Singla et al., 2020).

To date, there is evidence to suggest that nurses can play a greater role in the psychological treatment of women with PPD. However, a majority of the research that has assessed the effective of nurse-delivered psychotherapeutic interventions for PPD have grouped nurses with other healthcare professionals and so isolating the effect of nurses alone is difficult. For example, using a randomized controlled trial (RCT) design, Murray and colleagues (Cooper et al., 2003) demonstrated that a group of nurses, midwives, and psychologists could deliver effective individual CBT for PPD. Interestingly, clinical improvements were greater following a nurse or midwife-delivered intervention, compared to the psychologist-delivered intervention. Morrell and colleagues used a cluster RCT to demonstrate that 8 weeks of individual CBT or person-centered therapy delivered by health visitors (nurses or midwives) led to symptom improvements at 6 and 12 months following maternal intervention (Morrell et al., 2009).

Using an 8-week psychoeducation group intervention with a CBT component, Honey and colleagues demonstrated that nurses and midwives could deliver an intervention that led to improvements in mothers’ symptoms 6 months following intervention completion (Honey et al., 2002).

Recently, Dennis and colleagues conducted a RCT to test the effectiveness of individual IPT delivered by nurses over the phone and found IPT to be more effective than treatment as usual (Dennis et al., 2020). Although these studies highlight the potential for nurses to deliver effective psychotherapy to women with PPD, many of these studies aggregated nurses with other healthcare workers and just one study included a group intervention.

Given this background, Van Lieshout and colleagues recently conducted an RCT to test the effectiveness of a PHN-delivered group CBT intervention designed to treat mothers with PPD in a community setting (Van Lieshout et al., 2020). This PHN-delivered intervention effectively treated symptoms of depression and anxiety in mothers, and changes appeared to remain stable six months following treatment. In fact, changes in maternal symptoms following this intervention were similar in magnitude to other studies of psychotherapeutic interventions delivered by expert therapists (Sockol, 2015, 2018).

**2.6 Task-Shifting to Peers with Lived Experience**

Still, the unique experiences of women and individuals with PPD often may make them reluctant to disclose their symptoms to healthcare professionals. For this reason, provisioning the treatment of PPD to those who have a history of PPD, but have since recovered (e.g., peers) may play a key role in increasing treatment among those with PPD. In a qualitative study looking at mothers’ support needs, Letourneau and colleagues (2007) found that women had a desire to receive support from someone who understands them and has had similar experiences. Support facilitated by peers has been found to show the promise when compared to other interventions, including those delivered by professionals and paraprofessionals (Leger & Letourneau, 2015). Given that peer support may be especially beneficial for women with PPD, designing psychotherapeutic interventions delivered by peers may be especially effective for PPD treatment. The ability to truly empathize with the individual receiving support is what can set peer support apart from other forms of social support. In fact, a key characteristic of peer support providers that may be beneficial is that they have experiential knowledge and have “been through it” themselves (Nicole et al., 2007). To those with PPD, this may have a dramatic impact on their motivation to seek and remain in treatment.

To mothers and birthing parents with PPD, peers are a particularly credible source of information, and are seen as less judgemental, less stigmatizing, and more approachable than healthcare professionals (Bryan & Arkowitz, 2015; Montgomery et al., 2012; Singla et al., 2014). Those with PPD may see peers as less likely to report common problems to child welfare authorities, they promote the normalization of symptoms, and have valuable experiential knowledge. They also serve as positive role models, highlighting potential pathways to recovery for PPD sufferers while providing support and guidance. Importantly, feelings of mutual empathy and empowerment may be a particularly important aspect of peer treatment delivery for those with PPD. Being given the opportunity to facilitate the recovery of individuals currently experiencing PPD provides peers with the opportunity to serve as a role model, enhance their own problem-solving skills and learn vicariously through their treatment of others. Importantly, recent reviews suggest that peers may be just as effective as professionals at treating individuals with depression using CBT (Bryan & Arkowitz, 2015; Lavender et al., 2016).

To date, few studies have examined the effectiveness of a peer-delivered intervention on the treatment of PPD. Dennis and colleagues assessed the effectiveness of an individual, peer, telephone-based intervention for pregnant women and found this peer-based intervention to be effective in preventing PPD in those classified as being at-risk of PPD (Dennis et al., 2009). Yet in another study, LeTourneau and colleagues used a peer-delivered intervention with women who currently had PPD and found that their individual, home-based peer intervention did not lead to reductions in symptoms of PPD (Letourneau et al., 2015).

More recently, Fuhr and colleagues conducted a RCT in rural India where pregnant women with depression participated in a behaviourally-based psychosocial intervention delivered by other women in their community (Fuhr et al., 2019). They found no differences in depression symptom severity in their treatment and control groups. This intervention was also implemented in an RCT that took place in Pakistan (Sikander et al., 2019).While some improvement in symptoms of PPD were found, these improvements did not persist at 6-months of follow up. However, it is not clear whether the peers in these trials had lived experience of PPD. Because these trials were conducted in low and middle-income countries, it is also difficult to apply their findings to the context of high-income countries like Canada. Considering the potential for peer delivery to have a major impact on PPD treatment, there is a need to design peer interventions for PPD that are in treatment formats that those with PPD prefer (e.g., group CBT in community settings) and are delivered by individuals that make them feel comfortable (peers).

Postpartum depression is relatively common (Gaynes et al., 2005) and recovery rates are high, highlighting the large population of recovered “peers” that could exist to help current sufferers. Given this large supply of potential peers, women’s desire to help others recover from PPD, and the possibility that they may be able to deliver CBT as effectively as trained professionals (Bryan & Arkowitz, 2015; Montgomery et al., 2010), task-shifting the psychotherapeutic treatment of PPD to peers, particularly in group format, offers a potentially effective, accessible, and cost-effective way to reduce the burden of PPD on women and mitigate any negative developmental consequences on their infants. Providing mothers with PPD with effective and accessible treatments that they prefer may be an impactful step towards reducing the prevalence of mental health disorder in the Canadian population.

**3. Objectives of the Present Thesis**

A key paradigm in mental health research has been that developmental outcomes have their origin in the perinatal period. Despite the substantial amount of evidence that has connected PPD to a number of negative outcomes in infants, we have yet to sufficiently examine whether treating maternal PPD could reduce these effects. Interventions designimped to allow for timelier PPD treatment may reduce the transmission of psychiatric risk from mother to infant, and therefore reduce the risk of psychiatric disorders across the lifespan. Furthermore, early prevention of psychiatric disorder may be much more cost- effective, less burdensome on the healthcare system, and may provide a more effective solution to reducing the prevalence of mental illness in Canada and beyond.

The following chapters in this dissertation include three studies that sought to assess whether maternal treatment of PPD with task-shifted, group CBT interventions can begin to interrupt the transmission of psychiatric risk from mother to infant. The first study tested the efficacy of a novel, peer-delivered group CBT PPD intervention in treating symptoms of depression in mothers, while the second study examined whether maternal participation in this peer-delivered intervention would also lead to adaptive change in multiple markers of infant ER following maternal treatment. The third and final study examined whether a PHN-delivered intervention that was effective in treating maternal PPD can also result in changes across multiple markers of infant ER. Taken together, this body of work sought to determine whether task-shifted interventions for maternal PPD are effective in both treating mothers and mitigating the negative effects of PPD exposure on infant ER.

**Chapter 2: Peer-Delivered Cognitive-Behavioural Therapy for Postpartum Depression: A Randomized Controlled Trial**

In the first study, we used a randomized controlled trial (RCT) with a waitlist control group to examine whether a nine-week Cognitive Behavioural Therapy (CBT) group delivered by peers in a community centre could treat PPD in mothers. Peers included women who had a history of PPD but had since recovered and were willing to be trained to deliver group psychotherapy in a community-setting. We found that this peer-delivered group CBT significantly improved symptoms of depression and anxiety in women. We assessed stability in symptom improvement and found that reductions in symptoms remained stable six months after treatment initiation.

**Chapter 3: The Impact of Peer-Delivered Cognitive Behavioural Therapy for Postpartum Depression on Infant Emotion Regulation: A Randomized Controlled Trial**

After finding the peer-delivered group CBT intervention to be effective in treating maternal PPD, we sought to determine if maternal PPD improvement by way of this treatment would also lead to adaptive changes in markers of ER in their infants. Markers of infant ER included two measures of infant physiology and one maternal-report measure of behaviour. We found evidence of adaptive change in two physiological measures of infant ER but not a behavioural measure of infant temperament following maternal treatment. No change was observed in infant physiology following maternal treatment in infants of mothers who were taking part in a nine-week waitlist period.

**Chapter 4: PHN-Delivered CBT for PPD: A Randomized Controlled Trial Assessing the Effects of Maternal PPD Treatment on Infant Emotion Regulation**

Finally, we examined whether a second task-shifted intervention that included group CBT delivery in a community setting by Public Health Nurses (PHNs) would also lead to adaptive change in infant ER. This study used an RCT design with a control group of women with PPD who received treatment-as-usual. Following nine weeks of maternal treatment, we found evidence of infant ER change in a single physiological marker of infant ER, while we found no change in two other markers.

We sought to examine whether maternal treatment with a task-shifted intervention for PPD would translate to adaptive changes in their infants, break the familial cycle of mental health risk, and potentially have a large public health impact. Overall, our findings suggest that PPD interventions delivered by non-professionals, may lead to adaptive changes in infant ER following just nine weeks of maternal treatment. These results hint at the potential of timely maternal treatment to disrupt the transmission of psychiatric risk from parent to infant.

The first study in this thesis has been published, while the second study is under review, and the final study is in the process of being prepared for submission. The first and second study of this thesis include data from the same randomized controlled trial and as a result, there is duplication in the methods. The second and third study used the same outcome measures to assess their main outcome, infant ER, as such, there are instances of duplication in the methods sections of these two studies.

**References**

Ainsworth, M. S. (1979). Infant–mother attachment. *American Psychologist*, *34*(10), 932.

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/https://doi.org/10.1176/appi.books.9780890425787

Anda, R. F., Felitti, V. J., Bremner, J. D., Walker, J. D., Whitfield, C., Perry, B. D., Dube, S. R., & Giles, W. H. (2006). The enduring effects of abuse and related adverse experiences in childhood: A convergence of evidence from neurobiology and epidemiology. *European Archives of Psychiatry and Clinical Neuroscience*, *256*(3), 174–186. https://doi.org/10.1007/s00406-005-0624-4

Apter-Levi, Y., Pratt, M., Vakart, A., Feldman, M., Zagoory-Sharon, O., & Feldman, R. (2016). Maternal depression across the first years of life compromises child psychosocial adjustment; relations to child HPA-axis functioning. *PSYCHONEUROENDOCRINOLOGY*, *64*, 47–56. https://doi.org/10.1016/j.psyneuen.2015.11.006

Atzil, S., Hendler, T., & Feldman, R. (2011). Specifying the neurobiological basis of human attachment: Brain, hormones, and behavior in synchronous and intrusive mothers. *Neuropsychopharmacology*, *36*(13), 2603–2615. https://doi.org/10.1038/npp.2011.172

Atzil, S., Hendler, T., & Feldman, R. (2014). The brain basis of social synchrony. *SOCIAL COGNITIVE AND AFFECTIVE NEUROSCIENCE*, *9*(8), 1193–1202. https://doi.org/10.1093/scan/nst105

Barry, T. J., Murray, L., Fearon, R. M. P., Moutsiana, C., Cooper, P., Goodyer, I. M., Herbert, J., & Halligan, S. L. (2015). Maternal postnatal depression predicts altered offspring biological stress reactivity in adulthood. *Psychoneuroendocrinology*, *52*, 251–260. https://doi.org/10.1016/j.psyneuen.2014.12.003

Beauchaine, T. P., Gatzke-Kopp, L., & Mead, H. K. (2007). Polyvagal theory and developmental psychopathology: Emotion dysregulation and conduct problems from preschool to adolescence. *Biological Psychology*, *74*(2), 174–184.

Beck, C. T., & Gable, R. K. (2000). Postpartum Depression Screening Scale: development and psychometric testing. *Nursing Research*, *49*(5), 272–282.

Belsky, J., & Fearon, R. M. P. (2002). Early attachment security, subsequent maternal sensitivity, and later child development: does continuity in development depend upon continuity of caregiving? *Attachment & Human Development*, *4*(3), 361–387.

Berger, L. M. (2005). Income, family characteristics, and physical violence toward children. *Child Abuse & Neglect*, *29*(2), 107–133.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology*, *30*(2), 183–196.

Bina, R. (2020). Predictors of postpartum depression service use: A theory-informed, integrative systematic review. *Women and Birth*, *33*(1), e24–e32. https://doi.org/10.1016/j.wombi.2019.01.006

Boyd, R. C., Mogul, M., Newman, D., & Coyne, J. C. (2011). Screening and referral for postpartum depression among low-income women: A qualitative perspective from community health workers. *Depression Research and Treatment*, *2011*. https://doi.org/10.1155/2011/320605

Brennan, P. A., Pargas, R., Walker, E. F., Green, P., Jeffrey Newport, D., & Stowe, Z. (2008). Maternal depression and infant cortisol: influences of timing, comorbidity and treatment. *Journal of Child Psychology and Psychiatry*, *49*(10), 1099–1107. https://doi.org/10.1111/j.1469-7610.2008.01914.x

Brummelte, S., & Galea, L. A. M. (2016). Postpartum depression: Etiology, treatment and consequences for maternal care. *Hormones and Behavior*, *77*, 153–166. https://doi.org/10.1016/j.yhbeh.2015.08.008

Bryan, A. E. B., & Arkowitz, H. (2015). Meta-Analysis of the Effects of Peer-Administered Psychosocial Interventions on Symptoms of Depression. *American Journal of Community Psychology*, *55*(3–4), 455–471. https://doi.org/10.1007/s10464-015-9718-y

Burke, L. (2003). The impact of maternal depression on familial relationships. *International Review of Psychiatry*, *15*(3), 243–255. https://doi.org/10.1080/0954026031000136866

Butler, A. C., Chapman, J. E., Forman, E. M., & Beck, A. T. (2006). The empirical status of cognitive-behavioral therapy: A review of meta-analyses. *Clinical Psychology Review*, *26*(1), 17–31. https://doi.org/10.1016/j.cpr.2005.07.003

Byatt, N., Biebel, K., Friedman, L., Debordes-Jackson, G., & Ziedonis, D. (2013). Women’s perspectives on postpartum depression screening in pediatric settings: A preliminary study. *Archives of Women’s Mental Health*, *16*(5), 429–432. https://doi.org/10.1007/s00737-013-0369-4

Calkins, S. D., Dollar, J. M., Wideman, L., & Studies, F. (2021). *for mental and physical health challenges*. *31*(3), 957–970. https://doi.org/10.1017/S0954579419000415.Temperamental

Chapman, S. L. C., & Wu, L.-T. (2013). Postpartum substance use and depressive symptoms: a review. *Women & Health*, *53*(5), 479–503.

Chibanda, D., Shetty, A. K., Tshimanga, M., Woelk, G., Stranix-Chibanda, L., & Rusakaniko, S. (2014). Group problem-solving therapy for postnatal depression among HIV-positive and HIV-negative mothers in zimbabwe. *Journal of the International Association of Providers of AIDS Care*, *13*(4), 335–341. https://doi.org/10.1177/2325957413495564

Coates, A. O., Schaefer, C. A., & Alexander, J. L. (2004). Detection of postpartum depression and anxiety in a large health plan. *The Journal of Behavioral Health Services & Research*, *31*(2), 117–133.

Coates, R., Ayers, S., & de Visser, R. (2014). Women’s experiences of postnatal distress: A qualitative study. *BMC Pregnancy and Childbirth*, *14*(1), 1–14. https://doi.org/10.1186/1471-2393-14-359

Colodro-Conde, L., Couvy-Duchesne, B., Zhu, G., Coventry, W. L., Byrne, E. M., Gordon, S., Wright, M. J., Montgomery, G. W., Madden, P. A. F., & Ripke, S. (2018). A direct test of the diathesis–stress model for depression. *Molecular Psychiatry*, *23*(7), 1590–1596.

Cooper, P. J., Murray, L., Wilson, A., & Romaniuk, H. (2003). Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. I. Impact on maternal mood. *British Journal of Psychiatry*, *182*(MAY), 412–419. https://doi.org/10.1192/bjp.182.5.412

Cox, E. Q., Sowa, N. A., Meltzer-Brody, S. E., & Gaynes, B. N. (2016). The perinatal depression treatment cascade: Baby steps toward improving outcomes. *Journal of Clinical Psychiatry*, *77*(9), 1189–1200. https://doi.org/10.4088/JCP.15r10174

Dennis, C.-L. (2014). Psychosocial interventions for the treatment of perinatal depression. *Best Practice & Research Clinical Obstetrics & Gynaecology*, *28*(1), 97–111.

Dennis, C.-L., & Chung-Lee, L. (2006). Postpartum Depression Help-Seeking Barriers and Maternal Treatment Preferences: A Qualitative Systematic Review. *Birth*, *33*(4), 323–331. https://doi.org/10.1111/j.1523-536X.2006.00130.x

Dennis, C. L., Hodnett, E., Kenton, L., Weston, J., Zupancic, J., Stewart, D. E., & Kiss, A. (2009). Effect of peer support on prevention of postnatal depression among high risk women: Multisite randomised controlled trial. *BMJ (Online)*, *338*(7689), 280–283. https://doi.org/10.1136/bmj.a3064

Dennis, Cindy Lee, Grigoriadis, S., Zupancic, J., Kiss, A., & Ravitz, P. (2020). Telephone-based nurse-delivered interpersonal psychotherapy for postpartum depression: Nationwide randomised controlled trial. *British Journal of Psychiatry*, *216*(4), 189–196. https://doi.org/10.1192/bjp.2019.275

Dias, C. C., & Figueiredo, B. (2015). Breastfeeding and depression: a systematic review of the literature. *Journal of Affective Disorders*, *171*, 142–154.

Diego, M. A., Field, T., Jones, N. A., & Hernandez-Reif, M. (2006). Withdrawn and intrusive maternal interaction style and infant frontal EEG asymmetry shifts in infants of depressed and non-depressed mothers. *INFANT BEHAVIOR & DEVELOPMENT*, *29*(2), 220–229. https://doi.org/10.1016/j.infbeh.2005.12.002

Ding, Y., Xu, X., Wang, Z., Li, H., & Wang, W. (2014). The relation of infant attachment to attachment and cognitive and behavioural outcomes in early childhood. *Early Human Development*, *90*(9), 459–464.

Duffett-Leger, L., Watson, W., Tryphonopoulos, P. D., Letourneau, N. L., Dennis, C.-L., Este, D., Stewart, M., & Benzies, K. (2012). Postpartum Depression is a Family Affair: Addressing the Impact on Mothers, Fathers, and Children. *Issues in Mental Health Nursing*, *33*(7), 445–457. https://doi.org/10.3109/01612840.2012.673054

Edge, D., & MacKian, S. C. (2010). Ethnicity and mental health encounters in primary care: help-seeking and help-giving for perinatal depression among Black Caribbean women in the UK. *Ethnicity & Health*, *15*(1), 93–111. https://doi.org/10.1080/13557850903418836

Edwards, E., & Timmons, S. (2005). A qualitative study of stigma among women suffering postnatal illness. *Journal of Mental Health*, *14*(5), 471–481. https://doi.org/10.1080/09638230500271097

Edwards, V. J., Holden, G. W., Felitti, V. J., & Anda, R. F. (2003). Relationship between multiple forms of childhood maltreatment and adult mental health in community respondents: results from the adverse childhood experiences study. *American Journal of Psychiatry*, *160*(8), 1453–1460.

Feldman, R. (2007a). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(3–4), 329–354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Feldman, R. (2007b). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, *16*(6), 340–345.

Feldman, R. (2016). The neurobiology of mammalian parenting and the biosocial context of human caregiving. *Hormones and Behavior*, *77*, 3–17. https://doi.org/10.1016/j.yhbeh.2015.10.001

Feldman, R., Magori-Cohen, R., Galili, G., Singer, M., & Louzoun, Y. (2011). Mother and infant coordinate heart rhythms through episodes of interaction synchrony. *Infant Behavior and Development*, *34*(4), 569–577.

Feldman, R., Rosenthal, Z., & Eidelman, A. I. (2014). Maternal-Preterm Skin-to-Skin Contact Enhances Child Physiologic Organization and Cognitive Control Across the First 10 Years of Life. *BIOLOGICAL PSYCHIATRY*, *75*(1), 56–64. https://doi.org/10.1016/j.biopsych.2013.08.012

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., Koss, M. P., Marks, J. S., & Perma-Nente, K. (1998). Relationship of Childhood Abuse and Household Dysfunction to Many of the Leading Causes of Death in Adults The Adverse Childhood Experiences (ACE) Study. In *Am J Prev Med* (Vol. 14, Issue 4). www.elsevier.

Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., Zimmerman, E. A., & Kuhn, C. (1988). Infants of depressed mothers show “depressed” behavior even with nondepressed adults. *Child Development*, *59*(6), 1569–1579. https://doi.org/10.1111/j.1467-8624.1988.tb03684.x

Field, T, Diego, M., Hernandez-Reif, M., Schanberg, S., Kuhn, C., Yando, R., & Bendell, D. (2002). Prenatal depression effects on the foetus and neonate in different ethnic and socio-economic status groups. *JOURNAL OF REPRODUCTIVE AND INFANT PSYCHOLOGY*, *20*(3), 149–157. https://doi.org/10.1080/026468302760270809

Field, Tiffany. (1992). Infants of depressed mothers. *Development and Psychopathology*, *4*(1), 49–66. https://doi.org/10.1017/S0954579400005551

Field, Tiffany. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. *Infant Behavior and Development*, *33*(1), 1–6. https://doi.org/https://doi.org/10.1016/j.infbeh.2009.10.005

Field, Tiffany, & Diego, M. (2008). *Vagal activity , early growth and emotional development*. *31*, 361–373. https://doi.org/10.1016/j.infbeh.2007.12.008

Field, Tiffany, Diego, M., & Hernandez-Reif, M. (2006). Prenatal depression effects on the fetus and newborn: a review. *Infant Behavior and Development*, *29*(3), 445–455.

Field, Tiffany, Pickens, J., Fox, N. A., Nawrocki, T., & Gonzalez, J. (1995). Vagal tone in infants of depressed mothers. *Development and Psychopathology*, *7*(2), 227–231. https://doi.org/10.1016/j.jad.2014.04.024

Fox, N. (1994). Dynamic Cerebral Processes Underlying Emotion Regulation. *Monographs of the Society for Research in Child Development*, *59*(2/3), 152–166. https://doi.org/10.1007/sl

Fox, N. A. (1991). If It’s Not Left, It’s Right. *American Psychologist,* *46*(8), 863–872.

Fuhr, D. C., Weobong, B., Lazarus, A., Vanobberghen, F., Weiss, H. A., Singla, D. R., Tabana, H., Afonso, E., De Sa, A., D’Souza, E., Joshi, A., Korgaonkar, P., Krishna, R., Price, L. S. N., Rahman, A., & Patel, V. (2019). Delivering the Thinking Healthy Programme for perinatal depression through peers: an individually randomised controlled trial in India. *The Lancet Psychiatry*, *6*(2), 115–127. https://doi.org/10.1016/S2215-0366(18)30466-8

Gaynes, B. N., Gavin, N., Meltzer-Brody, S., Lohr, K. N., Swinson, T., Gartlehner, G., Brody, S., & Miller, W. C. (2005). Perinatal depression: prevalence, screening accuracy, and screening outcomes. *Evidence Report/Technology Assessment (Summary)*, *119*, 1–8. https://doi.org/10.1037/e439372005-001

Gianino, A., & Tronick, E. Z. (1988). *The mutual regulation model: The infant’s self and interactive regulation and coping and defensive capacities.*

Goodman, J. H. (2004a). Paternal postpartum depression, its relationship to maternal postpartum depression, and implications for family health. *Journal of Advanced Nursing*, *45*(1), 26–35.

Goodman, J. H. (2004b). Postpartum depression beyond the early postpartum period. *JOGNN - Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *33*(4), 410–420. https://doi.org/10.1177/0884217504266915

Goyal, D., Gay, C., & Lee, K. A. (2010). How much does low socioeconomic status increase the risk of prenatal and postpartum depressive symptoms in first-time mothers? *Women’s Health Issues*, *20*(2), 96–104.

Groh, A. M., Narayan, A. J., Bakermans‐Kranenburg, M. J., Roisman, G. I., Vaughn, B. E., Fearon, R. M. P., & van IJzendoorn, M. H. (2017). Attachment and temperament in the early life course: A meta‐analytic review. *Child Development*, *88*(3), 770–795.

Hadfield, H., & Wittkowski, A. (2017). Women’s Experiences of Seeking and Receiving Psychological and Psychosocial Interventions for Postpartum Depression: A Systematic Review and Thematic Synthesis of the Qualitative Literature. *Journal of Midwifery and Women’s Health*, *62*(6), 723–736. https://doi.org/10.1111/jmwh.12669

Halligan, S. L., Murray, L., Martins, C., & Cooper, P. J. (2007). Maternal depression and psychiatric outcomes in adolescent offspring: A 13-year longitudinal study. *Journal of Affective Disorders*, *97*(1–3), 145–154. https://doi.org/10.1016/j.jad.2006.06.010

Harmon-Jones, E., & Allen, J. J. B. (1997). Behavioral activation sensitivity and resting frontal EEG asymmetry: covariation of putative indicators related to risk for mood disorders. *Journal of Abnormal Psychology*, *106*(1), 159.

Harmon-Jones, E., & Gable, P. A. (2017). On the role of asymmetric frontal cortical activity in approach and withdrawal motivation: An updated review of the evidence. *Psychophysiology*, *1*. https://doi.org/10.1111/psyp.12879

Heim, C., Newport, D. J., Mletzko, T., Miller, A. H., & Nemeroff, C. B. (2008). The link between childhood trauma and depression: insights from HPA axis studies in humans. *Psychoneuroendocrinology*, *33*(6), 693–710.

Heneghan, A. M., Mercer, M. B., & DeLeone, N. L. (2004). Will Mothers Discuss Parenting Stress and Depressive Symptoms with Their Child’s Pediatrician? *Pediatrics*, *113*(3 I), 460–467. https://doi.org/10.1542/peds.113.3.460

Herman, J. P., McKlveen, J. M., Ghosal, S., Kopp, B., Wulsin, A., Makinson, R., Scheimann, J., & Myers, B. (2016). Regulation of the hypothalamic-pituitary-adrenocortical stress response. *Comprehensive Physiology*, *6*(2), 603.

Higgins, A., Downes, C., Carroll, M., Gill, A., & Monahan, M. (2018). There is more to perinatal mental health care than depression: Public health nurses reported engagement and competence in perinatal mental health care. *Journal of Clinical Nursing*, *27*(3–4), e476–e487.

Hofer, M. A. (1994). Early relationships as regulators of infant physiology and behavior. *Acta Paediatrica*, *83*, 9–18.

Honey, K. L., Bennett, P., & Morgan, M. (2002). A brief psycho‐educational group intervention for postnatal depression. *British Journal of Clinical Psychology*, *41*(4), 405–409.

Horowitz, J. A., & Goodman, J. (2004). A longitudinal study of maternal postpartum depression symptoms. *Research and Theory for Nursing Practice*, *18*(2/3), 149.

Jolley, S. N., & Betrus, P. (2007). Comparing postpartum depression and major depressive disorder: issues in assessment. *Issues in Mental Health Nursing*, *28*(7), 765–780.

Kaldewaij, R., Koch, S. B. J., Volman, I., Toni, I., & Roelofs, K. (2016). On the control of social approach–avoidance behavior: Neural and endocrine mechanisms. *Social Behavior from Rodents to Humans*, 275–293.

Kalmakis, K. A., & Chandler, G. E. (2015). Health consequences of adverse childhood experiences: A systematic review. In *Journal of the American Association of Nurse Practitioners* (Vol. 27, Issue 8, pp. 457–465). Blackwell Publishing Ltd. https://doi.org/10.1002/2327-6924.12215

Kinsella, M. T., & Monk, C. (2009). Impact of maternal stress, depression and anxiety on fetal neurobehavioral development. *Clinical Obstetrics and Gynecology*, *52*(3), 425–440. https://doi.org/10.1097/GRF.0b013e3181b52df1

Kohn, N., Eickhoff, S. B., Scheller, M., Laird, A. R., Fox, P. T., & Habel, U. (2014). Neural network of cognitive emotion regulation—an ALE meta-analysis and MACM analysis. *Neuroimage*, *87*, 345–355.

Krzeczkowski, J. E., Schmidt, L. A., Ferro, M. A., & Van Lieshout, R. J. (2022). Follow the leader: Maternal transmission of physiological regulatory support to distressed infants in real-time. *Journal of Psychopathology and Clinical Science*, *131*(5), 524.

Krzeczkowski, J. E., Schmidt, L. A., & Van Lieshout, R. J. (2021a). Changes in infant emotion regulation following maternal cognitive behavioral therapy for postpartum depression. *Depression and Anxiety*, *September 2020*, 1–10. https://doi.org/10.1002/da.23130

Krzeczkowski, J. E., Schmidt, L. A., & Van Lieshout, R. J. (2021b). Changes in infant emotion regulation following maternal cognitive behavioral therapy for postpartum depression. *Depression and Anxiety*, *December 2020*, 1–10. https://doi.org/10.1002/da.23130

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart rate variability and cardiac vagal tone in psychophysiological research - Recommendations for experiment planning, data analysis, and data reporting. *Frontiers in Psychology*, *8*, 1–18. https://doi.org/10.3389/fpsyg.2017.00213

Lavender, T. J., Ebert, L., & Jones, D. (2016). An evaluation of perinatal mental health interventions: An integrative literature review. *Women and Birth*, *29*(5), 399–406. https://doi.org/10.1016/j.wombi.2016.04.004

Lee, C. (1997). Social context, depression and the transition to motherhood. *British Journal of Health Psychology*, *2*(2), 93–108. https://doi.org/10.1111/j.2044-8287.1997.tb00527.x

Leger, J., & Letourneau, N. (2015). New mothers and postpartum depression: A narrative review of peer support intervention studies. *Health and Social Care in the Community*, *23*(4), 337–348. https://doi.org/10.1111/hsc.12125

Letourneau, N. L., Dennis, C.-L., Cosic, N., & Linder, J. (2017). The effect of perinatal depression treatment for mothers on parenting and child development: A systematic review. *Depression and Anxiety*, *34*(10), 928–966. https://doi.org/10.1002/da.22687

Letourneau, N., Secco, L., Colpitts, J., Aldous, S., Stewart, M., & Dennis, C. L. (2015). Quasi-experimental evaluation of a telephone-based peer support intervention for maternal depression. *Journal of Advanced Nursing*, *71*(7), 1587–1599. https://doi.org/10.1111/jan.12622

Lohoff, F. W. (2010). Overview of the genetics of major depressive disorder. *Current Psychiatry Reports*, *12*(6), 539–546.

Lovejoy, M. C., Graczyk, P. A., O’Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior. *Clinical Psychology Review*, *20*(5), 561–592. https://doi.org/10.1016/S0272-7358(98)00100-7

Lupien, S. J., Parent, S., Evans, A. C., Tremblay, R. E., Zelazo, P. D., Corbo, V., Pruessner, J. C., & Seguin, J. R. (2011). Larger amygdala but no change in hippocampal volume in 10-year-old children exposed to maternal depressive symptomatology since birth. *Proceedings of the National Academy of Sciences*, *108*(34), 14324–14329. https://doi.org/10.1073/pnas.1105371108

Lusby, C. M., Goodman, S. H., Bell, M. A., & Newport, D. J. (2014a). Electroencephalogram patterns in infants of depressed mothers. *Developmental Psychobiology*, *56*(3), 459–473. https://doi.org/10.1002/dev.21112

Lusby, C. M., Goodman, S. H., Bell, M. A., & Newport, D. J. (2014b). Electroencephalogram patterns in infants of depressed mothers. *DEVELOPMENTAL PSYCHOBIOLOGY*, *56*(3), 459–473. https://doi.org/10.1002/dev.21112

Lusby, C. M., Goodman, S. H., Yeung, E. W., Bell, M. A., & Stowe, Z. N. (2016). Infant EEG and temperament negative affectivity: Coherence of vulnerabilities to mothers’ perinatal depression. *DEVELOPMENT AND PSYCHOPATHOLOGY*, *28*(4, 1, SI), 895–911. https://doi.org/10.1017/S0954579416000614

MacQueen, G. M., Frey, B. N., Ismail, Z., Jaworska, N., Steiner, M., Lieshout, R. J. V., Kennedy, S. H., Lam, R. W., Milev, R. V., Parikh, S. V., & Ravindran, A. V. (2016). Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 clinical guidelines for the management of adults with major depressive disorder: Section 6. Special populations: Youth, women, and the elderly. *Canadian Journal of Psychiatry*, *61*(9), 588–603. https://doi.org/10.1177/0706743716659276

McEwen, B. S. (2003). Early life influences on life-long patterns of behavior and health. In *Mental Retardation and Developmental Disabilities Research Reviews* (Vol. 9, Issue 3, pp. 149–154). https://doi.org/10.1002/mrdd.10074

McLearn, K. T., Minkovitz, C. S., Strobino, D. M., Marks, E., & Hou, W. (2006a). Maternal depressive symptoms at 2 to 4 months post partum and early parenting practices. *Archives of Pediatrics & Adolescent Medicine*, *160*(3), 279–284.

McLearn, K. T., Minkovitz, C. S., Strobino, D. M., Marks, E., & Hou, W. (2006b). The timing of maternal depressive symptoms and mothers’ parenting practices with young children: implications for pediatric practice. *Pediatrics*, *118*(1), e174–e182.

Meaney, M. J. (2018). Perinatal maternal depressive symptoms as an issue for population health. *American Journal of Psychiatry*, *175*(11), 1084–1093. https://doi.org/10.1176/appi.ajp.2018.17091031

Milgrom, J., Negri, L. M., Gemmill, A. W., McNeil, M., & Martin, P. R. (2005). A randomized controlled trial of psychological interventions for postnatal depression. *British Journal of Clinical Psychology*, *44*(4), 529–542. https://doi.org/10.1348/014466505X34200

Milgrom, J., Skouteris, H., Worotniuk, T., Henwood, A., & Bruce, L. (2012). The association between ante-and postnatal depressive symptoms and obesity in both mother and child: a systematic review of the literature. *Women’s Health Issues*, *22*(3), e319–e328.

Mills, E. P., Finchilescu, G., & Lea, S. J. (1995). Postnatal depression-An examination of psychosocial factors. *South African Medical Journal*, *85*(2), 99–105.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, *108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Mohr, D. C., Ho, J., Duffecy, J., Baron, K. G., Lehman, K. A., Jin, L., & Reifler, D. (2010). Perceived barriers to psychological treatments and their relationship to depression. *Journal of Clinical Psychology*, *66*(4), 394–409.

Montgomery, E. C., Kunik, M. E., Wilson, N., Stanley, M. A., & Weiss, B. (2010). Can paraprofessionals deliver cognitive-behavioral therapy to treat anxiety and depressive symptoms? *Bulletin of the Menninger Clinic*, *74*(1), 45–62. https://doi.org/10.1521/bumc.2010.74.1.45

Montgomery, P., Mossey, S., Adams, S., & Bailey, P. H. (2012). Stories of women involved in a postpartum depression peer support group. *International Journal of Mental Health Nursing*, *21*(6), 524–532. https://doi.org/10.1111/j.1447-0349.2012.00828.x

Morawetz, C., Bode, S., Baudewig, J., & Heekeren, H. R. (2017). Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. *Social Cognitive and Affective Neuroscience*, *12*(4), 569–585. https://doi.org/10.1093/scan/nsw169

Morrell, C. J., Slade, P., Warner, R., Paley, G., Dixon, S., Walters, S. J., Brugha, T., Barkham, M., Parry, G. J., & Nicholl, J. (2009). Clinical effectiveness of health visitor training in psychologically informed approaches for depression in postnatal women: pragmatic cluster randomised trial in primary care. *Bmj*, *338*.

Murray, L., Arteche, A., Fearon, P., Halligan, S., Goodyer, I., & Cooper, P. (2011). Maternal postnatal depression and the development of depression in offspring up to 16 years of age. *Journal of the American Academy of Child & Adolescent Psychiatry*, *50*(5), 460–470.

Murray, L., Fearon, P., & Cooper, P. (2015). Postnatal Depression, Mother-Infant Interactions, and Child Development Prospects for Screening and Treatment. In Milgrom, J and Gemmill, AW (Ed.), *IDENTIFYING PERINATAL DEPRESSION AND ANXIETY: EVIDENCE-BASED PRACTICE IN SCREENING, PSYCHOSOCIAL ASSESSMENT, AND MANAGEMENT* (pp. 139–164).

Negron, R., Martin, A., Almog, M., Balbierz, A., & Howell, E. A. (2013). Social support during the postpartum period: mothers’ views on needs, expectations, and mobilization of support. *Maternal and Child Health Journal*, *17*(4), 616–623.

Netsi, E., Pearson, R. M., Murray, L., Cooper, P., Craske, M. G., & Stein, A. (2018). Association of persistent and severe postnatal depression with child outcomes. *JAMA Psychiatry*, *75*(3), 247–253. https://doi.org/10.1001/jamapsychiatry.2017.4363

NICE. (2007). *NICE clinical guideline 45: Antenatal and postnatal mental health*. *2007*(April), 48.

NICE. (2015). Antenatal and postnatal mental health: clinical management and service guidance. *Essentially MIDIRS*, *6*(1), 14. www.nice.org.uk/guidance/cg192%0Ahttp://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2012910556&site=ehost-live

Nicole, L., Duffett‐Leger, L., Stewart, M., Hegadoren, K., Dennis, C., Rinaldi, C. M., & Stoppard, J. (2007). Canadian mothers’ perceived support needs during postpartum depression. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, *36*(5), 441–449.

Nielsen, D., Videbech, P., Hedegaard, M., Dalby, J., & Secher, N. J. (2000). Postpartum depression: identification of women at risk. *BJOG: An International Journal of Obstetrics & Gynaecology*, *107*(10), 1210–1217.

Nomura, Y., Wickramaratne, P. J., Warner, V., Mufson, L., & Weissman, M. M. (2002). Family discord, parental depression, and psychopathology in offspring: ten-year follow-up. *Journal of the American Academy of Child & Adolescent Psychiatry*, *41*(4), 402–409.

O’Connor, T. G., Bergman, K., Sarkar, P., & Glover, V. (2013). Prenatal cortisol exposure predicts infant cortisol response to acute stress. *Developmental Psychobiology*, *55*(2), 145–155.

O’Hara, M. W. (2009). Postpartum depression: what we know. *Journal of Clinical Psychology*, *65*(12), 1258–1269.

O’Hara, M. W., & McCabe, J. E. (2013). Postpartum Depression: Current Status and Future Directions. *Annual Review of Clinical Psychology*, *9*(1), 379–407. https://doi.org/10.1146/annurev-clinpsy-050212-185612

O’Higgins, M., Roberts, I. S. J., Glover, V., & Taylor, A. (2013). Mother-child bonding at 1 year; associations with symptoms of postnatal depression and bonding in the first few weeks. *Archives of Women’s Mental Health*, *16*(5), 381–389.

Patel, V., Weobong, B., Weiss, H. A., Anand, A., Bhat, B., Katti, B., Dimidjian, S., Araya, R., Hollon, S. D., & King, M. (2017). The Healthy Activity Program (HAP), a lay counsellor-delivered brief psychological treatment for severe depression, in primary care in India: a randomised controlled trial. *The Lancet*, *389*(10065), 176–185.

Paulus, P., Judd, L., Wells, B., & Rapaport, H. (1996). Depressive in a Sample of the General. *Psychiatry: Interpersonal and Biological Processes*, 1411–1417.

Porges, S., & Furman, S. (2011). The Early Development of the Autonomic Nervous System Provides a Neural Platform for Social Behaviour: A Polyvagal Perspective. *Infant and Child Development*, *20*, 106–118. https://doi.org/10.1002/icd

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*(2), 116–143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Prevatt, B. S., Lowder, E. M., & Desmarais, S. L. (2018). Peer-support intervention for postpartum depression: Participant satisfaction and program effectiveness. *Midwifery*, *64*(January), 38–47. https://doi.org/10.1016/j.midw.2018.05.009

Prevention, C. for D. C. and. (2019). *Preventing Adverse Childhood Experiences (ACEs) to improve U.S. health*.

Propper, C., & Moore, G. A. (2006). The influence of parenting on infant emotionality: A multi-level psychobiological perspective. *Developmental Review*, *26*(4), 427–460. https://doi.org/10.1016/j.dr.2006.06.003

Putnam, S. P., Helbig, A. L., Gartstein, M. A., Rothbart, M. K., & Leerkes, E. (2014). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. *Journal of Personality Assessment*, *96*(4), 445–458. https://doi.org/10.1080/00223891.2013.841171

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and Heterotypic Continuity of Fine-grained Temperament during Infancy, Toddlerhood, and Early Childhood. *Infant and Child Development*, *17*(6), 387–405. https://doi.org/10.1002/icd

Rahman, A., Hamdani, S. U., Awan, N. R., Bryant, R. A., Dawson, K. S., Khan, M. F., Azeemi, M. M.-U.-H., Akhtar, P., Nazir, H., & Chiumento, A. (2016). Effect of a multicomponent behavioral intervention in adults impaired by psychological distress in a conflict-affected area of Pakistan: a randomized clinical trial. *Jama*, *316*(24), 2609–2617.

Reay, R., Matthey, S., Ellwood, D., & Scott, M. (2011). Long-term outcomes of participants in a perinatal depression early detection program. *Journal of Affective Disorders*, *129*(1–3), 94–103.

Rodrigues, S. M., LeDoux, J. E., & Sapolsky, R. M. (2009). The influence of stress hormones on fear circuitry. *Annual Review of Neuroscience*, *32*, 289–313.

Rothbart, M. K. (2007). Temperament , Development, and Personality. *Current Directions in Psychological Science*, *16*(4), 207–212.

Sanger, C., Iles, J. E., Andrew, C. S., & Ramchandani, P. G. (2015). Associations between postnatal maternal depression and psychological outcomes in adolescent offspring: a systematic review. *Archives of Women’s Mental Health*, *18*(2), 147–162.

Santoro, K., & Peabody, H. (2010). Identifying and Treating Maternal Depression : Strategies & Considerations for Health Plans. *Washington, DC: National Institute of Health Care Management*, 1–28.

Seeley, W. W., Menon, V., Schatzberg, A. F., Keller, J., Glover, G. H., Kenna, H., Reiss, A. L., & Greicius, M. D. (2007). Dissociable intrinsic connectivity networks for salience processing and executive control. *Journal of Neuroscience*, *27*(9), 2349–2356.

Segre, L. S., O’Hara, M. W., Arndt, S., & Beck, C. T. (2010). Nursing care for postpartum depression, part 1: do nurses think they should offer both screening and counseling? *MCN: The American Journal of Maternal/Child Nursing*, *35*(4), 220–225.

Shadrina, M., Bondarenko, E. A., & Slominsky, P. A. (2018). Genetics factors in major depression disease. *Frontiers in Psychiatry*, *9*(JUL), 1–18. https://doi.org/10.3389/fpsyt.2018.00334

Sikander, S., Ahmad, I., Atif, N., Zaidi, A., Vanobberghen, F., Weiss, H. A., Nisar, A., Tabana, H., Ain, Q. U., & Bibi, A. (2019). Delivering the Thinking Healthy Programme for perinatal depression through volunteer peers: a cluster randomised controlled trial in Pakistan. *The Lancet Psychiatry*, *6*(2), 128–139.

Sikander, S., Lazarus, A., Bangash, O., Fuhr, D. C., Weobong, B., Krishna, R. N., Ahmad, I., Weiss, H. A., Price, L. S., Rahman, A., & Patel, V. (2015). The effectiveness and cost-effectiveness of the peer-delivered Thinking Healthy Programme for perinatal depression in Pakistan and India: The SHARE study protocol for randomised controlled trials. *Trials*, *16*(1), 1–14. https://doi.org/10.1186/s13063-015-1063-9

Singla, D., Lazarus, A., Atif, N., Sikander, S., Bhatia, U., Ahmad, I., Nisar, A., Khan, S., Fuhr, D., Patel, V., & Rahman, A. (2014). “Someone like us”: Delivering maternal mental health through peers in two South Asian contexts. *Journal of Affective Disorders*, *168*, 452–458. https://doi.org/10.1016/j.jad.2014.07.017

Singla, D., Lemberg-Pelly, S., Lawson, A., Zahedi, N., Thomas-Jacques, T., & Dennis, C. L. (2020). Implementing psychological interventions through nonspecialist providers and telemedicine in high-income countries: Qualitative study from a multistakeholder perspective. *JMIR Mental Health*, *7*(8). https://doi.org/10.2196/19271

Singla, D. R., Kohrt, B. A., Murray, L. K., Anand, A., Chorpita, B. F., Patel, V., Network, H., Carolina, N., Angeles, L., & Medicine, S. (2017). Psychological Treatment for the World: Lessons from LMIC. *Annual Review of Clinical Psychology*, *49*, 149–181. https://doi.org/10.1146/annurev-clinpsy-032816-045217.Psychological

Slomian, J., Honvo, G., Emonts, P., Reginster, J. Y., & Bruyère, O. (2019). Consequences of maternal postpartum depression: A systematic review of maternal and infant outcomes. In *Women’s Health* (Vol. 15). https://doi.org/10.1177/1745506519844044

Sockol, L. E. (2015). A systematic review of the efficacy of cognitive behavioral therapy for treating and preventing perinatal depression. *Journal of Affective Disorders*, *177*, 7–21. https://doi.org/10.1016/j.jad.2015.01.052

Sockol, L. E. (2018). A systematic review and meta-analysis of interpersonal psychotherapy for perinatal women. *Journal of Affective Disorders*, *232*(February), 316–328. https://doi.org/10.1016/j.jad.2018.01.018

Thayer, J. F., & Brosschot, J. F. (2005). Psychosomatics and psychopathology: Looking up and down from the brain. *Psychoneuroendocrinology*, *30*(10), 1050–1058. https://doi.org/10.1016/j.psyneuen.2005.04.014

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, *37*(2), 141–153. https://doi.org/10.1007/s12160-009-9101-z

Thomas, L. J., Scharp, K. M., & Paxman, C. G. (2014). Stories of Postpartum Depression: Exploring Health Constructs and Help-Seeking in Mothers’ Talk. *Women and Health*, *54*(4), 373–387. https://doi.org/10.1080/03630242.2014.896442

Thompson, R. A. (1994). Emotion Regulation: A Theme in Search of Definition. In *Monographs of the Society for Research in Child Development* (Vol. 59, Issue 2/3, p. 25). https://doi.org/10.2307/1166137

Tronick, E., & Beeghly, M. (2011). Infants’ meaning-making and the development of mental health problems. *American Psychologist*, *66*(2), 107–119. https://doi.org/10.1037/a0021631

Van den Bergh, B. R. H. (2011). Developmental programming of early brain and behaviour development and mental health: a conceptual framework. *Developmental Medicine & Child Neurology*, *53*, 19–23.

Van Lieshout, R. J., Layton, H., Feller, A., Ferro, M. A., Biscaro, A., & Bieling, P. J. (2020). Public health nurse delivered group cognitive behavioral therapy (CBT) for postpartum depression: A pilot study. *Public Health Nursing*, *37*(1), 50–55. https://doi.org/10.1111/phn.12664

Van Lieshout, R. J., Layton, H., Savoy, C. D., Haber, E., Feller, A., Biscaro, A., Bieling, P. J., & Ferro, M. A. (2022). Public Health Nurse-delivered Group Cognitive Behavioural Therapy for Postpartum Depression: A Randomized Controlled Trial. *Canadian Journal of Psychiatry*, *67*(6), 432–440. https://doi.org/10.1177/07067437221074426

Weiss, M. J. S., & Wagner, S. H. (1998). Discussion. *American Journal of Preventive Medicine*, *14*(4), 356–360. https://doi.org/10.1016/s0749-3797(98)00011-7

Weissman, M. M., Wickramaratne, P., Nomura, Y., Warner, V., Daniel Pilowsky, M., & Helen Verdeli, M. (2006). Offspring of Depressed Parents: 20 Years Later. In *Am J Psychiatry* (Vol. 163, Issue 6).

Weissman, M. M., Wickramaratne, P., Nomura, Y., Warner, V., Verdeli, H., Pilowsky, D. J., Grillon, C., & Bruder, G. (2005). *Families at High and Low Risk for Depression A 3-Generation Study*.

Wisner, K. L., Parry, B. L., & Piontek, C. M. (2002). Postpartum depression. *New England Journal of Medicine*, *347*(3), 194–199.

Woolhouse, H., Gartland, D., Mensah, F., & Brown, S. J. (2015). Maternal depression from early pregnancy to 4 years postpartum in a prospective pregnancy cohort study: implications for primary health care. *BJOG: An International Journal of Obstetrics & Gynaecology*, *122*(3), 312–321.

**Chapter 2**

**Study 1**: Peer-Delivered Cognitive Behavioural Therapy for Postpartum Depression: A Randomized Controlled Trial

**Authors**: Bahar Amani, Donya Merza, Calan Savoy, David Streiner, Peter Bieling, Mark A. Ferro, Ryan J. Van Lieshout

**Context and Implications:** As discussed in Chapter 1, maternal Postpartum depression (PPD) has harmful effects for mothers and their infants. Yet, the healthcare system is unable to provide those with PPD with timely, accessible, evidence-based treatments. As a result, this study sought to determine if a task-shifted intervention, peer-delivered group Cognitive Behavioural Therapy (CBT) is effective in treating those with PPD.

Our findings that a peer-delivered intervention effectively treated symptoms of PPD, anxiety, and may have led to improvements in mother-infant interactions, are promising. Task-shifting the treatment of PPD may be an effective solution to the limitations of existing healthcare systems and may ensure that more women are able to access the treatment they need.

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**Abstract**

**Objective**: To determine if a 9-week group cognitive-behavioural therapy (CBT) intervention delivered by women who have recovered from postpartum depression (peers) can effectively reduce symptoms of postpartum depression (PPD) and anxiety and improve social support and the mother-infant relationship.

**Methods**: A sample of 73 mothers living in Ontario, Canada, were randomized into experimental and waitlist control groups between March 2018 and February 2020. Participants were ≥ 18 years of age, had an infant < 12 months old, were fluent in English, and scored ≥ 10 on the Edinburgh Postnatal Depression Scale. The experimental group completed the 9-week group CBT intervention immediately after study enrollment, while the control group did so after a 9-week waiting period. All outcomes were assessed at enrollment (n = 54) and 9 weeks later (n = 38). Outcomes were assessed in the experimental group at 6 months to assess treatment stability.

**Results**: Peer-delivered group CBT for PPD led to clinically and statistically significant improvements in symptoms of depression (F1,47 = 22.52, P < .01) and anxiety (F1,45 = 20.56, P < .05) in the experimental group, and these improvements were stable at the 6-month follow-up. Perceptions of impaired mother-infant bonding (t15 = 3.72, P < .01) and rejection and pathological anger (t15 = 3.01, P < .01) also decreased at the 6-month follow-up in the experimental group.

**Conclusions**: Peer-delivered group CBT for PPD effectively treats symptoms of PPD and anxiety and may lead to improvements in the mother-infant relationship. This intervention is an effective and potentially scalable means by which access to a treatment that meets the needs and wants of mothers with PPD can be increased.

**Clinical Trials Registration:** ClinicalTrials.gov Identifier: NCT03285139

**Introduction**

Postpartum depression (PPD) affects up to 1 in 5 mothers and can have profound effects on them and their families (Gluckman et al., 2010; Heim & Binder, 2012). Even though PPD increases the risk of future depressive episodes, parenting problems, and emotional, behavioural, and cognitive difficulties in offspring (Barry et al., 2015; Burke, 2003; Judd et al., 1996; Lovejoy et al., 2000; Murray et al., 2015; O’Hara & McCabe, 2013), just 15% of mothers with PPD receive evidence-based care (Cox et al., 2016; Kingston et al., 2015). Although primary health care providers routinely see women in the puerperium, they often lack the time and expertise to provide the treatment most women prefer: psychotherapy (Goodman, 2009; O’Mahen & Flynn, 2008; Simhi et al., 2019).

Barriers to the receipt of evidence-based care include mothers’ reluctance to disclose symptoms for fear of being misunderstood or judged (O’Mahen & Flynn, 2008), lengthy waitlists for specialized psychiatric services (Bina, 2020; Boyd et al., 2011; Edge & MacKian, 2010), the high costs of private psychotherapy (Bina, 2020; Singla et al., 2020), and a lack of compliance with more accessible options like computerized psychotherapy (Carlbring et al., 2018; Gilbody et al., 2015).

Peer-administered interventions (PAIs), those delivered by former sufferers, are increasingly recognized as alternatives to traditional mental health services and can overcome some barriers to PPD treatment (Bryan & Arkowitz, 2015; Dennis & Chung-Lee, 2006; Goodman, 2009; Newman et al., 2019). They capitalize on the number of women who have experienced PPD and the fact that levels of therapist training may not predict psychotherapy effectiveness (Bickman, 1999; Dennis et al., 2017). Studies that have examined the impact of PAIs for depression among the general population suggest that they have the most impact if they are structured and use evidence-based interventions (e.g., Cognitive Behavioural Therapy (CBT); Bryan & Arkowitz, 2015).

Women who have recovered from PPD are an approachable and empathic source of support and experiential knowledge (Mead et al., 2001; Montgomery et al., 2012; Resnick & Rosenheck, 2008; Solomon, 2004). If trained to deliver structured evidence-based psychotherapies, peers could improve treatment access and uptake (Bryan & Arkowitz, 2015), reduce stigma (Dennis & Chung-Lee, 2006; Holopainen, 2002), and broaden social networks (Prevatt et al., 2018). Participation in group-based interventions during the perinatal period can be particularly helpful as they foster feelings of support and connectedness and can lead to reductions in PPD symptoms (Klier et al., 2001; Pessagno & Hunker, 2013).

Studies of peer-based interventions for PPD have been undertaken, but these are not widely used clinically. Unstructured, individual, telephone-based peer support reduced PPD symptoms in one study (Letourneau et al., 2015), while another trial of one-on-one peer support in home visits (Letourneau et al., 2011) did not. A recent trial of a psychosocial intervention delivered in pregnancy by community-dwelling women in rural India led to no differences in depression symptom severity between intervention and control groups (Fuhr et al., 2019). The same intervention was used in a randomized controlled trial (RCT) in rural Pakistan, where it led to modest improvements in PPD symptoms that did not persist 6 months later (Sikander et al., 2019). In both studies, women were from the community, but had not necessarily experienced PPD.

The primary objective of the present study was to determine if a 9-week group CBT intervention delivered by women who had previously recovered from PPD can effectively reduce PPD in current sufferers. Secondary objectives included examining its impact on maternal anxiety, social support, and the mother-infant relationship.

**Methods**

**Trial Design**

Mothers living in the city of Brantford, Ontario, Canada, and outlying areas were recruited between March 2018 and February 2020 into this one-site RCT with experimental and waitlist control groups. This study took place between March 2018 and February 2020 (ClinicalTrials.gov identifier: NCT03285139). Participants were randomized in a 1:1 ratio to receive the 9-week intervention at enrollment (experimental group) or 9 weeks later (waitlist control group). Mothers in both groups could receive usual care (e.g., medication, psychotherapy) during the study. No changes to study methods were made after study commencement. It received ethical approval from the Hamilton Integrated Research Ethics Board, and all participants provided informed consent.

Data were collected at study enrollment (T1), 9 weeks post-randomization (T2), and 6 months later (T3). Data were collected electronically using REDCap (Harris et al., 2009, 2019).

**Participants**

Women were recruited via online advertising (ie, Facebook), our community partner, local health care providers, or self-referral. Participants were ≥ 18 years old, had an infant < 12 months of age, were fluent in English, and had an Edinburgh Postnatal Depression Scale (EPDS) score ≥ 10 (Cox & Sagovsky, 1987). They had to be free of bipolar, psychotic, or current substance use disorders per the Mini-International Neuropsychiatric Interview (MINI; Sheehan, Lecrubier, Janavs, Knapp, 1998). Eligibility was determined by EPDS cutoff to optimize uptake and maximize generalizability since up to 30% of mothers have these levels of symptoms (Meaney, 2018).

**Intervention**

The 9-week peer-delivered intervention was based on a previously developed and validated program (Van Lieshout et al., 2020; Van Lieshout, Yang, Haber, 2017). Weekly 2-hour sessions were delivered by 2 peer facilitators. The first half of each session involved instruction and practice of core CBT skills, followed by 1 hour of unstructured discussion on topics relevant to those with PPD (e.g., sleep, supports; Sheehan, Lecrubier, Janavs, Knapp, 1998). Core cognitive skills (e.g., cognitive restructuring) are introduced and practiced from week 1. Behavioural techniques (behavioural activation, relaxation, goal-setting) are introduced in week 2 and continue throughout. The 9-week intervention was administered at a centrally located community center to maximize accessibility.

Peer facilitator recruitment/training. Peer facilitators had recovered from PPD and were identified via responses to social media advertising (ie, Facebook). Ten peers were selected after completing a written application and telephone interview and having depression/anxiety levels below clinical cut-offs (Beck Depression Inventory-II score < 1744 and 7-item Generalized Anxiety Disorder scale [GAD-7] score < 10; (Spitzer et al., 2006)) at recruitment.

Their training included 2 days of in-classroom instruction, participation in a 9-week observership of the CBT intervention delivered by 2 experienced therapists in a hospital setting (followed by a 1-hour discussion post-session), and the delivery of the intervention in pairs. An experienced therapist listened to session recordings and provided 1 hour of supervision to peer facilitators weekly.

**Outcome Measures**

Participants’ sociodemographic characteristics (e.g., age, household income) and clinical data were self-reported. Participants provided data on our primary outcome (PPD) and the secondary outcomes anxiety (GAD-7), social support (Social Provisions Scale; SPS), and mother-infant relationship (Postpartum Bonding Questionnaire; PBQ) at T1 and T2. The experimental group provided data on these measures 6 months after study initiation (T3) to assess treatment stability. After completing the intervention (T2), participants also completed the Scale to Assess the Therapeutic Relationship-Patient (STAR-P; McGuire-Snieckus et al., 2007).This 12-item measure assesses the nature of the therapeutic relationship between participants and peers using 3 subscales: positive collaboration, positive clinician input, and non-supportive clinician input.

Our primary outcome (PPD) was assessed using the EPDS, a 10-item self-report scale. A score ≥ 10 is indicative of possible depression (Cox & Sagovsky, 1987). The MINI was also administered to examine change in current major depressive disorder (MDD) diagnosis from T1 to T2.

Secondary outcomes included anxiety, which was assessed using the GAD-7 (Spitzer et al., 2006), a commonly used 7-item self-report scale measuring symptoms of generalized anxiety disorder, the most frequent comorbidity of PPD. Social support was measured with the SPS, a 24-item self-report measure of the degree to which the social relationships within an individual’s life provide support (Weiss, 1974). Feelings of low support and social isolation are common with PPD, and group-based interventions are potentially beneficial in the perinatal period because they increase social support and feelings of connectedness (Milgrom et al., 2005).

Mother-infant relationship quality was measured using the PBQ (Brockington, Fraser, 2006), a 25‐item measure of disorders of the mother‐infant relationship. It includes 4 subscales: impaired bonding, rejection and pathological anger, infant‐focused anxiety, and incipient abuse. Problems with mother-infant relationship quality are harmful potential consequences of PPD, but since some studies suggest that psychotherapy can improve mother-infant relationship quality (Cooper et al., 2003), it was assessed in this study.

**Sample Size and Statistical Analysis**

An a priori power analysis suggested that a sample of 74 women was adequate to detect a group-by-time interaction effect of medium effect size between treatment groups based on a type I error of 0.05 and 80% power (Bryan & Arkowitz, 2015; Huang et al., 2020; Van Lieshout et al., 2020). Data analyses were conducted using SPSS version 26 (Lachin, 2000). T-tests and χ2 tests compared baseline sociodemographic and clinical characteristics between groups. We also examined predictors of loss to follow-up.

Outcome data were analyzed on an intention-to-treat basis in which all follow-up data were analyzed according to participants’ randomization. Linear mixed effects models (LMMs) with restricted maximum likelihood estimation were used to examine the effect of the intervention. Data were structured as a 2-level hierarchy in which outcomes at T1 and T2 were nested within participants to examine the effect of the intervention between groups and over time. Group assignment was included as a fixed effect predictor to account for participants’ being nested within CBT groups. Logistic regression assessed whether randomization increased the odds of (1) a clinically meaningful change from T1 to T2 in EPDS scores (≥ 4 points; (Matthey, 2004) )and (2) remission of current MDD at T2 among participants with MDD at T1. Finally, the Matthey Reliable Change Index (RCI) criteria for the EPDS were also used to classify T1 to T2 score change into 4 categories: (1) “recovered”: EPDS score decreased by ≥ 4 points and was < 10, (2) “improved (but not fully recovered)”: EPDS score decreased by ≥ 4 points but had scores ≥ 10, (3) “deteriorated”: EPDS score increased by ≥ 4 points, and (4) “unchanged”: EPDS score decreased by < 3 points.

Treatment stability. To examine whether the effects of the intervention were stable in the experimental group, paired-samples t-tests were conducted to compare means at T2 and T3 within the experimental group. The Pearson r was also used to define intervention effect stability.

**Results**

Of 105 women screened, 73 met eligibility criteria and were randomized between March 2018 and February 2020 (Figure 1). Thirty-seven were randomized to the experimental group and 36 to the control group. The onset of COVID-19 prevented us from recruiting our target sample of 74 participants. Fifty-four participants (74%) provided data at T1, 38 (52%) at T2, and 17 experimental group participants provided data at T3.

Baseline demographic characteristics did not significantly differ between groups (Table 1). Table 2 includes outcome means and effect sizes. At T1, the mean (SD) experimental group EPDS score was 16.0 (3.7), and 70.4% of participants (19/27) had current MDD. In the control group, the mean (SD) EPDS score was 16.8 (4.0), and 65.4% of participants (17/26) had current MDD. Generalized anxiety disorder (GAD; 58.3% [21/36]), panic disorder (38.9% [14/36]), and obsessive-compulsive disorder (27.8% [10/36]) were the most common comorbidities across groups. Of those without current MDD, the most common diagnoses were panic disorder (47.1% [8/17]) and GAD (29.4% [5/17]). At T1, 88.9% of participants (48/54) reported lifetime MDD. From T1 to T2, there were no changes in the number of mental health care visits and in psychotropic medication use in the experimental and control groups.

Peer facilitators were between 20 and 57 years old at recruitment and held a wide range of occupations (e.g., administrative assistant, early childhood educator). Three had prior work experience in health care.

Diagram

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Table

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There were no differences in baseline characteristics of participants who provided data at T1 and T2, and those lost to follow-up. Eighty-four percent of participants (38/45) attended 5 or more of their 9 weekly sessions. Ten groups were delivered with a mean of 5 participants assigned to each group.

There was a significant group-by-time interaction for change in EPDS scores between T1 and T2 (F1,44.22 = 13.74, p < .01). We analyzed results separately by treatment group and found the main effect of time on EPDS scores was significant (F1,47 = 22.52, p < .01), and mean scores decreased by 5.4 after treatment in the experimental group. From T1 to T2, participants in the experimental group were 32 times more likely to experience a clinically significant improvement in EPDS scores (≥ 4 points) than control participants (OR = 32.14; 95% CI, 3.51 to 294.22). Those in the experimental group also had 9 times the odds of no longer meet diagnostic criteria for current MDD at T2 relative to control participants (OR = 9.00; 95% CI, 1.14 to 71.04). Table

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Using the Matthey RCI criteria, 40.9% of experimental participants (9/22) were classified as recovered, 54.5% (12/22) as improved, and 4.5% (1/22) as deteriorated at T2. Among the control group, 6.3% of the participants (1/16) were classified as recovered, 31.3% of participants (5/16) as improved, 25.0% (4/16) as deteriorated, and 37.5% (6/16) as unchanged. These proportions differed between groups (χ23 = 14.8, p < .01).

Paired-samples t-tests suggested that EPDS scores were not statistically significantly different from T2 (mean [SD] = 11.1 [4.4]) to T3 (10.6 [6.1]) in the experimental group (t15 = 0.48, p= .64). The Pearson correlation also showed that stability from T2 to T3 was high (r = 0.81, p < .01).

A statistically significant group-by-time interaction predicted GAD-7 scores between T1 and T2 (F1,38.85 = 20.77, p < .01). In the experimental group, the main effect of time on GAD-7 scores was also statistically significant (F1,45 = 20.56, p < .01), such that participants improved over time with mean scores decreasing by approximately 5.5 points at T2. A paired-samples t test showed that GAD-7 scores were not significantly different from T2 (mean [SD] = 7.56 [4.27], n = 16) to T3 (8.13 [4.87]) in the experimental group (t15 = 0.82, p = .42). Pearson correlation determined that stability from T2 to T3 was also high (r = 0.83, p < .01), suggesting that intervention effects were stable for anxiety as well.

There was no statistically significant group-by-time interaction to predict social support from T1 to T2, and SPS scores were not different from T2 to T3 in the experimental group. There were also no statistically significant group-by-time interactions predicting mother-infant relationship outcomes for any PBQ subscale from T1 to T2. However, scores on the impaired bonding subscale changed from T2 (mean [SD] = 10.81 [3.49], n =16) to T3 (6.69 [4.06]) in the experimental group (t15 = 3.72, p ≤ .01), as did scores on the rejection and pathological anger subscale (T2 (6.38 [2.66], n = 16), T3 (3.69 [3.32]; t15 = 3.01,p ≤ .01).

STAR-P results also highlighted that participants experienced a high level of positive collaboration with their peer facilitators, (mean [SD] = 21.47 [2.92], total score = 24, n = 17), positive peer facilitator input (10.35 [2.03], total score = 12), and low levels of non-supportive peer facilitator input (11.24 [1.35], total score = 12).

**Discussion**

The findings of this study suggest that peers can deliver effective group CBT to women currently struggling with PPD to produce statistically and clinically significant improvements in symptoms of depression and anxiety, effects that were stable up to 6 months. Nearly 95% of women in the experimental group reported recovery or improvement in PPD post-intervention. The intervention did not impact mothers’ perceptions of social support. This lack of impact may be because CBT does not target social support directly (as interpersonal therapy [IPT] does). Peer-delivered group CBT for PPD did not affect the mother-infant relationship immediately post-treatment, but improvements were observed at 6-month follow-up, suggesting that the effects of treatment on this outcome may take more time to manifest.

The magnitude of treatment effect on PPD symptoms in the present study is similar to those found in previous treatment trials of IPT (Sockol, 2018) and CBT (Sockol, 2015) delivered by professionals. The effect of the current intervention may be larger than those for prior peer-delivered treatments for PPD (Huang et al., 2020) because it is based on an evidence-based treatment (Bryan & Arkowitz, 2015) and delivered in a group (Harris et al., 2009; Letourneau et al., 2011, 2015; Sikander et al., 2019). Not only does group therapy tend to be more cost-effective, it also has the added benefit of building networks of support, reducing stigma and shame. The strengths of the peer intervention are further highlighted by STAR-P results suggesting that participants experienced a mutual openness and trust with their facilitators and felt encouraged and listened to and that peer facilitators could empathize with them.

Peer-delivered group CBT also reduced symptoms of anxiety. Despite anxiety’s being the most common comorbidity of PPD (Taylor & Johnson, 2013), relatively little research has focused on its treatment in the perinatal period (Dennis et al., 2009; Fawcett et al., 2019) particularly in the context of PPD. The observed effects may be due to the fact that CBT is also an effective treatment for anxiety (Beck, 1993).

We also found that intervention effects on depression and anxiety were stable up to 6 months post-randomization. Our use of a validated CBT protocol, participants’ ability to access other treatments, and peer delivery could have contributed to the stability of our findings. Our results are consistent with those from studies of group psychotherapy for PPD delivered by professionals that found a continuation of treatment effects long-term (Klier et al., 2001; Pessagno & Hunker, 2013).

Despite this study’s strengths, its limitations should be noted. Although we had sufficient statistical power to detect meaningful changes, our sample was relatively small. In keeping with the geographic region from which we recruited participants, there was little ethnic diversity, which could affect the generalizability of the results. That said, the sociodemographic characteristics of our sample were similar to those of other RCTs of PPD treatment conducted in higher-income countries (Milgrom et al., 2005; O’Mahen et al., 2013; Wozney et al., 2017). Our study took place in Canada, where health care is universally available, which could limit the applicability of our findings to other countries. Participants in our study were permitted to access other mental health care resources, which could have influenced the observed findings. This study also encountered substantial loss to follow-up between study timepoints. However, our attrition rates were similar to those reported in other RCTs of treatments for PPD (Huang et al., 2020; Lachin, 2000; Matthey, 2004). Additionally, the use of a waitlist control group (rather than placebo control) may have led to larger effects than had a different control group been used (Gold et al., 2017). A waitlist control group was selected because placebo-controlled trials tend to be avoided in new mothers for ethical reasons, and evidence suggests that PPD is not characterized by a significant worsening of symptoms over 3 months (Beeghly et al., 2002; Goodman, 2004).

Another limitation is that we did not measure peer leaders’ adherence to the CBT intervention delivery. Although our results suggest women benefited from the intervention, we did not assess the impact of fidelity to the CBT model on these outcomes. Lastly, we were unable to assess whether there were differential treatment effects based on peer facilitators, as individual peers were randomly assigned to deliver each group. Moreover, while peers were effective in reducing symptoms of PPD, it is not known if peer facilitators need to have experienced PPD to deliver the intervention effectively. For example, it is not clear that women who have suffered from depression at other points in their lives would have been more or less effective.

Future studies should examine the effectiveness of peer-delivered group CBT for PPD in larger trials and in settings where universal health care may not be available. They should also assess cost-effectiveness and attempt to determine if peers can deliver effective group CBT for PPD in the absence of psychotherapy supervision. Given the impact of COVID-19 on treatment availability coupled with the challenges of accessing treatment in rural communities, the effectiveness of online delivery could also be investigated. If successful, virtual interventions could reduce further barriers to treatment and increase access to care.

Despite the substantial burden of PPD on women, children, and their families, the health care system currently struggles to address the treatment needs and preferences of many mothers. Peer-delivered group CBT for PPD has the potential to address these gaps, reducing waitlists and impacts on specialized psychiatric services. Not only does this intervention target the many barriers to PPD treatment, it also was designed with the needs and preferences of mothers in mind. This intervention therefore represents a special opportunity to foster a sense of community among women with PPD, with which feelings of isolation and stigma are common. Peer-delivered group CBT may be an effective and scalable means of addressing the limitations of existing health care systems to address PPD and has the potential to reach women who would otherwise not receive treatment, significantly improving outcomes for them, their families, and society.

**References**

Barry, T. J., Murray, L., Fearon, R. M. P., Moutsiana, C., Cooper, P., Goodyer, I. M., Herbert, J., & Halligan, S. L. (2015). Maternal postnatal depression predicts altered offspring biological stress reactivity in adulthood. *Psychoneuroendocrinology*, *52*, 251–260. https://doi.org/10.1016/j.psyneuen.2014.12.003

Beck, A. T. (1993). *Cognitive Therapy Past, Present, & Future.pdf* (pp. 194–198).

Beeghly, M., Weinberg, M. K., Olson, K. L., Kernan, H., Riley, J., & Tronick, E. Z. (2002). Stability and change in level of maternal depressive symptomatology during the first postpartum year. *Journal of Affective Disorders*, *71*(1–3), 169–180. https://doi.org/10.1016/S0165-0327(01)00409-8

Bickman, L. (1999). Practice Makes Perfect and Other Myths about Mental Health Services. *American Psychologist*, *54*(11), 965–978. https://doi.org/10.1037/h0088206

Bina, R. (2020). Predictors of postpartum depression service use: A theory-informed, integrative systematic review. *Women and Birth*, *33*(1), e24–e32. https://doi.org/10.1016/j.wombi.2019.01.006

Boyd, R. C., Mogul, M., Newman, D., & Coyne, J. C. (2011). Screening and referral for postpartum depression among low-income women: A qualitative perspective from community health workers. *Depression Research and Treatment*, *2011*. https://doi.org/10.1155/2011/320605

Brockington IF, Fraser C, W. D. (2006). The Postpartum Bonding Questionnaire: A validation. *Arch Womens Ment Health.*, *9*(5), 233–242.

Bryan, A. E. B., & Arkowitz, H. (2015). Meta-Analysis of the Effects of Peer-Administered Psychosocial Interventions on Symptoms of Depression. *American Journal of Community Psychology*, *55*(3–4), 455–471. https://doi.org/10.1007/s10464-015-9718-y

Burke, L. (2003). The impact of maternal depression on familial relationships. *International Review of Psychiatry*, *15*(3), 243–255. https://doi.org/10.1080/0954026031000136866

Carlbring, P., Andersson, G., Cuijpers, P., Riper, H., & Hedman-Lagerlöf, E. (2018). Internet-based vs. face-to-face cognitive behavior therapy for psychiatric and somatic disorders: an updated systematic review and meta-analysis. *Cognitive Behaviour Therapy*, *47*(1), 1–18. https://doi.org/10.1080/16506073.2017.1401115

Cooper, P. J., Murray, L., Wilson, A., & Romaniuk, H. (2003). Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. I. Impact on maternal mood. *British Journal of Psychiatry*, *182*(MAY), 412–419. https://doi.org/10.1192/bjp.182.5.412

Cox, E. Q., Sowa, N. A., Meltzer-Brody, S. E., & Gaynes, B. N. (2016). The perinatal depression treatment cascade: Baby steps toward improving outcomes. *Journal of Clinical Psychiatry*, *77*(9), 1189–1200. https://doi.org/10.4088/JCP.15r10174

Cox, J. L., & Sagovsky, J. M. H. R. (1987). *Detection of Postnatal Depression Development of the 10-item Edinburgh Postnatal Depression Scale*. 782–786.

Dennis, C.-L., & Chung-Lee, L. (2006). Postpartum Depression Help-Seeking Barriers and Maternal Treatment Preferences: A Qualitative Systematic Review. *Birth*, *33*(4), 323–331. https://doi.org/10.1111/j.1523-536X.2006.00130.x

Dennis, C. L., Hodnett, E., Kenton, L., Weston, J., Zupancic, J., Stewart, D. E., & Kiss, A. (2009). Effect of peer support on prevention of postnatal depression among high risk women: Multisite randomised controlled trial. *BMJ (Online)*, *338*(7689), 280–283. https://doi.org/10.1136/bmj.a3064

Dennis, Cindy Lee, Falah-Hassani, K., & Shiri, R. (2017). Prevalence of antenatal and postnatal anxiety: Systematic review and meta-analysis. *British Journal of Psychiatry*, *210*(5), 315–323. https://doi.org/10.1192/bjp.bp.116.187179

Edge, D., & MacKian, S. C. (2010). Ethnicity and mental health encounters in primary care: help-seeking and help-giving for perinatal depression among Black Caribbean women in the UK. *Ethnicity & Health*, *15*(1), 93–111. https://doi.org/10.1080/13557850903418836

Fawcett, E. J., Fairbrother, N., Cox, M. L., White, I. R., & Fawcett, J. M. (2019). The prevalence of anxiety disorders during pregnancy and the postpartum period: A multivariate Bayesian meta-analysis. *Journal of Clinical Psychiatry*, *80*(4). https://doi.org/10.4088/JCP.18r12527

Fuhr, D. C., Weobong, B., Lazarus, A., Vanobberghen, F., Weiss, H. A., Singla, D. R., Tabana, H., Afonso, E., De Sa, A., D’Souza, E., Joshi, A., Korgaonkar, P., Krishna, R., Price, L. S. N., Rahman, A., & Patel, V. (2019). Delivering the Thinking Healthy Programme for perinatal depression through peers: an individually randomised controlled trial in India. *The Lancet Psychiatry*, *6*(2), 115–127. https://doi.org/10.1016/S2215-0366(18)30466-8

Gilbody, S., Littlewood, E., Hewitt, C., Brierley, G., Tharmanathan, P., Araya, R., Barkham, M., Bower, P., Cooper, C., Gask, L., Kessler, D., Lester, H., Lovell, K., Parry, G., Richards, D. A., Andersen, P., Brabyn, S., Knowles, S., Shepherd, C., … White, D. (2015). Computerised cognitive behaviour therapy (cCBT) as treatment for depression in primary care (REEACT trial): Large scale pragmatic randomised controlled trial. *The BMJ*, *351*, 1–13. https://doi.org/10.1136/bmj.h5627

Gluckman, P. D., Hanson, M. A., & Buklijas, T. (2010). A conceptual framework for the developmental origins of health and disease. *Journal of Developmental Origins of Health and Disease*, *1*(1), 6–18. https://doi.org/10.1017/S2040174409990171

Gold, S. M., Enck, P., Hasselmann, H., Friede, T., Hegerl, U., Mohr, D. C., & Otte, C. (2017). Control conditions for randomised trials of behavioural interventions in psychiatry: a decision framework. *The Lancet Psychiatry*, *4*(9), 725–732. https://doi.org/10.1016/S2215-0366(17)30153-0

Goodman, J. H. (2004). Postpartum depression beyond the early postpartum period. *JOGNN - Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *33*(4), 410–420. https://doi.org/10.1177/0884217504266915

Goodman, J. H. (2009). Women’s Attitudes, Preferences, and Perceived Barriers to Treatment for Perinatal Depression. *Birth*, *36*(1), 60–69. https://doi.org/10.1111/j.1523-536X.2008.00296.x

Harris, P. A., Taylor, R., Minor, B. L., Elliott, V., Fernandez, M., O’Neal, L., McLeod, L., Delacqua, G., Delacqua, F., & Kirby, J. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics*, *95*, 103208.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010

Heim, C., & Binder, E. B. (2012). Current research trends in early life stress and depression: Review of human studies on sensitive periods, gene-environment interactions, and epigenetics. *Experimental Neurology*, *233*(1), 102–111. https://doi.org/10.1016/j.expneurol.2011.10.032

Holopainen, D. (2002). The experience of seeking help for postnatal depression. *Australian Journal of Advanced Nursing, The*, *19*(3), 39-44.

Huang, R., Yan, C., Tian, Y., Lei, B., Yang, D., Liu, D., & Lei, J. (2020). Effectiveness of peer support intervention on perinatal depression: A systematic review and meta-analysis. *Journal of Affective Disorders*, *276*(June), 788–796. https://doi.org/10.1016/j.jad.2020.06.048

Judd, L. L., Paulus, M. P., Wells, K. B., & Rapaport, M. (1996). Socioeconomic burden of subsyndromal depressive symptoms and major depression in a sample of the general population. *American Journal of Psychiatry*, 1411–1417.

Kingston, D., Austin, M. P., Heaman, M., McDonald, S., Lasiuk, G., Sword, W., Giallo, R., Hegadoren, K., Vermeyden, L., Van Zanten, S. V., Kingston, J., Jarema, K., & Biringer, A. (2015). Barriers and facilitators of mental health screening in pregnancy. *Journal of Affective Disorders*, *186*, 350–357. https://doi.org/10.1016/j.jad.2015.06.029

Klier, C. M., Muzik, M., Rosenblum, K. L., & Lenz, G. (2001). Interpersonal psychotherapy adapted for the group setting in the treatment of postpartum depression. *Journal of Psychotherapy Practice and Research*, *10*(2), 124–131.

Lachin, J. M. (2000). Statistical considerations in the intent-to-treat principle. *Controlled Clinical Trials*, *21*(3), 167–189. https://doi.org/10.1016/S0197-2456(00)00046-5

Letourneau, N., Secco, L., Colpitts, J., Aldous, S., Stewart, M., & Dennis, C. L. (2015). Quasi-experimental evaluation of a telephone-based peer support intervention for maternal depression. *Journal of Advanced Nursing*, *71*(7), 1587–1599. https://doi.org/10.1111/jan.12622

Letourneau, N., Stewart, M., Dennis, C.-L., Hegadoren, K., Duffett-Leger, L., & Watson, B. (2011). Effect of home-based peer support on maternal-infant interactions among women with postpartum depression: A randomized, controlled trial. *INTERNATIONAL JOURNAL OF MENTAL HEALTH NURSING*, *20*(5), 345–357. https://doi.org/10.1111/j.1447-0349.2010.00736.x

Lovejoy, M. C., Graczyk, P. A., O’Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior. *Clinical Psychology Review*, *20*(5), 561–592. https://doi.org/10.1016/S0272-7358(98)00100-7

Matthey, S. (2004). Calculating clinically significant change in postnatal depression studies using the Edinburgh Postnatal Depression Scale. *Journal of Affective Disorders*, *78*(3), 269–272. https://doi.org/10.1016/S0165-0327(02)00313-0

McGuire-Snieckus, R., McCabe, R., Catty, J., Hansson, L., & Priebe, S. (2007). A new scale to assess the therapeutic relationship in community mental health care: STAR. *Psychological Medicine*, *37*(1), 85–95. https://doi.org/10.1017/S0033291706009299

Mead, S., Hilton, D., & Curtis, L. (2001). Peer support: A theoretical perspective. *Psychiatric Rehabilitation Journal*, *25*(2), 134–141. https://doi.org/10.1037/h0095032

Meaney, M. J. (2018). Perinatal maternal depressive symptoms as an issue for population health. *American Journal of Psychiatry*, *175*(11), 1084–1093. https://doi.org/10.1176/appi.ajp.2018.17091031

Milgrom, J., Negri, L. M., Gemmill, A. W., McNeil, M., & Martin, P. R. (2005). A randomized controlled trial of psychological interventions for postnatal depression. *British Journal of Clinical Psychology*, *44*(4), 529–542. https://doi.org/10.1348/014466505X34200

Montgomery, P., Mossey, S., Adams, S., & Bailey, P. H. (2012). Stories of women involved in a postpartum depression peer support group. *International Journal of Mental Health Nursing*, *21*(6), 524–532. https://doi.org/10.1111/j.1447-0349.2012.00828.x

Murray, L., Fearon, P., & Cooper, P. (2015). Postnatal Depression, Mother-Infant Interactions, and Child Development Prospects for Screening and Treatment. In Milgrom, J and Gemmill, AW (Ed.), *IDENTIFYING PERINATAL DEPRESSION AND ANXIETY: EVIDENCE-BASED PRACTICE IN SCREENING, PSYCHOSOCIAL ASSESSMENT, AND MANAGEMENT* (pp. 139–164).

Newman, T. C., Hirst, J., & Darwin, Z. (2019). What enables or prevents women with depressive symptoms seeking help in the postnatal period? *British Journal of Midwifery*, *27*(4), 219–227. https://doi.org/10.12968/bjom.2019.27.4.219

O’Hara, M. W., & McCabe, J. E. (2013). Postpartum Depression: Current Status and Future Directions. *Annual Review of Clinical Psychology*, *9*(1), 379–407. https://doi.org/10.1146/annurev-clinpsy-050212-185612

O’Mahen, H. A., & Flynn, H. A. (2008). Preferences and Perceived Barriers to Treatment for Depression during the Perinatal Period. *Journal of Women’s Health*, *17*(8), 1301–1309. https://doi.org/10.1089/jwh.2007.0631

O’Mahen, H. A., Woodford, J., McGinley, J., Warren, F. C., Richards, D. A., Lynch, T. R., & Taylor, R. S. (2013). Internet-based behavioral activation-Treatment for postnatal depression (Netmums): A randomized controlled trial. *Journal of Affective Disorders*, *150*(3), 814–822. https://doi.org/10.1016/j.jad.2013.03.005

Pessagno, R. A., & Hunker, D. (2013). Using short-term group psychotherapy as an evidence-based intervention for first-time mothers at risk for postpartum depression. *Perspectives in Psychiatric Care*, *49*(3), 202–209. https://doi.org/10.1111/j.1744-6163.2012.00350.x

Prevatt, B. S., Lowder, E. M., & Desmarais, S. L. (2018). Peer-support intervention for postpartum depression: Participant satisfaction and program effectiveness. *Midwifery*, *64*(January), 38–47. https://doi.org/10.1016/j.midw.2018.05.009

Resnick, S. G., & Rosenheck, R. A. (2008). Integrating peer-provided services: A quasi-experimental study of recovery orientation, confidence, and empowerment. *Psychiatric Services*, *59*(11), 1307–1314. https://doi.org/10.1176/ps.2008.59.11.1307

Sheehan D, Lecrubier Y, Janavs J, Knapp E, W. E. (1998). *The Development and Validation of a Structured Diagnostic Psychiatric Interview. J Clin Psychiatry.* *50*(20), 22–33.

Sikander, S., Ahmad, I., Atif, N., Zaidi, A., Vanobberghen, F., Weiss, H. A., Nisar, A., Tabana, H., Ain, Q. U., & Bibi, A. (2019). Delivering the Thinking Healthy Programme for perinatal depression through volunteer peers: a cluster randomised controlled trial in Pakistan. *The Lancet Psychiatry*, *6*(2), 128–139.

Simhi, M., Sarid, O., & Cwikel, J. (2019). Preferences for mental health treatment for post-partum depression among new mothers. *Israel Journal of Health Policy Research*, *8*(1), 1–8. https://doi.org/10.1186/s13584-019-0354-0

Singla, D., Lemberg-Pelly, S., Lawson, A., Zahedi, N., Thomas-Jacques, T., & Dennis, C. L. (2020). Implementing psychological interventions through nonspecialist providers and telemedicine in high-income countries: Qualitative study from a multistakeholder perspective. *JMIR Mental Health*, *7*(8). https://doi.org/10.2196/19271

Sockol, L. E. (2015). A systematic review of the efficacy of cognitive behavioral therapy for treating and preventing perinatal depression. *Journal of Affective Disorders*, *177*, 7–21. https://doi.org/10.1016/j.jad.2015.01.052

Sockol, L. E. (2018). A systematic review and meta-analysis of interpersonal psychotherapy for perinatal women. *Journal of Affective Disorders*, *232*(February), 316–328. https://doi.org/10.1016/j.jad.2018.01.018

Solomon, P. (2004). M Phyllis Solomon The article defines peer support/peer provided services; discusses the underlying psychosocial processes of these services; and delineates the benefits to peer. *Spring*, 392–402. https://doi.org/10.2975/27.2004.392.401

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092

Taylor, J., & Johnson, M. (2013). The role of anxiety and other factors in predicting postnatal fatigue: From birth to 6 months. *Midwifery*, *29*(5), 526–534. https://doi.org/10.1016/j.midw.2012.04.011

Van Lieshout, R. J., Layton, H., Feller, A., Ferro, M. A., Biscaro, A., & Bieling, P. J. (2020). Public health nurse delivered group cognitive behavioral therapy (CBT) for postpartum depression: A pilot study. *Public Health Nursing*, *37*(1), 50–55. https://doi.org/10.1111/phn.12664

Van Lieshout RJ, Yang L, Haber E, F. M. (2017). Evaluating the effectiveness of a brief group cognitive behavioural therapy intervention for perinatal depression. *Arch Womens Ment Health*, *20*(1), 225–228.

Weiss, R. (1974). The Provisions of Social Relationships. *Doing Unto Others*, *January*, 17–26.

Wozney, L., Olthuis, J., Lingley-Pottie, P., McGrath, P. J., Chaplin, W., Elgar, F., Cheney, B., Huguet, A., Turner, K., & Kennedy, J. (2017). Strongest FamiliesTM Managing Our Mood (MOM): a randomized controlled trial of a distance intervention for women with postpartum depression. *Archives of Women’s Mental Health*, *20*(4), 525–537. https://doi.org/10.1007/s00737-017-0732-y

**Chapter 3**

**Study 2**: The Impact of Peer-Delivered Cognitive Behavioural Therapy for Postpartum Depression on Infant Emotion Regulation: A Randomized Controlled Trial

**Authors**: Bahar Amani, John E. Krzeczkowski, Calan Savoy, Louis A. Schmidt, Ryan J. Van Lieshout

**Context and Implications:** In Chapter 1 I highlight the importance of early experiences with mothers for optimal infant emotion regulation (ER) development and the consequences to ER development when infants are exposed to PPD. Study 2 examined whether treating mothers with a peer-delivered intervention can lead to adaptive changes in infant emotion regulation (ER) following just nine weeks.

Study 2 determined that infant of mothers who received peer-delivered treatment exhibited adaptive changes in two neurophysiological markers of ER, although no change was found in a maternal-report measure of infant temperament. This suggests that a potentially scalable, peer-delivered intervention may have the potential to aid in the disruption of the intergenerational transmission of psychiatric risk from mother to infant.

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**Abstract**

**Background**

Postpartum depression (PPD) affects up to one in five mothers and can have a significant negative impact on their infants. The effects of maternal PPD exposure on infant emotion regulation (ER) may be particularly harmful given their association with later psychopathology. Despite these links and the putative benefits of treating maternal PPD, it remains unclear if treatment can mitigate these risks.

**Methods**

Seventy-three mothers with PPD from Ontario, Canada were randomized to receive group cognitive behavioural therapy (CBT) delivered by women who had previously recovered from PPD (peers) plus treatment as usual (TAU) or TAU alone. Mothers were ≥18 years of age, had an infant <12 months-old, were fluent in English, and had an Edinburgh Postnatal Depression Scale (EPDS) score ≥10. Mothers in the experimental (CBT+TAU) group participated in the nine-week group CBT intervention, while control group mothers were placed on a waitlist for treatment for nine weeks. Infant ER was assess using two physiological measures (frontal alpha asymmetry (FAA) and High Frequency-Heart Rate Variability (HF-HRV)), as well as maternal reports of infant temperament. Infant data were collected at baseline (T1) and nine weeks later (T2).

**Results**

Infants of mothers who received peer-delivered group CBT for PPD plus TAU displayed more adaptive changes in two physiological markers of infant ER from T1 to T2 (FAA (F(1,56)=4.16, p=.046) and HF-HRV (F(1,28.1)=5.57, p=.03)) than the offspring of control mothers. The effect size of these changes for both markers was medium (FAA: *Hedges' g* = 0.52; HF-HRV: *Hedges’ g* = 0.73). Despite improvements in maternal PPD, no differences were noted in infant temperament from T1 to T2.

**Conclusions**

A brief, task-shifted, scalable intervention for mothers with PPD symptoms may be capable of treating PPD as well as adaptively improve infant ER. Replication in larger, more heterogenous samples will help determine if peer-delivered group CBT for PPD can help disrupt the transmission of psychiatric risk from mothers to their infants.

**Introduction**

Postpartum depression (PPD) affects up to one in five mothers and can have profound negative effects on them and their infants (Gaynes et al., 2005; Priel et al., 2019). Offspring exposed to PPD are at an increased risk for emotional, behavioural, and cognitive problems in childhood (Slomian et al., 2019), as well as psychiatric problems later in life (Netsi et al., 2018).

The adverse effects of PPD on infant emotion regulation (ER), the processes involved in modifying emotions in the service of future goals (Thompson, 1994), are common and particularly detrimental to offspring. Emotion regulatory capacity is established in infancy and early problems have been linked to an elevated risk for psychiatric disorders, school failure, and poverty (Calkins et al., 2019; Moffitt et al., 2011).

In the first postnatal year, elevated neuroplasticity of ER systems and their sensitivity to maternal affect and behaviour render it especially vulnerable to the effects of PPD (Calkins et al., 2019; Tottenham, 2019). However, since the development of ER is largely shaped by maternal interactions, the malleability of the brain during this period provides an opportunity to adaptively change infant physiology through maternal treatment.

To date, evidence from trials examining whether treating PPD can improve infant outcomes is inconsistent, and the impact of maternal treatment on offspring remains unclear. While some RCTs have found that treating PPD has benefits for infants (e.g, Cicchetti et al., 2000; Handley et al., 2017; Stein et al., 2018) others have not (e.g., Ammerman et al., 2015; Bilszta et al., 2012). However, most of these studies have relied on maternal reports alone and/or individual observational methods.

Only two RCTs have examined the impact of treating maternal PPD on infant ER, and both (Cohen et al., 2002; Stein et al., 2018) used a single method to assess ER despite recommendations that multiple modalities be used (Fox, 1998). As infant ER involves the activity of the nervous system and behavioural responses (Fox, 1998), multimodal approaches (e.g., physiological, behavioural) are needed to capture the full scope of functioning.

Physiological measures of ER provide the sensitivity to detect subtle changes in infants that may not manifest behaviourally. Since environmental changes can alter the development of the neurophysiological circuits underlying ER, it has been recommended that studies utilize sensitive, objective, physiological measures of infant ER systems. Past research has found that infants exposed to PPD display elevated right frontal asymmetry on electroencephalography (EEG; Lusby et al., 2014) as well as lower heart rate variability (HRV; Field & Diego, 2008), two markers of reduced ER capacity and later mental health risk (Allen & Reznik, 2015; Brunoni et al., 2013). Krzeczkowski and colleagues’ (2021) study of 80 mother-infant dyads recently observed improved ER in infants following maternal receipt of group cognitive behavioural therapy (CBT) for PPD. While a shift from greater right to left FAA and significant increases in HRV were observed in the infants following maternal treatment, this study used an observational design, comparing mothers with major depressive disorder (MDD) in a specialized tertiary care outpatient setting to healthy mother-infant dyads. It lacked an untreated PPD control group, and the intervention was delivered by expert therapists. Since most mothers with PPD receive treatment outside of these settings, it is important to examine the impact of interventions delivered in the community.

Cost-effective psychotherapies that can optimize engagement and be scaled are needed to maximize the societal impact of treating maternal PPD. Task shifting evidence-based psychotherapies like CBT is one potential way to increase uptake and impact. Individuals who have previously recovered from PPD (i.e., peers; Lavender et al., 2016) are seen as a particularly trustworthy and credible source of support and could be capable of providing effective treatment for PPD (Bryan & Arkowitz, 2015). Investigating infant outcomes associated with efficient evidence-based treatments delivered in the community would not only provide compelling evidence on whether this approach could increase maternal treatment uptake, but if intervening can adaptively alter infant ER.

The objective of this study was to compare the effects of peer-delivered group CBT intervention added to treatment as usual (TAU) for mothers with PPD to TAU alone on infant ER using two neurophysiological markers of ER (FAA, HRV) and maternal report of infant temperament.

**Methods**

**Trial Design**

This study included mothers recruited as part of a single-site, randomized controlled trial (RCT) that took place between March 2018 and March 2020 and assessed the effectiveness of peer-delivered group CBT for PPD in Brantford and Brant Region in Ontario, Canada. (ClinicalTrials.gov identifier: ***NCT03285139).*** After consent was obtained, participants were randomized in a 1:1 ratio to receive the nine-week peer-delivered group CBT intervention at enrollment (experimental group) or nine weeks later (control group).

Data were collected from mothers and infants at baseline (T1), and nine weeks later (T2). Physiological data were obtained in a private room, and questionnaire data were collected electronically using REDCap (Harris et al., 2009). Mothers in both groups could access treatment as usual (e.g., psychotherapy, medication). In Ontario, Canada, healthcare is universally available, so TAU may include medications and/or psychotherapy from a physician and/or clinician at a provincially-funded facility/program. Private therapists and other treatments could also be utilized by mothers.

Approval for research conducted with human participants was granted by the Hamilton Integrated Research Ethics Board and all participants provided informed consent. No study methods changed after trial commencement. Study methods are reported following the CONSORT guidelines (Amani et al., 2021).

**Participants**

Mothers were recruited through online advertisements (e.g., Facebook), community partners (e.g., Kids Can Fly), healthcare providers (e.g., family physicians), and self-referral. Mothers had to be ≥18 years of age, have an infant <12 months-old, be fluent in English, and have an Edinburgh Postnatal Depression Scale (EPDS) score ≥10 at enrollment. This EPDS score is one of the most commonly used cut-offs for identifying mothers who might have PPD (Cox & Sagovsky, 1987; O’Connor et al., 2016) and was selected to maximize eligibility. Up to one in three mothers have these levels of symptoms (Meaney, 2018) and this cut-off has a sensitivity >85% for major depressive episodes (Levis et al., 2020). Participants also had to be free of a bipolar, psychotic, or current substance use disorder as per the Mini International Neuropsychiatric Interview (MINI; Sheehan, Lecrubier, Janavs, Knapp, 1998).

**Intervention**

The nine-week peer-delivered group CBT intervention was based on a validated and manualized program (Van Lieshout, Yang, Haber, 2017) that had previously been task-shifted to public health nurses (Van Lieshout et al., 2020). It involved nine weekly two-hour sessions delivered by a pair of randomly-assigned peer facilitators. The first half of each weekly session involved instruction and practice of core CBT skills and was followed by an hour of unstructured discussion of a topic relevant to mothers with PPD (e.g., transitions, sleep). The intervention was delivered at a centrally-located community centre in Brantford, Ontario. Mothers were free to bring their infants to the weekly group.

***Peer Recruitment and Training****:* Peer facilitators were recruited via social media to identify mothers who had recovered from PPD and were willing to be trained to deliver group CBT. Ten peers were selected based on their written application, a telephone interview, and scores below clinical cut-offs on the Beck Depression Inventory-II (<17; Beck et al., 1988) and Generalized Anxiety Disorder-7 scale (<10; Spitzer, Kroenke, Williams, 2006). The training program included two days of in-classroom learning, followed by a nine-week observership, and then group delivery and supervision after each session (Amani et al., 2021).

**Infant Outcome Measures**

Sociodemographic characteristics and clinical data were reported by mothers, and infant physiological data were acquired during study visits at T1 (baseline) and T2 (nine weeks later) with mother-infant dyads. Given that ER is best captured using a combination of modalities, the present study included two common physiological indices of ER, (a) frontal alpha asymmetry (FAA) and (b) high frequency-heart rate variability (HF-HRV), as well as an informant measure of ER.

***Procedure:*** Physiological data were collected from infants during six-minutes of quiet rest. Recordings were taken after dyads were given time to acclimate to the testing room and at a time when infants were in a calm but alert state. Mothers were asked to hold their infants and sit upright during EEG and electrocardiographic (ECG) recordings.

***Frontal Alpha Asymmetry (FAA):***FAA was calculated using EEG recordings taken during six-minutes of rest. EEG was recorded using a custom, research-grade, wireless dry-EEG headband developed for infants by InteraXon. These were used for their portability and their potential to measure FAA reliably and validly in infants. The band was placed across the infant’s forehead and wrapped behind the ears. The band includes 5 sensors, two temporoparietal (TP9 and TP10), two frontal (AF7 and AF8), and a reference electrode in the centre of the forehead (Fpz). Data were transmitted from the sensors to the MINDMonitor app where data were epoched to one second intervals and underwent real-time Fast Fourier Transformation (FFT). Data were visually inspected for indications of segments with noise or weak signals that were then excluded. FAA was calculated by subtracting the log-transformed alpha power (4-8 Hz) at AF7 from AF8. Alpha frequency bands in infants have been identified as being within the 4-9 Hz range (Fox et al., 2001).

**High Frequency-Heart Rate Variability (HF-HRV*):*** Data were recorded by placing pediatric ECG electrodes on the infants’ right shoulder blade and their left-most lower back. HF-HRV was calculated from the ECG trace by extracting the power spectrum (0.24 to 1.04 Hz) that corresponds with respiration for infants (Laborde et al., 2017). Data were then acquired during the six-minute resting-state task using Biolab software (version 3.2.3, Mindware Technologies). Mindware HRV Analysis software was first used to visually inspect data for artifacts, and then to analyze the data in the 0.24 to1.04 Hz frequency domain.

***Temperament****:* Mothers reported on infant temperament using the Infant Behavior Questionnaire-Revised (IBQ-R) Short-Form where 91-items on infant behaviour are rated on a seven-point scale (Putnam, Helbig, Gartstein, Rothbart, 2014). *A priori,* we chose to focus on the orienting/regulatory capacity domain of the IBQ-R to assess ER as it combines the following subscales: soothability, duration of orientation, low intensity pleasure, and cuddliness. This domain is predictive of later effortful control and is a reliable index of ER system functioning (Putnam et al., 2008). Higher scores are indicative of more regulatory behaviours and greater ER capacity. Previous work has linked increased ER capacity measured with physiological measures with increased orienting/regulatory scores (Krzeczkowski et al., 2021).

***Maternal Postpartum Depression:*** To determine the effect of the CBT intervention on mothers, we also examined maternal EPDS scores at T1 and T2. The EPDS is a gold standard measure of PPD that consists of ten items (0-3 points) with higher scores suggesting worse symptoms of depression (Cox & Sagovsky, 1987).

**Statistical Analysis**

Potential predictors of attrition were examined for those who completed the study versus those who enrolled but did not complete the intervention and/or T2 measures. Linear mixed effects models (LMM) with restricted [maximum likelihood](https://www.sciencedirect.com/topics/medicine-and-dentistry/maximum-likelihood-method) estimation were used. Data were structured as a two-level hierarchy with outcomes at T1 and T2 nested within each participant to assess the effect of the intervention over time between experimental and control groups. A random-effects intercept was included to adjust for unobserved heterogeneity at the level of the individual participant and control for clustering effects. Group assignment was included as a fixed effect predictor to account for participants being nested within CBT groups. Models with significant interactions were then stratified by group to identify the magnitude of change following the completion of the intervention by the experimental group. Hedges’ *g* was calculated using experimental group means before and after treatment to determine the magnitude of the treatment effect.

**Results**

Sociodemographic data stratified by group are in Table 1. At study initiation, 105 mothers were screened for participation, 73 met eligibility criteria and were randomized to either experimental or waitlist control groups (Figure 1). On average, mothers in the present study were 31.2 years old (SD=4.7), 95.8% were married/common-law and mothers had on average 14.6 (SD=1.7) years of education. Nearly 68 % had a diagnosis of current MDD. Infants were 5.3 months-old (SD=3.9), and 55.1% were male. Ten CBT groups were delivered and an average of five mothers were assigned to each group. Eighty-four percent of mothers attended at least five CBT sessions.

**Figure 1.** CONSORT Flow Diagram

*Diagram

Description automatically generated*

**Table 1**. Baseline Characteristics of Participating Mothers and Infants

|  |  |  |
| --- | --- | --- |
|  | Experimental Group | Waitlist Control Group |
| Sample Size, N | 25 | 23 |
| Infant Age, months, *mean* (SD) | 5.0 (4.5) | 5.6 (3.3) |
| Infant Birthweight m(SD), grams | 3426.0 (562.8) | 3538.5 (593.0) |
| Infant Gestational age m(SD) weeks | 38.0 (7.3) | 38.4 (4.3) |
| Infant Sex, male, % | 65.4% | 43.5% |
| Maternal Age,Years, *mean* (SD) | 32.4(4.4) | 29.9(4.7) |
| Household Income, *mean* (SD) *a* | $75,652.2 (22,120.8) | $67,000 (21,788.5) |
| Marital Status, % |  |  |
| Married/Common-law | 100% | 91.0% |
| Maternal Ethnicity, % |  |  |
| White | 96.0% | 95.7% |
| Maternal Education (# Years, *mean* (SD)) | 14.5 (18) | 14.2 (1.4) |
| Baseline EPDS, *mean* (SD) | 15.8 (3.7) | 17.0 (4.1) |
| Baseline GAD-7, *mean* (SD) | 12.7 (4.4) | 12.1 (4.7) |
| Number of MINI diagnoses in Mothers, *mean* (SD) | 2.3 (1.4) | 2.5 (1.6) |
| Maternal Psychiatric Comorbidity, Yes, % | 69.2 % | 70.8% |
| Maternal Psychotropic Medication Use % | 30.8% | 26.3% |

*a* Before Tax, $CAD

Abbreviations: EPDS, Edinburgh Postnatal Depression Scale; GAD-7, Generalized Anxiety Disorder-7, MINI= Mini International Neuropsychiatric Interview, SD=standard deviation

The 10 peer facilitators ranged from 20-57 years old, had various occupational backgrounds (e.g., administrative assistant, early childhood educator), and three had prior experience working in healthcare (Amani et al., 2021).

Forty-eight participants provided data on at least one outcome measure at T1 and 32 participants provided data at T2 (Figure 1). From T1 to T2, attrition rates were 32% in the experimental group and 34.8% in the control group. All baseline sociodemographic and clinical characteristics were examined as potential predictors of attrition. There were no differences in any of our baseline sociodemographic or clinical characteristics between participants who did not complete the study in either the experimental or control groups. Those who completed data collection did not differ from those who did not. Psychotropic medication use or psychotherapy participation outside of the trial intervention were not different between groups. Table 2 includes means, standard deviations, and sample sizes on infant outcome measures.

**Table 2.** Outcome Measure Means Before (T1) and After the Nine-Week Intervention (T2) in the Experimental and Control Group Infants

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Time 1 | | | Time 2 | | | | |  | |
| Outcome | Experimental  Mean (SD) | *n* | Control  Mean (SD) | *n* | Experimental  Mean (SD) | *n* | Control  Mean (SD) | *n* | *Hedges’* *g* | |
| FAA | -.02 (.08) | 20 | -.01 (.11) | 18 | .03 (.11) | 15 | -.04 (.08) | 14 | .52 | |
| HF-HRV | 3.12 (1.40) | 24 | 3.57 (.84) | 23 | 4.09 (1.10) | 15 | 3.47 (.79) | 15 | .73 | |
| IBQ-R-REG | 5.07 (.56) | 25 | 5.21 (.70) | 21 | 4.79 (.72) | 17 | 5.22 (.62) | 15 | .44 |

HF-HRV; High Frequency-Heart Rate Variability; FAA, Frontal Alpha Asymmetry; IBQ-R-REG; Infant Behavior Questionnaire-Revised, Orienting/Regulatory Capacity; SD=standard deviation

***High Frequency Heart Rate Variability***

At baseline, infants in the experimental and control group did not differ in HF-HRV. LMM analyses revealed a significant group by time interaction to predict change in HF-HRV between T1 and T2 (F(1,28.1)=5.57, p=.03), suggesting that maternal treatment predicted infants’ mean HF-HRV at T2. Next, we analyzed by group and determined that the main effect of time on HF-HRV scores was statistically significant (*F*(1,16.1)=10.9, p=.00). The size of this effect was medium (*Hedges’ g* = 0.73) from T1 to T2, and mean HF-HRV values (Table 2) at T1 and T2 suggested that following treatment, infants in the experimental group manifested an increase in HF-HRV following the nine-week intervention period. Data collected via ECG could not be analyzed from one control participant at T1 and one experimental participant at T2.

***Frontal Alpha Asymmetry***

Mean FAA at baseline was not statistically significantly different between experimental and control group infants. LMM analysis revealed a significant group by time interaction to predict change in FAA between T1 and T2 (F(1,56)=4.16, p=.046), suggesting that group assignment predicted change in FAA over time. To further examine the effect of the intervention in the experimental group, we stratified by group and found that the main effect of time on infant FAA was not statistically significant, though *p=.05* (*F*(1,17.4)=4.42) and the size of the effect was medium (*Hedges’ g* =0.52). Means reported in Table 2 suggest that while the experimental group infants demonstrated a shift to left frontal asymmetry (FAA=.03) at T2, the control group did not. EEG data from one experimental and one control participant at T1, and one experimental participant at T2 were unanalyzable.

***Orienting/Regulatory Capacity (Temperament)***

At baseline these IBQ-R scores were not statistically significantly different between groups. The results of the LMM analysis did not show a statistically significant group by time interaction to predict orienting/regulatory capacity (F(1,31.1)=.868, p=.36) between T1 and T2.

**Maternal Depression**

In the present study, mothers in the experimental group had a mean EPDS score of 15.8(SD=3.7) at T1, and 10.6 (SD=4.2) at T2. Mothers in the waitlist control group had a mean EPDS score of 17.0 (SD=4.1) at T1, and 16.8 (SD=5.2) at T2. The results of our LMM analysis supported a statistically significant group by time interaction predicting change in EPDS scores between T1 and T2 (F(1,41.8)=13.0, p<.01). We analyzed EPDS score by group and found that the main effect of time on EPDS was significant (*F*(1,23.76)=25.7, *p*=.00), suggesting that mothers in the experimental group experienced a clinically significant reduction in depression symptoms following treatment.

**Discussion**

In the present study, maternal treatment of PPD with a nine-week peer-delivered group CBT intervention led to adaptive changes in two neurophysiological markers of infant ER (FAA and HF-HRV). However, while the effect size of these changes was large, and the intervention improved maternal symptoms of PPD, mothers did not report a statistically significant improvement in infant temperament.

To our knowledge, just three studies have examined changes in measures of offspring ER following maternal treatment for PPD (Cohen et al., 2002; Krzeczkowski et al., 2021; Stein et al., 2018). One RCT (Stein et al., 2018) examined whether CBT combined with a parenting treatment or active control treatment differentially affected an observational measure of infant ER (e.g., Barrier paradigm). They found that infants in both groups displayed ER that matched non-clinical norms after treatment, although this study did not measure infant ER prior to maternal treatment. In another randomized trial that included two different mother-infant PPD interventions (e.g., mother–infant psychodynamic psychotherapy and infant-focused therapy), Cohen et al. (2002) found that an observational measure of infant ER (e.g., Bayley Infant Behavior Rating Scale) improved six months after the intervention. In both RCTs, offspring ER were measured after two years of age and only measured through examiner-rated observations of behaviour. The single study (Krzeczkowski et al., 2021) that used multiple measures of ER suggested that maternal treatment with group CBT for PPD delivered by expert therapists could lead to adaptive changes in FAA, HF-HRV, and parent reports of infant temperament. However, that study’s observational design raises the possibility that regression to the mean could have contributed to findings.

This study appears to be the first to use an RCT design to assess the impact of maternal PPD treatment on multiple measures of infant ER. In keeping with the findings of Krzeczkowski and colleagues, we found that maternal PPD treatment led to changes in FAA and HF-HRV. However, we did not observe changes in maternal report of infant temperament. The exact reasons for the differences in these studies are unclear, but could have been contributed by differences in participants between the two studies. All mothers in Krzeczkowski and colleagues' study required an MDD diagnosis to participate, and over half (55%) were on antidepressants. In addition, all mothers in that study had been referred to a specialized perinatal mental health clinic and had been receiving treatment for up to two months prior to trial initiation.

Our study found evidence of adaptive changes to both corticolimbic (FAA) and parasympathetic (HF-HRV) systems of infant ER following maternal PPD treatment. Since mothers with PPD are at increased risk for less empathic, sensitive, and responsive behaviour to their infants’ needs (Slomian et al., 2019), and are more likely to be intrusive or withdrawn in their interactions with infants (Field et al., 2003), and because the physiological systems that regulate ER are highly sensitive to the caregiving environment (Calkins et al., 2008; Moore & Calkins, 2004), the changes that we observed in infant ER may be contributed to by alterations to caregiving and mother-infant relationship. In the present study, infants whose mothers were in the experimental group experienced adaptive changes to HF-HRV following maternal treatment. Past research has connected mother-infant synchrony (Moore & Calkins, 2004) and maternal sensitivity (Calkins et al., 2008) to increased vagal tone and higher resting HR. The present study also found a shift to left FAA in the experimental group infants which could be suggestive of a possible change in amygdala-prefrontal cortex circuity (Gee et al., 2013) and its subsequent regulation of amygdala activity. Perhaps mothers became less withdrawn after treatment since withdrawal has been linked with right frontal asymmetry among infants exposed to PPD (Diego et al., 2001). While not assessed directly in this study, improvements in the quality of mother-infant interactions may be a potential mechanism through which treatment affects infant ER, though future work is needed to examine this association further.

The following study limitations should also be noted. Given the challenges of collecting physiological data from infants, recruiting mothers with PPD, and the early cessation of this study due to the COVID-19 pandemic, our sample size is relatively small. This may have reduced statistical power to detect changes, for example in measures of infant temperament. However, the size of our sample is comparable to studies that have collected physiological data from infants (Field et al., 1995; Lusby et al., 2014) and there were no differences between participants who were lost to follow-up versus those who completed the study. Second, participants were primarily white, married or common-law, and lived in a region where universal healthcare is available, affecting the generalizability of our findings. We used the Muse EEG band to assess FAA because it allowed for mobile EEG data from infants in a community setting. It is important to highlight that the Muse EEG band is a newer technology and has not been as widely used in infant research, though our results were consistent with those from a study that used traditional dense-array EEG (Krzeczkowski et al., 2021). Additionally, we did not measure other key ER systems, such as the hypothalamic pituitary adrenal (HPA) axis, and infant outcomes were only measured before and after treatment. Although a later, longer-term follow-up visit was planned, because of the COVID-19 pandemic, it was not possible.

Future work should aim to replicate our findings in a larger sample over a longer period of follow-up to assess the stability of ER changes in infants. Assessing the impact of PPD interventions delivered virtually is an important next step to reduce barriers to treatment and ensure widespread reach. The peer intervention should also be tested in areas without universal healthcare to determine if treatments for PPD can lead to similar changes across different contexts. Lastly, because we examined resting-state measures of ER, and stress reactivity is an important indicator of ER capacity (Fox, 1998), future work should examine whether maternal treatment affects infant stress reactivity using a combination of observational stress paradigms and measures of HPA axis activity (e.g., salivary cortisol).

Our findings suggest that an affordable and brief task-shifted intervention designed to meet the needs and preferences of mothers may lead to adaptive changes in infant ER. This work highlights the importance of early intervention, the potential role it may play in ensuring optimal infant development, and the potential of the peer intervention to have a significant public health impact.

**References**

Allen, J. J. B., & Reznik, S. J. (2015). Frontal EEG asymmetry as a promising marker of depression vulnerability: Summary and methodological considerations. *Current Opinion in Psychology*, *4*, 93–97. https://doi.org/10.1016/j.copsyc.2014.12.017

Amani, B., Merza, D., Savoy, C., Streiner, D., Bieling, P., Ferro, M., & R, V. L. (2021). Peer-Delivered Cognitive Behavioral Therapy for Postpartum Depression: A Randomized Controlled Trial. *Journal of Clinical Psychiatry*, *83*(1), 0–0.

Ammerman, R. T., Altaye, M., Putnam, F. W., Teeters, A. R., Zou, Y., & Van Ginkel, J. B. (2015). Depression improvement and parenting in low-income mothers in home visiting. *Archives of Women’s Mental Health*, *18*(3), 555–563. https://doi.org/10.1007/s00737-014-0479-7

Beck, A. T., Steer, R. A., Garbin, M. G., & van der Voorn, B. (1988). Psychometric Properties of the Beck Depression Inventory: Twenty-five years of Evaluation. *Clinical Psychology Review*, *8*, 77–100. https://doi.org/10.1016/j.psychres.2007.11.018

Bilszta, J. L. C., Buist, A. E., Wang, F., & Zulkefli, N. R. (2012). Use of video feedback intervention in an inpatient perinatal psychiatric setting to improve maternal parenting. *Archives of Women’s Mental Health*, *15*(4), 249–257. https://doi.org/10.1007/s00737-012-0283-1

Brunoni, A. R., Kemp, A. H., Dantas, E. M., Goulart, A. C., Nunes, M. A., Boggio, P. S., Mill, J. G., Lotufo, P. A., Fregni, F., & Benseñor, I. M. (2013). Heart rate variability is a trait marker of major depressive disorder: Evidence from the sertraline vs electric current therapy to treat depression clinical study. *International Journal of Neuropsychopharmacology*, *16*(9), 1937–1949. https://doi.org/10.1017/S1461145713000497

Bryan, A. E. B., & Arkowitz, H. (2015). Meta-Analysis of the Effects of Peer-Administered Psychosocial Interventions on Symptoms of Depression. *American Journal of Community Psychology*, *55*(3–4), 455–471. https://doi.org/10.1007/s10464-015-9718-y

Calkins, S. D., Dollar, J. M., & Wideman, L. (2019). Temperamental vulnerability to emotion dysregulation and risk for mental and physical health challenges. *Development and Psychopathology*, *31*(3), 957–970. https://doi.org/10.1017/S0954579419000415

Calkins, S. D., Graziano, P. A., Berdan, L. E., Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal - Child relationship quality during toddlerhood. *Developmental Psychobiology*, *50*(8), 751–766. https://doi.org/10.1002/dev.20344

Cicchetti, D., Rogosch, F. A., & Toth, S. L. (2000). The efficacy of Toddler-Parent Psychotherapy for fostering cognitive development in offspring of depressed mothers. *Journal of Abnormal Child Psychology*, *28*(2), 135–148. https://doi.org/10.1023/A:1005118713814

Cohen, N. J., Lojkasek, M., Muir, E., Muir, R., & Parker, C. J. (2002). Six-month follow-up of two mother-infant psychotherapies: Convergence of therapeutic outcomes. *Infant Mental Health Journal*, *23*(4), 361–380. https://doi.org/10.1002/imhj.10023

Cox, J. L., & Sagovsky, J. M. H. R. (1987). *Detection of Postnatal Depression Development of the 10-item Edinburgh Postnatal Depression Scale*. 782–786.

Diego, M. A., Field, T., & Hernandez-Reif, M. (2001). BIS/BAS scores are correlated with frontal eeg asymmetry in intrusive and withdrawn depressed mothers. *Infant Mental Health Journal*, *22*(6), 665–675. https://doi.org/10.1002/imhj.1025

Field, T., & Diego, M. (2008). *Vagal activity , early growth and emotional development*. *31*, 361–373. https://doi.org/10.1016/j.infbeh.2007.12.008

Field, T., Diego, M., Hernandez-Reif, M., Schanberg, S., & Kuhn, C. (2003). Depressed mothers who are “good interaction” partners versus those who are withdrawn or intrusive. *Infant Behavior and Development*, *26*(2), 238–252. https://doi.org/10.1016/S0163-6383(03)00020-1

Field, T., Fox, N. A., Pickens, J., & Nawrocki, T. (1995). Relative Right Frontal EEG Activation in 3- to 6-Month-Old Infants of “Depressed” Mothers. *Developmental Psychology*, *31*(3), 358–363. https://doi.org/10.1037/0012-1649.31.3.358

Fox, N. A. (1998). Temperament and regulation of emotion in the first years of life. *Pediatrics*, *102*(5 Suppl E), 1230–1235.

Fox, Nathan A., Henderson, H. A., Rubin, K. H., Calkins, S. D., & Schmidt, L. A. (2001). Continuity and discontinuity of behavioral inhibition and exuberance: Psychophysiological and behavioral influences across the first four years of life. *Child Development*, *72*(1), 1–21. https://doi.org/10.1111/1467-8624.00262

Gaynes, B. N., Gavin, N., Meltzer-Brody, S., Lohr, K. N., Swinson, T., Gartlehner, G., Brody, S., & Miller, W. C. (2005). Perinatal depression: prevalence, screening accuracy, and screening outcomes. *Evidence Report/Technology Assessment (Summary)*, *119*, 1–8. https://doi.org/10.1037/e439372005-001

Gee, D. G., Gabard-Durnam, L. J., Flannery, J., Goff, B., Humphreys, K. L., Telzer, E. H., Hare, T. A., Bookheimer, S. Y., & Tottenham, N. (2013). Early developmental emergence of human amygdala-prefrontal connectivity after maternal deprivation. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(39), 15638–15643. https://doi.org/10.1073/pnas.1307893110

Handley, E. D., Michl-Petzing, L. C., Rogosch, F. A., Cicchetti, D., & Toth, S. L. (2017). Developmental cascade effects of interpersonal psychotherapy for depressed mothers: Longitudinal associations with toddler attachment, temperament, and maternal parenting efficacy. *Development and Psychopathology*, *29*(2), 601–615. https://doi.org/10.1017/S0954579417000219

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010

Jones, N. A., Field, T., Fox, N. A., Davalos, M., Lundy, B., & Hart, S. (1998). Newborns of mothers with depressive symptoms are physiologically less developed. *Infant Behavior & Development*, *21*(3), 537–541. https://doi.org/10.1016/S0163-6383(98)90027-3

Krzeczkowski, J. E., Schmidt, L. A., & Van Lieshout, R. J. (2021). Changes in infant emotion regulation following maternal cognitive behavioral therapy for postpartum depression. *Depression and Anxiety*, *December 2020*, 1–10. https://doi.org/10.1002/da.23130

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart rate variability and cardiac vagal tone in psychophysiological research - Recommendations for experiment planning, data analysis, and data reporting. *Frontiers in Psychology*, *8*, 1–18. https://doi.org/10.3389/fpsyg.2017.00213

Lavender, T. J., Ebert, L., & Jones, D. (2016). An evaluation of perinatal mental health interventions: An integrative literature review. *Women and Birth*, *29*(5), 399–406. https://doi.org/10.1016/j.wombi.2016.04.004

Levis, B., Negeri, Z., Sun, Y., Benedetti, A., & Thombs, B. D. (2020). Accuracy of the Edinburgh Postnatal Depression Scale (EPDS) for screening to detect major depression among pregnant and postpartum women: Systematic review and meta-analysis of individual participant data. *The BMJ*, *371*. https://doi.org/10.1136/bmj.m4022

Lusby, C. M., Goodman, S. H., Bell, M. A., & Newport, D. J. (2014). Electroencephalogram patterns in infants of depressed mothers. *DEVELOPMENTAL PSYCHOBIOLOGY*, *56*(3), 459–473. https://doi.org/10.1002/dev.21112

Meaney, M. J. (2018). Perinatal maternal depressive symptoms as an issue for population health. *American Journal of Psychiatry*, *175*(11), 1084–1093. https://doi.org/10.1176/appi.ajp.2018.17091031

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H. L., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Moore, G. A., & Calkins, S. D. (2004). Infants’ vagal regulation in the still-face paradigm is related to dyadic coordination of mother-infant interaction. *Developmental Psychology*, *40*(6), 1068–1080. https://doi.org/10.1037/0012-1649.40.6.1068

Netsi, E., Pearson, R. M., Murray, L., Cooper, P., Craske, M. G., & Stein, A. (2018). Association of persistent and severe postnatal depression with child outcomes. *JAMA Psychiatry*, *75*(3), 247–253. https://doi.org/10.1001/jamapsychiatry.2017.4363

O’Connor, E., Rossom, R. C., Henninger, M., Groom, H. C., & Burda, B. U. (2016). Primary Care Screening for and Treatment of Depression in Pregnant and Postpartum Women. *Jama*, *315*(4), 388. https://doi.org/10.1001/jama.2015.18948

Priel, A., Djalovski, A., Zagoory-Sharon, O., & Feldman, R. (2019). Maternal depression impacts child psychopathology across the first decade of life: Oxytocin and synchrony as markers of resilience. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *60*(1), 30–42. https://doi.org/10.1111/jcpp.12880

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and Heterotypic Continuity of Fine-grained Temperament during Infancy, Toddlerhood, and Early Childhood. *Infant and Child Development*, *17*(6), 387–405. https://doi.org/10.1002/icd

Putnam SP, Helbig AL, Gartstein MA, Rothbart MK, L. E. (2014). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. J Pers Assess. *J Pers Assess.*, *96*(4), 445–458.

Robert L Spitzer, Kurt Kroenke, Janet B W Williams, B. L. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder. *Arch Intern Med.*, *166*(10), 1092–7.

Sheehan D, Lecrubier Y, Janavs J, Knapp E, W. E. (1998). *The Development and Validation of a Structured Diagnostic Psychiatric Interview. J Clin Psychiatry.* *50*(20), 22–33.

Slomian, J., Honvo, G., Emonts, P., Reginster, J. Y., & Bruyère, O. (2019). Consequences of maternal postpartum depression: A systematic review of maternal and infant outcomes. In *Women’s Health* (Vol. 15). https://doi.org/10.1177/1745506519844044

Stein, A., Netsi, E., Lawrence, P. J., Granger, C., Kempton, C., Craske, M. G., Nickless, A., Mollison, J., Stewart, D. A., Rapa, E., West, V., Scerif, G., Cooper, P. J., & Murray, L. (2018). Mitigating the effect of persistent postnatal depression on child outcomes through an intervention to treat depression and improve parenting: a randomised controlled trial. *The Lancet Psychiatry*, *5*(2), 134–144. https://doi.org/10.1016/S2215-0366(18)30006-3

Thompson, R. A. (1994). Emotion Regulation: A Theme in Search of Definition. In *Monographs of the Society for Research in Child Development* (Vol. 59, Issue 2/3, p. 25). https://doi.org/10.2307/1166137

Tottenham, N. (2019). Early Adversity and the Neotenous Human Brain. *Biological Psychiatry*, *16*, 1–10. https://doi.org/10.1016/j.biopsych.2019.06.018

Van Lieshout, R. J., Layton, H., Feller, A., Ferro, M. A., Biscaro, A., & Bieling, P. J. (2020). Public health nurse delivered group cognitive behavioral therapy (CBT) for postpartum depression: A pilot study. *Public Health Nursing*, *37*(1), 50–55. https://doi.org/10.1111/phn.12664

Van Lieshout RJ, Yang L, Haber E, F. M. (2017). Evaluating the effectiveness of a brief group cognitive behavioural therapy intervention for perinatal depression. *Arch Womens Ment Health*, *20*(1), 225–228.

**Chapter 4**

**Study 3**: Public Health Nurse-Delivered Cognitive Behavioural Therapy for Postpartum Depression: Assessing the Effects of Maternal Treatment on Infant Emotion Regulation

**Authors**: Bahar Amani, John E. Krzeczkowski, Louis A. Schmidt, Ryan J. Van Lieshout

**Context and Implications:** Considering the consequences of PPD exposure on infant emotion regulation (ER) that are highlighted in Chapter 1, finding effective interventions for maternal PPD is of utmost importance. Study 3 examined whether a second task-shifted intervention, Public health nurse (PHN)-delivered intervention previously found to be effective in treating mothers, may also lead to adaptive changes in infant emotion regulation (ER) following just nine weeks.

Infants of mothers who participated in the PHN-delivered intervention exhibited adaptive changes in a single neurophysiological marker of ER. These findings provide further support for the effectiveness of PPD interventions delivered by non-professionals. A PHN-delivered intervention that is effective in treating symptoms of PPD in mothers, appears to also lead to adaptive changes in infant ER following just nine weeks of maternal treatment. Evidence of adaptive changes in infants following maternal treatment suggests that we may be able to break the familial cycle of mental health risk and ensure better outcomes for both mothers and infants.

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**Abstract**

**Background**

Postpartum depression (PPD) has consequences for both mothers and their infants. The effects of PPD on offspring emotion regulation (ER) are particularly deleterious as difficulties with ER predict an increased risk of psychopathology. The present study sought to examine the impact of maternal participation in a public health nurse (PHN)-delivered group cognitive behavioural therapy (CBT) intervention on infant ER.

**Methods**

One-hundred and forty-one mother-infant dyads were randomized between April 2017 to January 2020 to experimental (intervention and treatment as usual (TAU)) or control groups (TAU). Infant ER was measured at baseline (T1) and nine weeks later (T2) using two neurophysiological measures (frontal alpha asymmetry (FAA) and High Frequency-Heart Rate Variability (HF-HRV)), and informant-report of infant temperament.

**Results**

We found a statistically significant group by time interaction to predict change in HF-HRV between T1 and T2 (*F(*1,68.3)=4.04, *p*=.04), but no significant group by time interaction was found to predict change in FAA or temperament.

**Conclusions**

The results of this study suggest that PHN-delivered group CBT for PPD may lead to adaptive changes in a neurophysiological marker of infant ER. These findings highlight the importance of early maternal intervention and its potential to disrupt the transmission of risk from mothers to infants.

**Introduction**

Postpartum depression is a major public health problem that can have long-term adverse effects on mothers and birthing parents, and their infants (Gaynes et al., 2005; Heim & Binder, 2012; Kingston et al., 2012; Tronick & Reck, 2009). One in five mothers/birthing parents will develop postpartum depression (PPD; Gaynes et al., 2005) while up to one in three experience elevated levels of symptoms that do not exceed diagnostic thresholds for a diagnosis of major depressive disorder (MDD; Meaney, 2018). Left untreated, PPD costs $125,000 (CAD; Bauer et al., 2016) over the lifespan, 72% of which is attributed to emotional, behavioural, and/or cognitive problems in offspring (Bauer et al., 2016; S. H. Goodman et al., 2011; Slomian et al., 2019). The effects of PPD on offspring emotion regulation (ER) may be particularly deleterious since difficulties with ER predict an increased risk of most forms of psychopathology, as well as sub-optimal educational and labour market outcomes (Calkins et al., 2019; Panari et al., 2020; Shannon et al., 2007).

The development of the physiological systems involved in infant emotion regulatory capacity are influenced by early postnatal interactions with caregivers, particularly their mothers (Calkins et al., 2019; Tottenham, 2019). The autonomic nervous system (ANS; Porges, 2007; Thayer et al., 2009) and corticolimbic circuits in the brain (Field et al., 2002; Fox, 1991; Lusby et al., 2014, 2016) are key systems involved in the development of ER, and measures of their activity are robust indicators of emotion regulatory capacity. High Frequency Heart Rate Variability (HF-HRV) is a measure of the flexibility of the ANS to adapt to environmental conditions (Propper & Moore, 2006), while Frontal alpha asymmetry (FAA) indexes the relative activation of the left versus right frontal regions of the brain. Both HF-HRV and FAA can be used to measure ER in preverbal infants and are among the earliest markers of infant ER capacity (Field et al., 2002; Fox, 1991; Lusby et al., 2014, 2016; Porges, 2007; Thayer et al., 2009). Infants exposed to PPD tend to exhibit lower HRV and greater right FAA at rest, both of which predict poorer ER and an increased risk of psychiatric problems (Bornstein & Suess, 2000; Coan & Allen, 2004; Mason, 1975; Thayer & Brosschot, 2005).

Despite the long-term adverse effects of PPD and its impact on ER in infants, just 15% of mothers in developed countries will receive evidence-based treatment for PPD (Ko et al., 2012). Numerous barriers to care for mothers/birthing parents with PPD exist including a lack of affordable and preferred treatment options (e.g., psychotherapy) and long waitlists (Goodman, 2009; Jones, 2019). Task-shifting the treatment of PPD from specialized experts to those with less psychiatric training (e.g., public health nurses) is one means through which treatment access can be improved (Van Lieshout et al., 2021). While some evidence suggests that PHNs can deliver effective individual interpersonal psychotherapy (IPT; Dennis et al., 2020) and group Cognitive behavioural therapy (CBT) for PPD (Van Lieshout et al., 2020), it is not clear if such interventions can benefit infant ER.

To date, just three studies have examined the impact of treating maternal PPD on infant ER (Cohen et al., 2002; Krzeczkowski et al., 2021; Stein et al., 2018). Two of these studies used an experimental design (e.g., RCT; Cohen et al., 2002; Stein et al., 2018) and found evidence to suggest that maternal treatment for PPD may have a positive influence on infant ER. However, maternal treatment began after the first postnatal year, despite this period of time being important for infant ER development (Calkins et al., 2019; Tottenham, 2019) and in both studies, only single observational measures of infant behaviour were used to assess ER. It is important to note that observational and parent-report measures of infant behaviour alone may not capture the full scope of ER (Fox, 1998) and may lack the sensitivity to detect important changes. To date, just one study has measured infant ER following maternal treatment using physiological measures of infant ER (Krzeczkowski et al., 2021). Using an observational study design, Krzeczkowski and colleagues found increased HF-HRV and a shift from right to left FAA following nine weeks of group CBT for PPD delivered by experts to mothers in a specialized perinatal mental health clinic meeting DSM-5 diagnostic criteria for MDD (Krzeczkowski et al., 2021). However, given the observational design and a lack of a depressed control group, this study was not able to rule out whether changes in infants were due to treatment or potential confounding factors (Metelli & Chaimani, 2020).

Relative to treatments delivered by expert therapists in hospital settings, structured group interventions delivered by PHNs in community settings could have the potential to be more broadly, effectively, and efficiently scaled to improve PPD and infant ER. To help realize this substantial public health potential, the objective of the present study was to determine if participation in a nine-week PHN-delivered group CBT intervention could lead to potentially adaptive changes in infant ER as indexed by two neurophysiological markers (HF-HRV and FAA) and parental reports of infant temperament.

**Methods**

This study included mother-infant pairs who were part of a parallel-group, single-site, randomized controlled trial (RCT) assessing the effectiveness of a nine-week PHN-delivered group CBT intervention for PPD (Van Lieshout et al., 2021). This study took place in Ontario, Canada (ClinicalTrials.gov identifier: **NCT03039530*)*** between April 1, 2017 to January 20, 2020. Mother-infant dyads were randomized in a 1:1 ratio to experimental or control groups. Blocked randomization with block sizes of four, six, and eight was conducted by a statistician using R and implemented by the study coordinator using Research Electronic Data Capture (REDCap; Harris et al., 2009).

Experimental group participants enrolled in the nine-week intervention in addition to receiving treatment as usual (TAU) from their healthcare providers, while control participants received TAU alone. Since healthcare is universally available in Ontario, Canada, TAU could include medications and/or psychotherapy from a physician and/or clinician at a provincially-funded facility/program. Participants could also access private therapists or any other treatments they wished.

The current study was a secondary analysis of a study whose primary objective was to examine if PHN-delivered group CBT for PPD could lead to a clinically significant change in maternal PPD. *A priori* power analysis determined that a sample of 136 participants (68 per arm) would provide adequate statistical power to address this maternal objective. In addition, other studies examining infant ER have been of a similar sample size (Field et al., 1995; Lusby et al., 2014).

Data were collected at baseline (T1) and nine weeks later (post-treatment in the experimental group; T2). No data were collected at a T3 time point (6 months post-treatment) because of COVID-19 pandemic-related restrictions on face-to-face research in Ontario, Canada. Mothers completed questionnaires electronically using REDCap (Harris et al., 2009) and infant physiological data were collected during in-person study visits at T1 and T2. In-person study visits took place at Niagara Region Public Health. The present study was approved by the Hamilton Integrated Research and the Niagara Region Public Health Ethics Boards. Participants provided informed consent prior to randomization. No study methods changed after trial commencement.

Mother-infant dyads were recruited both through social media advertising (e.g., Facebook, Instagram) and healthcare providers (e.g., public health nurses, midwives, physicians, etc.). Mothers could self-refer to the study or be referred by a healthcare provider. Participants had to be ≥18 years-old, have an infant <12 months, and an Edinburgh Postnatal Depression Scale (EPDS) score ≥10. This EPDS cut-off is typically used in primary care settings to detect PPD (Earls et al., 2010), and was selected because almost 30% of postpartum women experience these levels of symptoms(Meaney, 2018). In addition, the use of EPDS enabled us to maximize eligibility and the public health relevance of our findings. Participants were also free of bipolar, psychotic, borderline or antisocial, or current substance use disorders as per the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998)

Six PHNs were trained to deliver the nine-week group CBT intervention which was effective in improving depression and anxiety in mothers (Van Lieshout et al., 2022). The intervention consisted of nine weekly two-hour sessions delivered by two PHNs. The first half of each session consisted of core CBT content, while the second half included psychoeducation and a group discussion of relevant topics (e.g., sleep, utilizing supports; Van Lieshout et al., 2017, 2020). No formal psychotherapy supervision took place during the intervention delivery, but an expert therapist was available to the PHNs to provide clinical support.

Sociodemographic, clinical, and infant temperament data were self-reported by mothers, while in-person physiological data were acquired from infants during in-person study visits.

Physiological data were collected from infants during a six-minute resting-state task. Electrocardiographic (ECG) and EEG recordings were taken while mothers were asked to hold their infants while sitting upright and facing a screensaver. Mothers were instructed not to speak to their infant and to refrain from moving them. Physiological recordings did not begin until dyads were given time to acclimate to the testing room and at a time when infants were calm but alert. Testers remained hidden behind a partition during physiological recordings.

**High Frequency- Heart Rate Variability (HF-HRV):** ECG data were collected with the Mindware Mobile Impedance Cardiograph **(**Mindware Technologies Ltd. Gahanna, OH). ECG electrodes were placed on infants' right shoulder blade and their left-most lower back. HF-HRV was calculated from the ECG trace by extracting the power spectrum that corresponds with respiration for infants (0.24 to 1.04 Hz; Laborde et al., 2017). Data were acquired during the six-minute resting-state task using Biolab software (version 3.2.3, Mindware Technologies Ltd. Gahanna, OH). Mindware HRV Analysis software was used to first inspect the data visually for artifacts, and next to analyze it on a 0.24 to 1 Hz frequency range. Higher values of resting HF-HRV are reflective of more adaptive control and flexibility of the nervous system to handle stress (Porges, 2007; Thayer et al., 2009).

***Frontal Alpha Asymmetry (FAA):***EEG data were collected using a custom dry-EEG headband developed by InteraXon for infant use (Krigolson et al., 2017; Ratti et al., 2017). In addition to their portability and ease-of-use, other infant studies suggest that they can collect reliable EEG data (Krigolson et al., 2017; Neto et al., 2021). Each headband includes 5 sensors, two temporoparietal (TP9 and TP10), two frontal (AF7 and AF8), and a fifth reference electrode in the center of the forehead (Fpz). Data were sent from the headband sensors to the MINDMonitor app where they were epoched to one second intervals before a real-time Fast Fourier Transformation (FFT) was performed. Data were then saved in comma separated value (CSV) format. Next, they were visually inspected for segments with noise or weak signals (e.g., repeating values). To calculate FAA, the log-transformed alpha power (4-8 Hz) at the left frontal hemisphere (AF7) was subtracted from the right frontal hemisphere (AF8). Alpha frequency bands in infants are typically within the 4-9 Hz range (Fox et al., 2001; Marshall et al., 2002). Greater resting relative right frontal asymmetric activity (indicated by values <0) reflects a predisposition to experiencing negative emotions, having more withdrawal-related tendencies, and is predictive of later psychopathology (Coan & Allen, 2004), while greater relative left frontal asymmetric activity is reflective of more approach-oriented behaviour and positive emotionality.

***Temperament:*** Mothers reported infant temperament using the Infant Behaviour Questionnaire-Revised (IBQ-R) Very Short-Form, a 37-item questionnaire where infant behaviour is rated on a 7-point scale (Putnam et al., 2006; Putnam et al., 2014). *A priori*, we decided to examine the orienting/regulatory capacity domain of the IBQ-R as the maternally reported measure of infant ER. This domain is a reliable marker of infant ER (Putnam et al., 2008). Higher scores on this domain suggest greater ER capacity and correlate with greater infant HF-HRV and left FAA (Krzeczkowski et al., 2021).

T-tests and chi-square tests were used to analyze differences in baseline characteristics between groups. Potential predictors of attrition on offspring ER outcomes (HF-HRV, FAA, IBQ-R) were also examined. Maternal depressive symptoms (mean EPDS scores) stratified by group at T1 and T2 were calculated to assess the treatment effect in mothers included in the present study sample.

We used linear mixed effects models (LMM) with restricted [maximum likelihood](https://www.sciencedirect.com/topics/medicine-and-dentistry/maximum-likelihood-method) estimation to examine the effect of the intervention on all three infant outcomes. Using a two-level hierarchy, outcome data at T1 and T2 were nested within each participant to assess the effect of the intervention over time between groups. To account for unobserved heterogeneity at the level of the individual participant and control for clustering effects, a random-effects intercept was included in the model. Lastly, group assignment was included as a fixed-effect predictor to account for participants being nested within different CBT groups. For outcomes that showed a statistically significant group by time interaction, we stratified by intervention group to identify the magnitude of change following the completion of treatment. Intervention effect was calculated for each outcome using means and standard deviations of outcome measures at T1 and T2 in the experimental group.

**Results**

Table 1 includes a summary of maternal and infant characteristics stratified by treatment group. A total of 141 mothers were randomized to experimental or control groups between April 1, 2017 to January 20, 2020 (Figure 1). Mothers were 30.8 years old (SD=4.7), 92.3% were married or common-law, and had 17.9 (SD=3.4) years of education. Of those in the present study, 67.3% had a MDD diagnosis and 29.9% were taking a psychotropic medication. Infants were a mean age of 5.4 months-old (SD=3.1) at enrollment, and 52.1% were male. No statistically significant differences were found in sociodemographic or clinical characteristics between experimental and control groups at baseline. On average, six mothers attended each CBT group, and 88.3% of participants attended 5 or more sessions.

At T1, 107 participants provided data on at least one outcome measure and 78 participants provided these data at T2. At T1, 53 experimental mother-infant dyads and 40 control group dyads attended in-person study visits. At T2, 37 experimental mother-infant dyads and 24 control group dyads attended in-person study visits. Table 2 includes means, standard deviations, and sample sizes on all measures.

**Figure 1.** CONSORT Flow Diagram

Diagram

Description automatically generated

We examined baseline characteristics of mothers and infants as potential predictors (infant age, infant sex, maternal age, income, marital status, education, MDD diagnosis, and psychiatric medication) of loss to follow-up for each outcome. None were found to be associated with any infant outcome (HF-HRV, FAA, IBQR-REG). From T1 to T2, attrition did not differ between groups for HF-HRV or IBQ-R scores, but loss to follow-up for FAA was 22.2% in the experimental group and 51.5% in the control group (*X2=9.23, p<.01).*

|  |  |  |
| --- | --- | --- |
|  | Experimental  Group | Control Group |
| Sample Size, N | 57 | 50 |
| Infant Age, months, *mean* (SD) | 5.2 (2.8) | 5.5 (3.4) |
| Infant Sex, male, % | 57.7% | 45.5% |
| Maternal Age,Years, *mean* (SD) | 31.4(4.9) | 30.2(4.5) |
| Household Income, *mean* (SD) *a* | $77,663(42,052.9) | $78,693 (43,859.9) |
| Marital Status, % |  |  |
| Single | 4.3% | 11.4% |
| Married/Common-law | 95.6% | 88.6% |
| Maternal Education (# Years, *mean* (SD)) | 17.7(3.5) | 18.0 (3.3) |
| Baseline EPDS, *mean* (SD) | 16.1 (4.4) | 15.7 (3.7) |
| Baseline PSWQ-7, *mean* (SD) | 64.6(8.8) | 63.9(9.4) |
| Maternal Psychotropic Medication Use % | 29.8% | 30% |
| Current MDD Diagnosis, Yes, % | 66.7 % | 68% |

**Table 1**. Baseline Characteristics of Participating Mothers and their Infants

*a*Before Tax, In Canadian dollars

Abbreviations: EPDS, Edinburgh Postnatal Depression Scale; PSWQ, Penn State Worry Questionnaire, SD=Standard Deviation, MDD, Major Depressive Disorder

\*p<0.05

**Maternal PPD Symptoms:** In the present study, mothers in the experimental group had EPDS scores that decreased from 16.1 (SD=4.4) to 10.6 (SD=4.6) after treatment, while mothers in the control group manifested a slight decrease in EPDS scores from 15.8 (SD=3.8) at T1 to 13.1 (SD=5.0) at T2. Improvement in the experimental group was greater than the control group (p<0.05).

**Table 2.** Impact of Group CBT for PPD on Physiological and Parent-Report Measures of Infant Emotion Regulation

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Time 1 | | | Time 2 | | | | |  |
| Outcome | Experimental  Mean (SD) | *n* | Control  Mean (SD) | *n* | Experimental  Mean (SD) | *n* | Control  Mean (SD) | *n* | *Hedge’s* *g* |
| FAA | .08 (.22) | 45 | .07 (.24) | 33 | .05 (.16) | 35 | .07 (.16) | 16 | .15 |
| HF-HRV | 3.40 (.99) | 47 | 3.32 (.87) | 37 | 4.20 (1.11) | 34 | 3.55 (.83) | 22 | .76\* |
| IBQ-R-REG | 5.23 (.82) | 56 | 5.07 (.77) | 50 | 5.30 (.64) | 45 | 5.19 (.67) | 33 | .09 |

HF-HRV; High Frequency-Heart Rate Variability; FAA, Frontal Alpha Asymmetry; IBQ-R-REG; Infant Behavior Questionnaire-Revised Very Short Form, Orienting/Regulatory Capacity; SD=Standard Deviation

\*statistically significant change (*p<.05)* in infant HF-HRV from T1 to T2 in the experimental group

**High Frequency- Heart Rate Variability:** Infant HF-HRV was not different between experimental and controls groups at T1. A statistically significant group by time interaction predicted change in HF-HRV between T1 and T2 (F(1,68.3)=4.04, p=.04), suggesting that maternal treatment predicted change in infant HF-HRV. After stratifying by group, we found that the main effect of time on HF-HRV scores was also statistically significant (*F*(1,36.6)=14.26, p=.001). After treatment, experimental group infants had an increase of 0.82 in HF-HRV while the control group experienced a mean increase of 0.22. The magnitude of this treatment effect was medium (*Hedges’ g*=.76) and suggests that infants’ ER improved with maternal treatment.

**Frontal Alpha Asymmetry:** At T1, mean FAA was not statistically significantly different between the experimental and control group infants. Results of the LMM indicated that there was no statistically significant group by time interaction to predict change in FAA scores over time (F(1,57.7)=.25, p=.62), suggesting that maternal treatment did not lead to changes in infant FAA. Experimental group means in Table 2 indicate that at T1 (FAA=.08) and T2 (FAA=.05), mean frontal asymmetric activity did not change substantially and remained as more left FAA following maternal treatment.

***Orienting/Regulatory Capacity (Temperament):*** At baseline, infants in the experimental and control group did not differ in IBQ-R. Mean scores at T1 and T2, stratified by group are presented in Table 2. To assess the effect of the intervention on maternal reports of infant ER, we used LMM to examine the orienting/regulatory capacity domain of the IBQ-R. Results of LMM indicated that there was no statistically significant group-by-time interaction to predict orienting/regulatory capacity (F(1,85.8)=.000, p=.99). Means reported in Table 2 suggest that maternal report of infant temperament was similar at both time points in both treatment arms.

**Discussion**

The results of this study suggest that PHN-delivered group CBT for PPD can lead to clinically significant improvements in PPD symptoms in mothers, as well as adaptive changes in a neurophysiological marker of infant ER (HF-HRV). However, it did not lead to statistically significant improvements in infant FAA or maternal reports of infant ER.

An increasing number of studies are examining the impact of maternal PPD treatment on infant outcomes, including markers of emotional, behavioural, and cognitive development (Ammerman et al., 2015; Bilszta et al., 2012; Cicchetti et al., 2000; Cohen et al., 2002; Cooper et al., 2003; Fonagy et al., 2016; Forman et al., 2007; Handley et al., 2017; Hart et al., 1998; Kersten-Alvarez et al., 2010; Meager & Milgrom, 1996; Misri et al., 2006; Onozawa et al., 2001; Stein et al., 2018b; Toth et al., 2006; Van Doesum et al., 2008; Verduyn et al., 2003). While only three of these measured offspring ER, they did report some positive influence of maternal treatment (Cohen et al., 2002; Krzeczkowski et al., 2021; Stein et al., 2018). However, two of these examined infant ER following maternal interventions delivered after the first postnatal year and both relied on observational assessments alone (Cohen et al., 2002; Stein et al., 2018). While the third study intervened in the first year of life and used physiological measures of ER, their sample was restricted to patients in a specialty perinatal mental health clinic and used an observational design with no PPD controls. The current study utilized a stronger study design (e.g., RCT), included mothers with a range of levels PPD symptoms living in the community, and a cost-effective and preferred, scalable treatment delivered by public health professionals (PHNs).

After nine weeks of treatment with group CBT for PPD, the present study found a statistically significant increase in infant HF-HRV of medium effect size. This is consistent with Krzeczkowski and colleagues’ observational study of an intervention delivered by expert therapists (Krzeczkowski et al., 2021) and a second RCT of group CBT delivered by mothers who had previously recovered from PPD (Amani et al., 2022 under review). Increases in infant HF-HRV suggest greater flexibility of the autonomic nervous system (ANS) through the activity of the vagus nerve (Porges, 2007; Porges et al., 2011; Quigley & Moore, 2018).

During the first year of life, the vagal circuitry that governs an infant’s sympathetic nervous system’s fight or flight response begins coordinating its circuits with higher-order cortical processes (Porges, 2007), resulting in the biobehavioural pathway that underlies the social engagement system (SES; Porges, 2007; Porges et al., 2011). This enables infants to use their social environment to regulate their emotions rather than relying on the more primitive fight or flight system (Porges et al., 2011). In fact, resting state HF-HRV indexes the balance of activity between these two systems (Porges et al., 2011). Since the socioemotional environment plays a key role in SES development (Porges et al., 2011), maternal PPD can negatively impact its development. Infants actively facilitate SES development by seeking out opportunities to engage with their mothers (Atzil et al., 2018). However, mothers with PPD are more likely to miss their infants’ cues and can fail to help their infants’ regulate their emotions (Moore & Calkins, 2004). Given the sensitivity of the SES to an infant’s social environment, even subtle changes (e.g., better recognition of infants’ cues by mothers) may have contributed to the adaptive changes in resting state HF-HRV observed. Indeed, maternal treatment may have reduced mothers’ symptoms of depression and/or anxiety and enabled their infants to better self-regulate, or maternal symptomatic improvements might have helped them to better engage their infants and enhance their self-regulation. However, since we did not specifically examine the factors that may change in mothers following treatment, we cannot say for certain why maternal treatment led to an increase in infant HF-HRV.

Unlike our previous trial of a peer-delivered PPD intervention (*under review*) and Krzeczkowski et al.’s observational study, we did not observe changes in FAA or maternally reported ER following treatment. It is not clear why our results differ, but it could be due to differences in sample characteristics and/or intervention delivery. Our sample was recruited from the community, and just 67.3% were diagnosed with MDD, compared to Krzeczkowski et al.’s clinical sample where all had MDD (Krzeczkowski et al., 2021). Moreover, participants in the peer-led RCT had fewer years of education and a lower mean household income (Amani et al., 2022 under review) than the present study. As a result, infants in the present study may have had less exposure to negative environmental factors (maternal depression, socioeconomic disadvantage) and so were more limited in the amount they could improve, reducing their ability to initiate changes to large-scale neural networks. Frontal alpha asymmetry and temperament assess stable (Brooker et al., 2017; Müller et al., 2015), trait-related (Fox, 1994; Rothbart, 2007; Smith et al., 2016) mechanisms through which infants interact with their environment (e.g., approach-withdrawal tendencies; Harmon-Jones & Gable, 2017) and both result from the coordinated activity of multiple brain regions (Davidson, 2000; Posner et al., 2012). Therefore, changes in FAA and temperament may require larger changes in an infant’s environment relative to infant HF-HRV, which is sensitive to more acute changes in socioemotional environments (Atzil et al., 2018), or take longer to manifest.

There may be additional reasons why we did not find change in infant FAA and temperament following maternal treatment. First, infants in our treatment group exhibited greater left frontal asymmetric activity prior to treatment (0.08), while infants in Krzeczkowski et al. presented greater right frontal asymmetric activity at baseline (Krzeczkowski et al., 2021). Second, we used a relatively new mobile, dry EEG system to measure FAA outside, and we may have also had inadequate statistical power to detect changes in FAA and temperament. For instance, while a *post-hoc* power calculation revealed that we had sufficient statistical power (0.96) to detect changes in HF-HRV, the power to detect differences in FAA and IBQ-R changes was much lower (0.16 and 0.12, respectively).

The results of this study should also be examined in the context of some further limitations. In our study, most of our participants were white, married, had several years of post-secondary education, and all lived in a region where healthcare is universally available. Therefore, our findings may not be generalizable to all groups with PPD. It is also important to note that our sample size is small and *post-hoc* power calculations suggest that we may not have had adequate statistical power to detect changes in two of our infant outcomes (FAA and IBQ-R). Additionally, more participant attrition was observed in the control group, and attrition on FAA was also significantly higher. Because physiological data from infants was collected in community settings, we used the MUSE EEG band for its portability and practicality. While it may have affected our FAA findings, a previous RCT by our group using this technology did replicate the findings of an observational study that used a full dense array EEG system (Krzeczkowski et al., 2021). Lastly, the pandemic limited our ability to examine timepoints beyond the immediate post-treatment period, highlighting the need to examine the longer-term effects of maternal PPD treatment on infant ER.

The findings of this study suggest that delivery of group CBT for PPD task-shifted to PHNs effectively reduced symptoms of depression in mothers and led to adaptive increases in infant HF-HRV after just nine weeks. These results suggest that treating maternal PPD could have the potential to alter infant ER and neurophysiology at the level of the ANS. However, maternal treatment did not lead to changes in FAA or maternal reports of temperament, and so studies of larger samples examining outcomes over longer time periods are required. While our work highlights the importance of early maternal intervention and its potential public health impact, more work is needed to further our understanding of the mechanisms responsible for putative infant ER change, and the potential long-term impact of early PPD treatment.

**References**

Ammerman, R. T., Altaye, M., Putnam, F. W., Teeters, A. R., Zou, Y., & Van Ginkel, J. B. (2015). Depression improvement and parenting in low-income mothers in home visiting. *Archives of Women’s Mental Health*, *18*(3), 555–563. https://doi.org/10.1007/s00737-014-0479-7

Atzil, S., Gao, W., Fradkin, I., & Barrett, L. F. (2018). Growing a social brain. *Nature Human Behaviour*, *2*(9), 624–636. https://doi.org/10.1038/s41562-018-0384-6

Bauer, A., Knapp, M., & Adelaja, B. (2016). Best practice for perinatal mental health care : the economic case. *PSSRU Report*.

Bilszta, J. L. C., Buist, A. E., Wang, F., & Zulkefli, N. R. (2012). Use of video feedback intervention in an inpatient perinatal psychiatric setting to improve maternal parenting. *Archives of Women’s Mental Health*, *15*(4), 249–257. https://doi.org/10.1007/s00737-012-0283-1

Bornstein, M. H., & Suess, P. E. (2000). Physiological self-regulation and information processing in infancy: Cardiac vagal tone and habituation. *Child Development*, *71*(2), 273–287. https://doi.org/10.1111/1467-8624.00143

Brooker, R. J., Canen, M. J., Davidson, R. J., & Hill Goldsmith, H. (2017). Short- and long-term stability of alpha asymmetry in infants: Baseline and affective measures. *Psychophysiology*, *54*(8), 1100–1109. https://doi.org/10.1111/psyp.12866

Calkins, S. D., Dollar, J. M., & Wideman, L. (2019). Temperamental vulnerability to emotion dysregulation and risk for mental and physical health challenges. *Development and Psychopathology*, *31*(3), 957–970. https://doi.org/10.1017/S0954579419000415

Cicchetti, D., Rogosch, F. A., & Toth, S. L. (2000). The efficacy of Toddler-Parent Psychotherapy for fostering cognitive development in offspring of depressed mothers. *Journal of Abnormal Child Psychology*, *28*(2), 135–148. https://doi.org/10.1023/A:1005118713814

Coan, J. A., & Allen, J. J. B. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological Psychology*, *67*(1–2), 7–50. https://doi.org/10.1016/j.biopsycho.2004.03.002

Cohen, N. J., Lojkasek, M., Muir, E., Muir, R., & Parker, C. J. (2002). Six-month follow-up of two mother-infant psychotherapies: Convergence of therapeutic outcomes. *Infant Mental Health Journal*, *23*(4), 361–380. https://doi.org/10.1002/imhj.10023

Cooper, P. J., Murray, L., Wilson, A., & Romaniuk, H. (2003). Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. I. Impact on maternal mood. *British Journal of Psychiatry*, *182*(MAY), 412–419. https://doi.org/10.1192/bjp.182.5.412

Davidson, R. J. (2000). Affective Style, Psychopathology, and Resilience: Brain Mechanisms and Plasticity. *American Psychologist*, *55*(11), 1214–1230.

Dennis, C. L., Grigoriadis, S., Zupancic, J., Kiss, A., & Ravitz, P. (2020). Telephone-based nurse-delivered interpersonal psychotherapy for postpartum depression: Nationwide randomised controlled trial. *British Journal of Psychiatry*, *216*(4), 189–196. https://doi.org/10.1192/bjp.2019.275

Earls, M. F., Siegel, B. S., Dobbins, M. I., Garner, A. S., McGuinn, L., Pascoe, J., Wood, D. L., Brown, R. T., Kupst, M. J., Martini, D. R., Sheppard, M., Cohen, G. J., & Smith, K. S. (2010). Clinical report - Incorporating recognition and management of perinatal and postpartum depression into pediatric practice. *Pediatrics*, *126*(5), 1032–1039. https://doi.org/10.1542/peds.2010-2348

Field, T., Diego, M., Hernandez-Reif, M., Schanberg, S., Kuhn, C., Yando, R., & Bendell, D. (2002). Prenatal depression effects on the foetus and neonate in different ethnic and socio-economic status groups. *JOURNAL OF REPRODUCTIVE AND INFANT PSYCHOLOGY*, *20*(3), 149–157. https://doi.org/10.1080/026468302760270809

Field, T., Fox, N. A., Pickens, J., & Nawrocki, T. (1995). Relative Right Frontal EEG Activation in 3- to 6-Month-Old Infants of “Depressed” Mothers. *Developmental Psychology*, *31*(3), 358–363. https://doi.org/10.1037/0012-1649.31.3.358

Fonagy, P., Sleed, M., & Baradon, T. (2016). Randomized controlled trial of parent-infant psychotherapy for parents with mental health problems and young infants. *Infant Mental Health Journal*, *37*(2), 97–114. https://doi.org/10.1002/imhj.21553

Forman, D. R., O’Hara, M. W., Stuart, S., Gorman, L. L., Larsen, K. E., & Coy, K. C. (2007). Effective treatment for postpartum depression is not sufficient to improve the developing mother-child relationship. *Development and Psychopathology*, *19*(2), 585–602. https://doi.org/10.1017/S0954579407070289

Fox, N. (1994). Dynamic Cerebral Processes Underlying Emotion Regulation. *Monographs of the Society for Research in Child Development*, *59*(2/3), 152–166. https://doi.org/10.1007/sl

Fox, N. A. (1991). If It’s Not Left, It’s Right. *American Psychologist,* *46*(8), 863–872.

Fox, N. A. (1998). Temperament and regulation of emotion in the first years of life. *Pediatrics*, *102*(5 Suppl E), 1230–1235.

Fox, N. A., Henderson, H. A., Rubin, K. H., Calkins, S. D., & Schmidt, L. A. (2001). Continuity and discontinuity of behavioral inhibition and exuberance: Psychophysiological and behavioral influences across the first four years of life. *Child Development*, *72*(1), 1–21. https://doi.org/10.1111/1467-8624.00262

Gaynes, B. N., Gavin, N., Meltzer-Brody, S., Lohr, K. N., Swinson, T., Gartlehner, G., Brody, S., & Miller, W. C. (2005). Perinatal depression: prevalence, screening accuracy, and screening outcomes. *Evidence Report/Technology Assessment (Summary)*, *119*, 1–8. https://doi.org/10.1037/e439372005-001

Goodman, J. H. (2009). Women’s attitudes, preferences, and perceived barriers to treatment for perinatal depression. *Birth*, *36*(1), 60–69. https://doi.org/10.1111/j.1523-536X.2008.00296.x

Goodman, S. H., Rouse, M. H., Connell, A. M., Broth, M. R., Hall, C. M., & Heyward, D. (2011). Maternal Depression and Child Psychopathology: A Meta-Analytic Review. *Clinical Child and Family Psychology Review*, *14*(1), 1–27. https://doi.org/10.1007/s10567-010-0080-1

Handley, E. D., Michl-Petzing, L. C., Rogosch, F. A., Cicchetti, D., & Toth, S. L. (2017). Developmental cascade effects of interpersonal psychotherapy for depressed mothers: Longitudinal associations with toddler attachment, temperament, and maternal parenting efficacy. *Development and Psychopathology*, *29*(2), 601–615. https://doi.org/10.1017/s0954579417000219

Harmon-Jones, E., & Gable, P. A. (2017). On the role of asymmetric frontal cortical activity in approach and withdrawal motivation: An updated review of the evidence. *Psychophysiology*, *1*. https://doi.org/10.1111/psyp.12879

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010

Hart, S., Field, T., & Nearing, G. (1998). Depressed mothers’ neonates improve following the MABI and a brazelton demonstration. *Journal of Pediatric Psychology*, *23*(6), 351–356. https://doi.org/10.1093/jpepsy/23.6.351

Heim, C., & Binder, E. B. (2012). Current research trends in early life stress and depression: Review of human studies on sensitive periods, gene-environment interactions, and epigenetics. *Experimental Neurology*, *233*(1), 102–111. https://doi.org/10.1016/j.expneurol.2011.10.032

Jones, A. (2019). Help seeking in the perinatal period: A review of barriers and facilitators. *Social Work in Public Health*, *34*(7), 596–605. https://doi.org/10.1080/19371918.2019.1635947

Kersten-Alvarez, L. E., Hosman, C. M. H., Riksen-Walraven, J. M., Van Doesum, K. T. M., & Hoefnagels, C. (2010). Long-term effects of a home-visiting intervention for depressed mothers and their infants. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *51*(10), 1160–1170. https://doi.org/10.1111/j.1469-7610.2010.02268.x

Kingston, D., Tough, S., & Whitfield, H. (2012). Prenatal and postpartum maternal psychological distress and infant development: A systematic review. *Child Psychiatry and Human Development*, *43*(5), 683–714. https://doi.org/10.1007/s10578-012-0291-4

Ko, J. Y., Farr, S. L., Dietz, P. M., & Robbins, C. L. (2012). Nonpregnant women of reproductive age, 2005 – 2009. *Journal of Women’S Health*, *21*(8), 830–836. https://doi.org/10.1089/jwh.2011.3466.Depression

Krigolson, O. E., Williams, C. C., Norton, A., Hassall, C. D., & Colino, F. L. (2017). Choosing MUSE: Validation of a low-cost, portable EEG system for ERP research. *Frontiers in Neuroscience*, *11*(MAR), 1–10. https://doi.org/10.3389/fnins.2017.00109

Krzeczkowski, J. E., Schmidt, L. A., & Van Lieshout, R. J. (2021). Changes in infant emotion regulation following maternal cognitive behavioral therapy for postpartum depression. *Depression and Anxiety*, *December 2020*, 1–10. https://doi.org/10.1002/da.23130

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart rate variability and cardiac vagal tone in psychophysiological research - Recommendations for experiment planning, data analysis, and data reporting. *Frontiers in Psychology*, *8*, 1–18. https://doi.org/10.3389/fpsyg.2017.00213

Lusby, C. M., Goodman, S. H., Bell, M. A., & Newport, D. J. (2014). Electroencephalogram patterns in infants of depressed mothers. *Developmental Psychobiology*, *56*(3), 459–473. https://doi.org/10.1002/dev.21112

Lusby, C. M., Goodman, S. H., Yeung, E. W., Bell, M. A., & Stowe, Z. N. (2016). Infant EEG and temperament negative affectivity: Coherence of vulnerabilities to mothers’ perinatal depression. *DEVELOPMENT AND PSYCHOPATHOLOGY*, *28*(4, 1, SI), 895–911. https://doi.org/10.1017/S0954579416000614

Marshall, P. J., Bar-Haim, Y., & Fox, N. A. (2002). Development of the EEG from 5 months to 4 years of age. *Clinical Neurophysiology*, *113*(8), 1199–1208. https://doi.org/10.1016/S1388-2457(02)00163-3

Mason, J. W. (1975). A historical view of the stress field. *Journal of Human Stress*, *1*(2), 22–36. https://doi.org/10.1080/0097840X.1975.9940405

Meager, I., & Milgrom, J. (1996). Group treatment for postpartum depression: A pilot study. *Australian and New Zealand Journal of Psychiatry*, *30*(6), 852–860. https://doi.org/10.3109/00048679609065055

Meaney, M. J. (2018). Perinatal maternal depressive symptoms as an issue for population health. *American Journal of Psychiatry*, *175*(11), 1084–1093. https://doi.org/10.1176/appi.ajp.2018.17091031

Metelli, S., & Chaimani, A. (2020). Challenges in meta-analyses with observational studies. *Evidence-Based Mental Health*, *23*(2), 83–87. https://doi.org/10.1136/ebmental-2019-300129

Misri, S., Reebye, P., Milis, L., & Shah, S. (2006). The impact of treatment intervention on parenting stress in postpartum depressed mothers: A prospective study. *American Journal of Orthopsychiatry*, *76*(1), 115–119. https://doi.org/10.1037/0002-9432.76.1.115

Moore, G. A., & Calkins, S. D. (2004). Infants’ vagal regulation in the still-face paradigm is related to dyadic coordination of mother-infant interaction. *Developmental Psychology*, *40*(6), 1068–1080. https://doi.org/10.1037/0012-1649.40.6.1068

Müller, B. C. N., Kühn-Popp, N., Meinhardt, J., Sodian, B., & Paulus, M. (2015). Long-term stability in children’s frontal EEG alpha asymmetry between 14-months and 83-months. *International Journal of Developmental Neuroscience*, *41*, 110–114. https://doi.org/10.1016/j.ijdevneu.2015.01.002

Neto, O. L., Haenni, S., Phuka, J., Ozella, L., Paolotti, D., Cattuto, C., Robles, D., & Lichand, G. (2021). Combining wearable devices and mobile surveys to study child and youth development in Malawi: Implementation study of a multimodal approach. *JMIR Public Health and Surveillance*, *7*(3). https://doi.org/10.2196/23154

Onozawa, K., Glover, V., Adams, D., Modi, N., & Kumar, R. C. (2001). Infant massage improves mother-infant interaction for mothers with postnatal depression. *Journal of Affective Disorders*, *63*(1), 201–207. https://doi.org/10.1016/S0165-0327(00)00198-1

Panari, C., Tonelli, M., & Mazzetti, G. (2020). Emotion regulation and employability: The mediational role of ambition and a protean career among unemployed people. *Sustainability (Switzerland)*, *12*(22), 1–13. https://doi.org/10.3390/su12229347

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*(2), 116–143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Porges, Stephen W., Furman, S. A. (2011). The Early Development of the Autonomic Nervous System Provides a Neural Platform for Social Behaviour: A Polyvagal Perspective. *Infant and Child Development*, *20*, 106–118. https://doi.org/10.1002/icd

Posner, M. I., Rothbart, M. K., Sheese, B. E., & Voelker, P. (2012). Control Networks and Neuromodulators of Early Development. *Developmental Psychology*, *48*(3), 827–835. https://doi.org/10.1037/a0025530.Control

Propper, C., & Moore, G. A. (2006). The influence of parenting on infant emotionality: A multi-level psychobiological perspective. *Developmental Review*, *26*(4), 427–460. https://doi.org/10.1016/j.dr.2006.06.003

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. https://doi.org/10.1016/j.infbeh.2006.01.004

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and Heterotypic Continuity of Fine-grained Temperament during Infancy, Toddlerhood, and Early Childhood. *Infant and Child Development*, *17*(6), 387–405. https://doi.org/10.1002/icd

Putnam SP, Helbig AL, Gartstein MA, Rothbart MK, L. E. (2014). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. J Pers Assess. *J Pers Assess.*, *96*(4), 445–458.

Quigley, K. M., & Moore, G. A. (2018). Development of cardiac autonomic balance in infancy and early childhood: A possible pathway to mental and physical health outcomes. *Developmental Review*, *49*(February), 41–61. https://doi.org/10.1016/j.dr.2018.06.004

Ratti, E., Waninger, S., Berka, C., Ruffini, G., & Verma, A. (2017). Comparison of medical and consumer wireless EEG systems for use in clinical trials. *Frontiers in Human Neuroscience*, *11*(August), 1–7. https://doi.org/10.3389/fnhum.2017.00398

Rothbart, M. K. (2007). Temperament , Development, and Personality. *Current Directions in Psychological Science*, *16*(4), 207–212.

Shannon, K. E., Beauchaine, T. P., Brenner, S. L., Neuhaus, E., & Gatzke-Kopp, L. (2007). Familial and temperamental predictors of resilience in children at risk for conduct disorder and depression. *Development and Psychopathology*, *19*(3), 701–727. https://doi.org/10.1017/S0954579407000351

Sheehan D, Lecrubier Y, Janavs J, Knapp E, W. E. (1998). *The Development and Validation of a Structured Diagnostic Psychiatric Interview. J Clin Psychiatry.* *50*(20), 22–33.

Slomian, J., Honvo, G., Emonts, P., Reginster, J. Y., & Bruyère, O. (2019). Consequences of maternal postpartum depression: A systematic review of maternal and infant outcomes. In *Women’s Health* (Vol. 15). https://doi.org/10.1177/1745506519844044

Smith, C. L., Diaz, A., Day, K. L., & Bell, M. A. (2016). Infant frontal electroencephalogram asymmetry and negative emotional reactivity as predictors of toddlerhood effortful control. *Journal of Experimental Child Psychology*, *142*, 262–273. https://doi.org/10.1016/j.jecp.2015.09.031

Stein, A., Netsi, E., Lawrence, P. J., Granger, C., Kempton, C., Craske, M. G., Nickless, A., Mollison, J., Stewart, D. A., Rapa, E., West, V., Scerif, G., Cooper, P. J., & Murray, L. (2018). Mitigating the effect of persistent postnatal depression on child outcomes through an intervention to treat depression and improve parenting: a randomised controlled trial. *The Lancet Psychiatry*, *5*(2), 134–144. https://doi.org/10.1016/S2215-0366(18)30006-3

Thayer, J. F., & Brosschot, J. F. (2005). Psychosomatics and psychopathology: Looking up and down from the brain. *Psychoneuroendocrinology*, *30*(10), 1050–1058. https://doi.org/10.1016/j.psyneuen.2005.04.014

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, *37*(2), 141–153. https://doi.org/10.1007/s12160-009-9101-z

Toth, S. L., Rogosch, F. A., Manly, J. T., & Cicchetti, D. (2006). The efficacy of toddler-parent psychotherapy to reorganize attachment in the young offspring of mothers with major depressive disorder: A randomized preventive trial. *Journal of Consulting and Clinical Psychology*, *74*(6), 1006–1016. https://doi.org/10.1037/0022-006X.74.6.1006

Tottenham, N. (2019). Early Adversity and the Neotenous Human Brain. *Biological Psychiatry*, *16*, 1–10. https://doi.org/10.1016/j.biopsych.2019.06.018

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, *17*(2), 147–156. https://doi.org/10.1080/10673220902899714

Van Doesum, K. T. M., Riksen-Walraven, J. M., Hosman, C. M. H., & Hoefnagels, C. (2008). A randomized controlled trial of a home-visiting intervention aimed at preventing relationship problems in depressed mothers and their infants. *Child Development*, *79*(3), 547–561. https://doi.org/10.1111/j.1467-8624.2008.01142.x

Van Lieshout, R. J., Layton, H., Feller, A., Ferro, M. A., Biscaro, A., & Bieling, P. J. (2020). Public health nurse delivered group cognitive behavioral therapy (CBT) for postpartum depression: A pilot study. *Public Health Nursing*, *37*(1), 50–55. https://doi.org/10.1111/phn.12664

Van Lieshout, R. J., Layton, H., Savoy, C. D., Haber, E., Feller, A., Biscaro, A., Bieling, P. J., & Ferro, M. A. (2022). Public Health Nurse-delivered Group Cognitive Behavioural Therapy for Postpartum Depression: A Randomized Controlled Trial. *Canadian Journal of Psychiatry*, 1–9. https://doi.org/10.1177/07067437221074426

Van Lieshout, R. J., Layton, H., Savoy, C., Haber, E., Feller, A., Biscaro, A., Bieling, P. J., & Ferro, M. A. (2021). Public Health Nurse-Delivered Group Cognitive Behavioural Therapy for Postpartum Depression: A Randomized Controlled Trial. *Under Review at Canadian Journal of Psychiatry*, 1–9. https://doi.org/10.1177/07067437221074426

Van Lieshout, R. J., Yang, L., Haber, E., & Ferro, M. A. (2017). Evaluating the effectiveness of a brief group cognitive behavioural therapy intervention for perinatal depression. *Archives of Women’s Mental Health*, *20*(1), 225–228. https://doi.org/10.1007/s00737-016-0666-9

Verduyn, C., Barrowclough, C., Roberts, J., Tarrier, N., & Harrington, R. (2003). Maternal depression and child behaviour problems Randomised placebo-controlled trial of a cognitive-behavioural group intervention. *British Journal of Psychiatry*, *183*, 342–348. https://doi.org/10.1192/bjp.183.4.342

**Chapter 5. Discussion**

To ensure better outcomes for both parents and their infants, this thesis aimed to contribute to the literature seeking to improve access to evidence-based treatment for PPD and the potential for treatment to benefit infants exposed to PPD. This thesis found that a nine-week, peer-delivered group cognitive behavioural therapy (CBT) intervention for PPD appeared to effectively treat maternal PPD. Mothers who participated in the nine-week intervention experienced clinically significant improvements in symptoms of depression and anxiety, changes that remained even six months after treatment. There was also evidence that maternal participation in a nine-week group CBT intervention for PPD led to adaptive change in at least one physiological marker of ER in their infants. The studies in this thesis highlight the potential of using task-shifting to fill a gap in the current healthcare system’s treatment of common, time-sensitive conditions like PPD. It appears that treating mothers may not only help improve their symptoms but may also mitigate PPD-related consequences for ER development and potentially disrupt the familial cycle of mental health risk.

**Implications for Mothers**

The guideline recommends a raised

threshold for using psychotropic drugs for some disorders (such

as mild or moderate depression or anxiety) and more emphasis

on providing psychological therapies. This requires greater and

faster availability of psychological interventions that meet the

needs of pregnant women and those with newborn babies.

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Clinical practice guidelines for the treatment of PPD recommend (NICE, 2007), and those with PPD (O’Mahen & Flynn, 2008) prefer, psychotherapeutic interventions like cognitive behavioural therapy (CBT). However, CBT is traditionally delivered by licensed mental health practitioners in medical settings, creating a number of potential impediments to treatment. Accessibility of even group CBT is rare, as costs are high (Payne & Myhr, 2010) and it requires referrals from healthcare professionals. In a qualitative study, Dennis and Chung-Lee explained that a common-barrier for women in accessing help for their PPD was not being able to disclose their symptoms publicly (Dennis & Chung-Lee, 2006). This reluctance to disclose their symptoms was further reinforced by women’s perceptions that their family members and healthcare providers would be unable to meet their needs and respond appropriately to their unique challenges (Dennis & Chung-Lee, 2006). Indeed, many with PPD decide to not seek treatment out of fear that their desire for psychotherapy will be dismissed and instead, they will be prescribed medication (Holopainen, 2002). One review found that women were reluctant to seek PPD treatment because they were told in the past to “wait and see what happened” by their healthcare providers (Hansotte et al., 2017). Understandably, experiences like these can leave mothers and birthing parents feeling ignored and dismissed by the healthcare system and can deter them from seeking future treatment for PPD. In order to truly increase access, major changes are needed in the way we deliver services to women and birthing parents to ensure that they can receive the treatment options for PPD that they prefer in a timely manner.

While past peer interventions have highlighted the potential of task-shifting the treatment of PPD, none appear to have been scaled and used widely in clinical practice to date. In one trial, Dennis and colleagues found that treatment with individual, telephone-based peer support led to half the risk of PPD at three months postpartum compared to a control group of untreated mothers with PPD (Dennis et al., 2009). In a second trial, when individual telephone-based peer support was used to treat those currently with PPD, Dennis and colleagues found significant change in depressive symptoms among participants (Letourneau et al., 2015). However, 11% of participants (four out of 34 participants) experienced symptom persistence or relapse. Following peer-delivered group CBT in the present thesis, just one participant (of 22 participants) experienced symptom worsening following treatment completion. Even once group CBT is over, participants are able to use the CBT strategies that they have learned, whereas in a peer support intervention, the benefits of the treatment may no longer be remain once treatment is over. Not only may our peer intervention be more effective, but its group delivery and structured format may give it more potential for scaling up. More recently, Prevatt and colleagues tested the effectiveness of a peer support intervention for PPD delivered in a group (Prevatt et al., 2018). While this group peer intervention appeared to reduce symptoms of depression in program participants, when post-treatment depression scores were compared to a sample of women with PPD who did not receive treatment, there were no differences in symptom reduction at the post-treatment follow-up between these two groups. In the present thesis however, peer-delivery of group CBT resulted in significant differences between our treatment and control group. Notably, Prevatt and colleagues peer intervention involved weekly support groups that were facilitated by maternal health professionals in addition to peers. Although we cannot say for certain, in keeping with past peer-delivered interventions (Bryan & Arkowitz, 2015) co-facilitation of the peer groups by mental health professionals may also have affected the effectiveness of their peer intervention.

Recently, a systematic review identified seven studies that tested the effectiveness of peer support interventions for PPD and found a medium treatment effect in maternal depression improvement following treatment (SMD=-0.51; Fang et al., 2022). In the present thesis, peer-delivered group CBT intervention appears to have a greater treatment effect (*hedges’ g* = 1.2). Evidence from peer interventions for depression in the general population have identified the use of structured and evidence-based psychotherapy as being key to ensuring that treatment has the greatest impact (Bryan & Arkowitz, 2015).While the present thesis only describes one study, it is possible that evidence-based psychotherapies that are delivered by peers may be capable of producing larger positive effects than non-specific support alone.

In Singla and colleagues’ recent meta-analysis of non-specialist (e.g., midwives, nurses, peers) treatments for perinatal depression, 15 studies that examined a PPD treatment were identified (Singla et al., 2021). Overall, these interventions had a treatment effect that was medium in magnitude (SMD= 0.38). Of these 15 treatment studies, just two included interventions delivered by peers (Letourneau et al., 2011; Taft et al., 2011). Letourneau and colleagues’ randomized trial of a home-based peer support for PPD involved individual support delivered by trained peers with a history of PPD. This peer intervention was found to not be effective in reducing symptoms in the treatment group, and instead had a treatment effect that favoured controls (SMD=-0.6; Letourneau et al., 2011). While Taft and colleague’s assessment of a weekly, home-visit intervention delivered by trained local mothers led to some reductions in maternal depressive symptoms in the treatment group, the treatment effect size was small (SMD=0.18) and differences were not statistically significant between treatment and control groups. Why these were not as effective as expected is not clear, though neither of these peer interventions included a structure, evidence-based psychotherapy. When Singla and colleagues conducted a subgroup analysis of evidence-based (e.g., CBT) and non-evidence-based interventions (e.g., support) among all non-specialist provider interventions, they found a greater treatment effect for those traditionally seen as ‘evidence-based’ (SMD=0.43) (vs. SMD=0.29). The present thesis’ peer intervention treatment effect appeared to be greater than the non-specialist provider evidence-based treatments for PPD (*hedges’ g* = 1.2) and its magnitude appears to be more in line with treatment effects found in previous trials of professionally delivered interpersonal psychotherapy (Sockol, 2018) and CBT (Sockol, 2015). Our greater treatment effect may be explained by the combination of treatment delivery by peers (Mead et al., 2001; Montgomery et al., 2012; Resnick & Rosenheck, 2008), its group format(Lavender et al., 2016), and the use of an evidence-based psychotherapy (MacQueen et al., 2016), all factors that have been found in previous studies to be especially beneficial to those with PPD. The weekly supervision that peers received following each weekly group CBT session may have also contributed to the greater treatment effect in our peer intervention. Lastly, it is important to note that there is evidence to suggest that studies with waitlist control groups have been found to have inflated effect sizes which may also be the case in the present thesis (Gold et al., 2017).

Group delivery of psychotherapy may also be especially beneficial to women and birthing parents during the postpartum period as it provides them with the experience of social support they may find lacking in their lives otherwise. In the present thesis, mothers were given the opportunity to be treated alongside a group of others who can truly empathize with them. The promise of social support can have a tremendous positive impact in women’s comfort in initiating treatment. Mothers and birthing parents may feel more comfortable participating in psychotherapy when in a room surrounded by individuals in similar circumstances who can relate to their experiences. Importantly, group intervention delivery by recovered former sufferers of PPD may facilitate the development of a community of support around PPD, while helping to normalize and destigmatize PPD. Indeed, the group format of these interventions may dramatically shift the perceptions of mothers and birthing parents with PPD. In the long-term, building these communities may make it easier for individuals to disclose their symptoms to others, actively seek help, and participate in treatment in the present and in the future.

The present thesis highlights the potential of a peer-delivered group psychotherapeutic intervention to effectively treat maternal PPD that not only provides an engaging solution to existing treatment barriers, but it has the potential for large-scale uptake and dissemination. Indeed, the task-shifting of the treatment of mild-to-moderate PPD may allow more specialized healthcare professionals to prioritize severe psychiatric cases, while allowing those with PPD to still receive effective, evidence-based care in a timely manner. The peer intervention in the present thesis was also designed to allow individuals to self-refer and did not require referral by a health care professional. This provides mothers and birthing parents with the opportunity to take control of their own treatment and bypass any potential gatekeeping by healthcare professionals. This is especially important given the knowledge that many family physicians do not have the training to make informed decisions regarding PPD treatment and may not be in the best position to screen for PPD. Indeed, the opportunity to self-refer for psychotherapeutic treatment could potentially have a tremendous impact on the number of women who feel comfortable seeking treatment for PPD.

**Implications for Infant Development**

In this thesis we demonstrate that a task-shifted intervention may not only effectively treat PPD, but it may also have the potential to disrupt the transmission of psychiatric risk from mother to infant by mitigating potential problems with ER development. Problems with emotion regulation (ER) as a result of maternal PPD exposure may explain the increased risk of poor offspring outcomes (Calkins et al., 2019; Panari et al., 2020; Shannon et al., 2007). Extant literature posits that PPD exposure may affect the ER brain networks that rely heavily on interactions with caregivers in the first year of life (Calkins et al., 2019; Tottenham, 2019). The findings in the present thesis suggest that maternal treatment with a brief, task-shifted group CBT intervention may mitigate these adverse consequences.

Of the research that has explored the impact of maternal PPD treatment on infant developmental outcomes, just three studies have assessed change in infant ER as an outcome (Cohen et al., 2002; Krzeczkowski et al., 2021; Stein et al., 2018) and each reported some positive influence of maternal treatment on infant ER. Stein et al. conducted a randomized controlled trial (RCT) where mothers were randomized to receive one of two interventions (Stein et al., 2018).While both interventions included group CBT, one intervention included a parenting treatment and the second an active control stress management treatment. To measure infant ER, this trial used the laboratory temperament assessment Battery (Lab-TAB) Barrier Paradigm, an observational measure that involves hiding a toy behind a clear barrier and observing infants’ reactions to not being able to reach the toy. A year following treatment initiation, infants in both groups appeared to display ER that matched non-clinical norms. While Stein and colleagues’ findings interpret their findings as suggesting that maternal CBT may benefit infant ER, there are a number of factors in their trial that should be noted. First, since participants in both groups received CBT and infant ER was compared to non-clinical norms, we cannot examine infant ER changes following maternal treatment against infants with mothers who were untreated. Stein and colleagues’ trial also did not measure infant ER at baseline (i.e., prior to maternal treatment) and as a result, infant ER change from before to after maternal treatment could not be examined.

In a second trial examined the effect of two different PPD interventions on infant ER (Cohen et al., 2002), Cohen and colleagues’ randomized mother-infant dyads to receive either mother–infant psychodynamic psychotherapy or an infant-focused therapy. Using an observational measure of infant ER (the Bayley Infant Behavior Rating Scale), they found that infants improved six months after both interventions were initiated. However, like Stein and colleagues’ trial, they did not include a no-treatment control group and offspring ER was measured using a single, observer-rated measure of behaviour.

More recently, an observational study conducted in Canada (Krzeczkowski et al., 2021) used two neurophysiological markers (FAA, HF-HRV) and a parental-report of infant behaviour to measure infant ER and its change in response to maternal PPD treatment. In this study, a nine-week group CBT for PPD delivered by expert therapists, appeared to lead to adaptive change in all three of the markers of infant ER. It is important to note that this study’s sample was restricted to patients in a specialty perinatal mental health clinic and used an observational design without a no-treatment control group. Nonetheless, this study was the first to use multiple measures of infant ER, including measures of infant neurophysiology, to assess infant ER before and after maternal treatment.

In line with Krzeczkowski et al.’s findings, PPD treatment delivered by peers led to changes in two neurophysiological measures of infant ER in the present thesis (FAA and HF-HRV), while therapy delivered by PHNs appeared to lead only to change in just a single measure of infant ER (HF-HRV). It is important to note that change in HF-HRV following maternal treatment with a task-shifted nine-week group CBT intervention appears to have occur consistently across all studies despite the differences in the treatment deliverer and study design. However, as will be discussed below, neither peer nor PHN-delivered treatment resulted in changes in maternal-report of infant temperament following treatment completion.

Both the present thesis’ peer intervention and Krzeczkowski et al.’s expert therapist-delivered intervention appeared to have led to change in FAA, while the PHN-delivered treatment did not. Given that both the peer and PHN interventions were effective in treating maternal PPD, differences in the results are likely not due to differences in the intervention but instead may be due to differences in the study samples. The differences between the samples treated with peer and PHN-delivered interventions are worth noting as they may have contributed to the differing results. Based on self-reported socio-demographic information, infants whose mothers were treated with the PHN-delivered intervention may have experienced a less adverse or negative environment than infants of mothers in the peer-delivered intervention. Indeed, mothers in the peer intervention appear to have a greater proportion of major depressive disorder (MDD) diagnoses, as well as a lower household income than mothers in the PHN intervention. Although we cannot know for certain, based on the socio-demographics data we do have, it is possible that infants of mothers in the PHN-intervention were not exposed to as negative an environment as those in the peer-intervention. Consequently, infants with mothers in the PHN-intervention may have experienced fewer negative effects to their socio-emotional environment and these consequences may not have reached the threshold of severity that would have resulted in changes to frontal cortical activity (i.e., greater right FAA) before maternal treatment. A number of studies have linked infant exposure to maternal PPD to greater right FAA at rest (Lusby et al., 2014; Wen et al., 2017). This would appear to support our findings that infants whose mothers participated in the PHN intervention demonstrated greater left FAA even before maternal treatment initiation. This highlights the possibility that these infants had a less negative socio-emotional environment to start. If this is the case, then it is possible that infants in the PHN-delivered treatment for PPD trial were limited in the amount that they could improve, thereby preventing us from observing changes to large-scale neural connections.

Given that FAA and measures of temperament assess trait-like, stable mechanisms that govern how infants interact with their environments (Brooker et al., 2017; Fox, 1994; Müller et al., 2015; Rothbart, 2007; Smith et al., 2016), this marker of ER capacity may require more substantial changes in an infant’s environment to see a substantial difference over time. On the other hand, HF-HRV may be more sensitive to acute changes in an infant’s socioemotional environment (Atzil et al., 2018). Infants’ social engagement system (SES) allows them to use their social environment to regulate their emotions instead of resorting to their more primitive fight or flight system (Porges, Furman, 2011; Porges, 2007). In fact, high frequency heart rate variability provides a measure of the balance of activity between these two systems(Porges, Furman, 2011). The development of an infants’ SES relies heavily on interactions with mothers. As PPD can negatively affect mothers’ ability to recognize and respond appropriately to their infants attempts at interaction, maternal treatment may allow for slight improvements in a mother’s sensitivity and ability to recognize infants’ cues. In turn, promoting infants’ use of their SES when in need of regulating their emotions and resulting in the observed changes to resting-state HF-HRV.

Frontal asymmetry is considered to be a moderator of emotional responses (Coan & Allen, 2004; Reznik & Allen, 2018) and as a result, its use as a measure of infant ER has been debated (Reznik & Allen, 2018; Swingler et al., 2014). Chapter 1 describes that resting state FAA is a measure of the relative difference between activity in the right and left frontal hemisphere of the brain (Coan et al., 2001; Coan & Allen, 2004). Greater right FAA is associated with withdrawal traits and behaviours, which in turn are associated with poorer ER (Coan et al., 2001; Coan & Allen, 2004). As a result, frontal asymmetry may identify the presence of a trait that places one at a greater risk of poor ER as opposed to a direct index of ER. Another finding from the ER literature worth noting is that studies that have assessed frontal asymmetry as an index of ER have found opposing results regarding the association between the relative activation of the frontal region of the brain and emotion responding. Right FAA has been associated with greater negative evaluation of stimuli (Adolph et al., 2017) and an association with greater depression scores in healthy adolescents (Grünewald et al., 2018). While infants of mothers with PPD who are withdrawn demonstrate greater right FAA, infants of mothers with PPD that are more intrusive during interactions display greater left FAA (Diego et al., 2006). In one study, Nusslock and colleagues reported that individuals who demonstrate greater left FAA were more prone to anxious apprehension while those with greater right FAA demonstrated a propensity for anxious arousal (Nusslock et al., 2015). While the literature on frontal asymmetry demonstrates the complexity of the frontal brain’s lateralization, it also highlights the value of using multiple methods to measure a process such as infant ER.

In the present thesis, no change in a maternal-report measure of temperament was found following peer and PHN-delivered treatment. Although we cannot say for certain, this may be because there are either no changes observed in infant behaviour following maternal treatment or that changes to temperament may take longer to emerge, and that examining change following just a nine-week maternal treatment may not be enough time to capture initial changes to temperament. Importantly, temperament is thought to be a trait-related and stable measure of an individual’s innate behavioural and emotional reactions to their environment (Rothbart, 2007). As a result, measures of temperament may not be as sensitive as methods of ER measurement such as HF-HRV. This may explain why many studies that have examined parental-report of infant behaviour do not find change in infants following maternal treatment during the perinatal period (Bilszta et al., 2012; Forman et al., 2007; Netsi et al., 2015). Maternal reports of temperament may not be sensitive enough to pick up these changes and studies that assess infant temperament following maternal treatment are often short and so they may not be long enough to capture any changes when and if they do occur.

**Maternal Treatment Effects on Infant Neurophysiology**

In the present thesis, we observed change in HF-HRV in therapy delivered by peers and PHNs. Change in this marker of infant ER is indicative of greater flexibility of the autonomic nervous system (ANS) through vagal activity (Propper & Moore, 2006). It may be possible that changes in mothers (e.g., sensitivity and responsiveness to infants, less withdrawal) may lead to change in vagal activity in their infants, thereby resulting in increases in resting state HF-HRV. Following treatment, mothers may have become more sensitive and attuned to their infant’s cues and/or may have learned how to better regulate themselves. In turn, infants may have begun to see their mothers as a source of support and someone that they can reliability depend on to regulate their emotions. Their infant’s openness to receiving support from their mothers may coincide with the increases in HF-HRV, a marker of ER that relies heavily on socioemotional input from caregivers.

How might changes in infants’ socioemotional input result in change to a neurophysiological marker of ER? We believe that changes in mothers following treatment may have led to changes in the neuronal connections that span the cortical (e.g., prefrontal cortex (PFC)) and subcortical (e.g., amygdala) regions that govern infant ER. The changes in mothers following treatment may have included a combination of factors including reductions in their symptoms of depression and anxiety, changes in their behaviour towards their infants (e.g., sensitivity to infants’ cues, consistency in parenting behaviours) and/or changes in the way that they outwardly regulate their own emotions. In particular, Chapter 1 highlights the importance of interactions with mothers in the development of infant ER. While attentive, sensitive mothers can identify and respond appropriately to their infant’s cues of distress and provide immediate regulatory support, mothers with PPD often experience reduced sensitivity and trouble with appropriate caregiving behaviours (Field, 1992; Slomian et al., 2019). We believe that the nine-week maternal treatments may have progressively improved any PPD-related effects to mother-infant interactions. Given that interactions with mothers are supported by the activity of the neurophysiological systems that govern attachment and socioemotional functioning (Atzil et al., 2011; Feldman, 2007, 2016), changes in the continuous mother-infant exchanges and socioemotional input from mothers, may in turn shape the neurophysiological ER systems.

Considering the plasticity of these neural networks early in life (Atzil et al., 2018), it is possible that improvements in the infant’s socio-emotional environment may lead to change after just nine weeks. For example, improvements in maternal socioemotional input and the subsequent regulatory support, may have potentially led to a reversal of PPD-related deficits in ER development. In Chapter 1, we highlighted the importance of the medial prefrontal cortex (mPFC), its reciprocal connection to the Amygdala, and its modulation of Amygdala reactivity to regulate emotions and use learning in the environment to guide emotional responding (Tottenham, 2015). The PFC performs top-down regulation of subcortical regions through connections between the dorsolateral PFC, the amygdala, and the dorsal anterior cingulate cortex (ACC)(Banks et al., 2007; Morawetz et al., 2017). As a result, impaired functioning of the PFC would affect the balance between PFC and subcortical activity. This imbalance has been found to be responsible for problems with ER (Heatherton & Wagner, 2011). Given the plasticity of these networks in the first year of life, it is likely that changes to the dyadic socioemotional environment during maternal treatment may adjust potential imbalances and mitigate consequences to infant ER.

**Limitations**

There are a number of limitations to consider. First, our participants were sampled from communities that had little diversity in sociodemographic characteristics. Across studies, a majority of our participants identified as white, were married or in common-law relationships and had household incomes in the middle-income range. Finally, since our studies took place in Ontario, Canada where universal healthcare is available, it is difficult to generalize our findings to other countries where this is not available.

Although the peer intervention appeared to be effective, the task-shifted intervention required weekly cognitive behavioural therapy (CBT) supervision by an experienced, mental health professional which is both expensive and requires the time of more experienced professionals. During peer intervention delivery we did not measure adherence to the CBT model and so we cannot determine the quality of CBT delivery. However, peers received weekly supervision by an experienced therapist which may have facilitated treatment fidelity during CBT delivery. Even though peers delivered group CBT that was effective in reducing symptoms of maternal PPD, we cannot identify what factors of the intervention may have contributed to its success. It is possible that the CBT material alone, or the group format and social support were responsible for treatment effects, or that a combination of factors contributed to treatment effectiveness. A clear understanding of the factors that contributed to the effectiveness of the intervention would have been valuable information to collect and could have informed the development of future interventions.

Lastly, while our measure of infant temperament is a gold-standard measure, maternal-report measures of infant behaviour may not be reliable (Gartstein et al., 2009), and this may have contributed to our null findings. Studies 2 and 3 involved collecting physiological data from infants in community centres not designed for research which added some challenge during research study visits and may have affected the quality of our infant neurophysiological data. Additionally, while the neurophysiological measures of infant ER that we used (FAA and HF-HRV) are indicators of the activity of brain networks involved in ER and were the ideal measures to use in awake, preverbal infants, they are not able to identify the activity of specific brain regions implicated in ER functioning. As a result, we can only infer what our findings mean in terms of neuronal activity in specific regions of the brain. Although, other methods of measuring brain activity in awake, preverbal infants safe, non-invasive methods do exist. Wearable neuroimaging methods such as high-density diffuse optical tomography functional near-infrared spectroscopy (HD-DOT fNIRS) system may allow for the measurement of cortical activity with three-dimensional images of brain regions and their connections in awake infants in response to stimuli (Frijia et al., 2021; Wheelock et al., 2019). Finally, our analysis of just infant resting-state ER activity limits our understanding of infant ER functioning and measures of infant ER functioning in the context of stress exposures may provide us with a more exhaustive measure of infant ER. Vagal tone for example, has demonstrated responsiveness to experiences of stress (Field et al., 1995; Kolacz et al., 2022) and its changes in response to stressors are thought to provide valuable insight to infant ER functioning (Porges, 2001, 2007; Thayer & Lane, 2000). A limitation in the present thesis is that we did not examine behavioural and neurophysiological measures of infant ER during stress-inducing tasks in addition to our measurement of infant resting-state activity. Metrics of ER in the context of both stress reactivity and resting-state tasks may provide us with a greater picture of infant ER capacity.

**Future Directions**

The present thesis used a randomized controlled trial (RCT) design and multiple-methods of ER measurement to demonstrate the effectiveness of a brief, task-shifted intervention on maternal PPD treatment and infant ER. Although our findings highlight the potential of a task-shifted maternal intervention to benefit both mothers and their infants, there is plenty of work needed to further (a) the development and implementation of task-shifted PPD interventions aimed at improving maternal treatment access and (b) our understanding of the mechanisms through which maternal treatment influences infant ER development.

The present thesis’ findings that a peer intervention for PPD is effective in treating mothers and benefits infants should be replicated with a larger, more heterogeneous sample.A multi-site randomized controlled trial (RCT) in Ontario that tests the effectiveness of the peer-intervention may allow for a more generalizable investigation of the maternal intervention effects among samples of mothers and birthing parents. To ensure the feasibility of this trial, online delivery of the intervention would be an important factor and allow for participation by individuals from more rural communities or facing other barriers to treatment. In addition, a larger sample would provide us with the power needed to study potential mediators of the relationship between maternal treatment and adaptive changes in infant ER. At present, it is unknown what specific changes are occurring in mothers following treatment that could explain why their infants are experiencing changes in markers of ER. Investigating potential factors that may change in mothers following treatment may be one way to reveal these mechanisms. This could potential mediators, such as maternal behaviour and mood, parenting quality, and mother-infant relationship. Uncovering the mechanism(s) behind maternal treatment and infant consequences would also allow interventions to be designed that better target these factors. Additionally, designing trials that have longer-term follow ups is an important next step in assessing the stability of ER changes following maternal treatment. This would provide us with a greater understanding of the impact of early maternal intervention and whether a nine-week maternal intervention for PPD in the first year of life could benefit infants across developmental periods.

Secondly, future intervention work should attempt to find ways to further reduce the burden of PPD on the healthcare system. At present, the peer intervention in this thesis was delivered by the lay individuals (peers) involved weekly supervision and by experienced mental health professionals. Although this approach was effective, it may limit the scalability of the peer-delivered group CBT intervention since offering the intervention depends on the availability of experienced professionals as well as the costs associated with weekly supervision delivered by these professionals. As a result, finding ways to assess peers’ treatment delivery and ensure its fidelity that is less time-consuming and expensive may help with scaling up the intervention. This could include testing whether the peer intervention can move away from weekly supervision delivery by experienced clinicians, to less frequent supervision, and/or include weekly cognitive behavioural therapy (CBT) supervision by other experienced peers.

In addition, future work should test additional modes of treatment delivery that would encourage more individuals to participant in treatment. For example, online group CBT would allow those who are unable to travel with a newborn the opportunity to receive evidence-based psychotherapy from the comfort of their own home. In addition, testing the delivery of our task-shifted intervention among communities with large groups of mothers and birthing parents that belong to different ethnic and cultural groups is an important next step in ensuring PPD treatment accessibility and effectiveness. This could allow for an assessment of the relevance of the content and design of the task-shifted group CBT intervention for different communities of mothers and birthing parents. Lastly, future trials of a task-shifted PPD interventions should used mixed-methods designs to understand the factors that either encouraged or deterred their participation, as well as the factors that may elucidate the factors that contribute to peer delivery effectiveness. An explanatory sequential mixed-methods design within a randomized controlled trial may provide us with valuable insight to participants’ experiences by using both quantitative and qualitative methods to understand treatment outcomes. Explanatory sequential mixed-methods designs involve an initial quantitative analysis followed by a qualitative component used to inform the interpretation of quantitative findings. In the context of an intervention for PPD, findings from quantitative analyses of symptom change in response to treatment and participant adherence to the intervention (e.g., attendance, homework completion) could be used to inform the development of qualitative interviews designed to gain a comprehensive understanding of participants’ experiences. This mixed-methods component would provide invaluable insight and aid in our efforts to ensure that treatment barriers are at a minimum and that mothers and birthing parents are giving the tools necessary to succeed in treatment.

Next, future work can further our understanding of maternal treatment effects on infant ER by conducting a more comprehensive examination of infant ER. In the present thesis, infant ER was measured during a resting-state task, although measures of infant ER during moments of stress exposure (e.g., maternal unresponsiveness) may be important indicators of infant ER capacity (Tronick, 1989). For example, the face-to-face still face paradigm (FFSF) is a validated task that allows researchers to measure ER in infants during a task that includes a socio-emotional stressors (Weinberg et al., 2008). In this task, mothers and infants participate in a two-minute play episode where mothers interact normally with their infants until given the cue to change into a “still-face” (a neutral expression with no interaction with their infant) for two minutes. Following this, dyads enter the reunion episode and mothers may interact normally with their infants for two minutes. This task has been widely used to assess the quality of mother-infant interaction quality and ER capacity (Mesman et al., 2009; Moore & Calkins, 2004; Weinberg et al., 2008). For infants, the lack of contingent responding during the still-face episode induces stress and often leads to infants exhibiting negative emotions, less social engagement, and avoidance behaviours. Normally, after an immediate carry-over of an infant’s negative reaction to the still-face episode, the dyad interacts normally during the reunion episode. The mutual regulation model (MRM), discussed extensively in Chapter 1 explains that mother-infant interactions involve exchanges of bidirectional behavioural and physiological signals used by both members of the dyad to deal with stress. Considering the importance of mothers’ responses to infant emotional distress in early ER development, and the importance of dyadic synchrony, measuring both mother and infant behavioural and physiological responses during a laboratory stress task would provide us with important information on both members of the dyad. Although the use of electroencephalography (EGG) and electrocardiography (ECG) provided us with reliable measures of infant ER, these measures of physiological activity do not allow for more fine-grain measures of specific brain function. Our findings suggest that PPD treatment may lead to adaptive change in parasympathetic nervous system (PSNS) and corticolimbic functioning, both systems that require the activity of the prefrontal brain regions, namely the medial Prefrontal Cortex (mPFC). Yet, no studies directly examine whether treating maternal depression could affect brain regions of interest, such as the mPFC. The use of neuroimaging techniques such as HD-DOT fNIRS would allow for the direct assessment of changes to core brain regions and provide us with an understanding of the mechanisms behind maternal PPD treatment and infant ER changes that go beyond the inferences we can make of brain region functioning based on infant neurophysiological activity. Functional near-infrared spectroscopy may be ideal for infant research because it is non-invasive, silent, and it can measure with a high level of movement from infants while they are awake (Frijia et al., 2021). This technology would allow us to target specific regions of the brain known to play an important role in the process of ER. For example, the mPFC and the subgenual cingulate region of the anterior cingulate cortex (ACC), two regions highlighted for their role in ER in Chapter 1. In Chapter 1, we also discuss the importance of mother-infant synchrony in infant ER development. The use of fNIRS may also provide the opportunity to examine dyadic synchrony through targeted examination of the right dorsolateral and frontopolar regions of the PFC in mothers and their infants. Synchronized dyadic activity in these regions is associated with greater mother-infant cooperation (Miller et al., 2019) and appears to mediate links between parent and child ER capacity (Reindl et al., 2018).

Finally, the findings of the present thesis should be used to inform future PPD care. The task-shifted interventions in this thesis may be ideal for integration into a stepped-care approach to PPD treatment. Our findings that mild to moderate PPD may be effectively treated with a task-shifted group CBT intervention highlights the potential for these interventions to find a place within multiple places in a stepped-care approach to the treatment of PPD. A stepped approach to PPD, where individuals participate in the least-intensive treatment before “stepping-up” to a more intensive treatment as needed, could have a tremendous impact on treatment access and may help to lessen the current bottleneck in the provision of mental healthcare. Considering the evidence to support brief, task-shifted PPD interventions and the suggestions of clinical practice guidelines in taking a stepped approach for PPD treatment (NICE, 2015), the task-shifted interventions in the present thesis may be exactly what is needed to improve postpartum mental healthcare.

**Conclusion**

Postpartum depression is a serious public health issue with potential lifelong consequences for mothers and their infants. Given the number of barriers to maternal receipt of treatment, finding effective methods of treating mothers and birthing parents in a timely manner is of utmost importance. The findings of the present thesis are an important step towards the widespread reach of PPD interventions that are evidence-based, designed to minimize barriers to access and based on women’s preferences. Our work demonstrates the potential of early intervention to disrupt the transmission of risk from mothers to infants, and the importance of breaking the cycle of depression from mother to infant since it could have a major positive impact on rates of psychiatric disorder in Canada and the world.

**References**

Adolph, D., von Glischinski, M., Wannemüller, A., & Margraf, J. (2017). The influence of frontal alpha-asymmetry on the processing of approach- and withdrawal-related stimuli—A multichannel psychophysiology study. *Psychophysiology*, *54*(9), 1295–1310. https://doi.org/10.1111/psyp.12878

Atzil, S., Gao, W., Fradkin, I., & Barrett, L. F. (2018). Growing a social brain. *Nature Human Behaviour*, *2*(9), 624–636. https://doi.org/10.1038/s41562-018-0384-6

Atzil, S., Hendler, T., & Feldman, R. (2011). Specifying the neurobiological basis of human attachment: Brain, hormones, and behavior in synchronous and intrusive mothers. *Neuropsychopharmacology*, *36*(13), 2603–2615. https://doi.org/10.1038/npp.2011.172

Banks, S. J., Eddy, K. T., Angstadt, M., Nathan, P. J., & Luan Phan, K. (2007). Amygdala-frontal connectivity during emotion regulation. *Social Cognitive and Affective Neuroscience*, *2*(4), 303–312. https://doi.org/10.1093/scan/nsm029

Bilszta, J. L. C., Buist, A. E., Wang, F., & Zulkefli, N. R. (2012). Use of video feedback intervention in an inpatient perinatal psychiatric setting to improve maternal parenting. *Archives of Women’s Mental Health*, *15*(4), 249–257. https://doi.org/10.1007/s00737-012-0283-1

Brooker, R. J., Canen, M. J., Davidson, R. J., & Hill Goldsmith, H. (2017). Short- and long-term stability of alpha asymmetry in infants: Baseline and affective measures. *Psychophysiology*, *54*(8), 1100–1109. https://doi.org/10.1111/psyp.12866

Bryan, A. E. B., & Arkowitz, H. (2015). Meta-Analysis of the Effects of Peer-Administered Psychosocial Interventions on Symptoms of Depression. *American Journal of Community Psychology*, *55*(3–4), 455–471. https://doi.org/10.1007/s10464-015-9718-y

Calkins, S. D., Dollar, J. M., & Wideman, L. (2019). Temperamental vulnerability to emotion dysregulation and risk for mental and physical health challenges. *Development and Psychopathology*, *31*(3), 957–970. https://doi.org/10.1017/S0954579419000415

Coan, J. A., & Allen, J. J. B. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological Psychology*, *67*(1–2), 7–50. https://doi.org/10.1016/j.biopsycho.2004.03.002

Coan, J. A., Allen, J. J. B., & Harmon-Jones, E. (2001). Voluntary facial expression and hemispheric asymmetry over the frontal cortex. *Psychophysiology*, *38*(6), 912–925. https://doi.org/10.1111/1469-8986.3860912

Cohen, N. J., Lojkasek, M., Muir, E., Muir, R., & Parker, C. J. (2002). Six-month follow-up of two mother-infant psychotherapies: Convergence of therapeutic outcomes. *Infant Mental Health Journal*, *23*(4), 361–380. https://doi.org/10.1002/imhj.10023

Dennis, C. L., Hodnett, E., Kenton, L., Weston, J., Zupancic, J., Stewart, D. E., & Kiss, A. (2009). Effect of peer support on prevention of postnatal depression among high risk women: Multisite randomised controlled trial. *BMJ (Online)*, *338*(7689), 280–283. https://doi.org/10.1136/bmj.a3064

Diego, M. A., Field, T., Jones, N. A., & Hernandez-Reif, M. (2006). Withdrawn and intrusive maternal interaction style and infant frontal EEG asymmetry shifts in infants of depressed and non-depressed mothers. *INFANT BEHAVIOR & DEVELOPMENT*, *29*(2), 220–229. https://doi.org/10.1016/j.infbeh.2005.12.002

Fang, Q., Lin, L., Chen, Q., Yuan, Y., Wang, S., Zhang, Y., Liu, T., Cheng, H., & Tian, L. (2022). Effect of peer support intervention on perinatal depression: A meta-analysis. *General Hospital Psychiatry*, *74*(December 2021), 78–87. https://doi.org/10.1016/j.genhosppsych.2021.12.001

Feldman, R. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(3–4), 329–354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Feldman, R. (2016). The neurobiology of mammalian parenting and the biosocial context of human caregiving. *Hormones and Behavior*, *77*, 3–17. https://doi.org/10.1016/j.yhbeh.2015.10.001

Field, T. (1992). Infants of depressed mothers. *Development and Psychopathology*, *4*(1), 49–66. https://doi.org/10.1017/S0954579400005551

Field, T., Pickens, J., Fox, N. A., Nawrocki, T., & Gonzalez, J. (1995). Vagal tone in infants of depressed mothers. *Development and Psychopathology*, *7*(2), 227–231. https://doi.org/10.1016/j.jad.2014.04.024

Forman, D. R., O’Hara, M. W., Stuart, S., Gorman, L. L., Larsen, K. E., & Coy, K. C. (2007). Effective treatment for postpartum depression is not sufficient to improve the developing mother-child relationship. *Development and Psychopathology*, *19*(2), 585–602. https://doi.org/10.1017/S0954579407070289

Fox, N. (1994). Dynamic Cerebral Processes Underlying Emotion Regulation. *Monographs of the Society for Research in Child Development*, *59*(2/3), 152–166. https://doi.org/10.1007/sl

Fox, N. A. (1994). Dynamic cerebral processes underlying emotion regulation. *Monographs of the Society for Research in Child Development*, *59*(2), 152–166.

Frijia, E. M., Billing, A., Lloyd-Fox, S., Vidal Rosas, E., Collins-Jones, L., Crespo-Llado, M. M., Amadó, M. P., Austin, T., Edwards, A., Dunne, L., Smith, G., Nixon-Hill, R., Powell, S., Everdell, N. L., & Cooper, R. J. (2021). Functional imaging of the developing brain with wearable high-density diffuse optical tomography: A new benchmark for infant neuroimaging outside the scanner environment. *NeuroImage*, *225*(October 2020), 117490. https://doi.org/10.1016/j.neuroimage.2020.117490

Gartstein, M. A., Bridgett, D. J., Dishion, T. J., & Kaufman, N. K. (2009). Depressed mood and maternal report of child behavior problems: Another look at the depression-distortion hypothesis. *Journal of Applied Developmental Psychology*, *30*(2), 149–160. https://doi.org/10.1016/j.appdev.2008.12.001

Gold, S. M., Enck, P., Hasselmann, H., Friede, T., Hegerl, U., Mohr, D. C., & Otte, C. (2017). Control conditions for randomised trials of behavioural interventions in psychiatry: a decision framework. *The Lancet Psychiatry*, *4*(9), 725–732. https://doi.org/10.1016/S2215-0366(17)30153-0

Grünewald, B. D., Greimel, E., Trinkl, M., Bartling, J., Großheinrich, N., & Schulte-Körne, G. (2018). Resting frontal EEG asymmetry patterns in adolescents with and without major depression. *Biological Psychology*, *132*(January), 212–216. https://doi.org/10.1016/j.biopsycho.2018.01.003

Hansotte, E., Payne, S. I., & Babich, S. M. (2017). Positive postpartum depression screening practices and subsequent mental health treatment for low-income women in Western countries: A systematic literature review. *Public Health Reviews*, *38*(1). https://doi.org/10.1186/s40985-017-0050-y

Holopainen, D. (2002). The experience of seeking help for postnatal depression. *Australian Journal of Advanced Nursing, The*, *19*(3), 39-44.

Kolacz, J., daSilva, E. B., Lewis, G. F., Bertenthal, B. I., & Porges, S. W. (2022). Associations between acoustic features of maternal speech and infants’ emotion regulation following a social stressor. *Infancy*, *27*(1), 135–158. https://doi.org/10.1111/infa.12440

Krzeczkowski, J. E., Schmidt, L. A., & Van Lieshout, R. J. (2021). Changes in infant emotion regulation following maternal cognitive behavioral therapy for postpartum depression. *Depression and Anxiety*, *December 2020*, 1–10. https://doi.org/10.1002/da.23130

Lavender, T. J., Ebert, L., & Jones, D. (2016). An evaluation of perinatal mental health interventions: An integrative literature review. *Women and Birth*, *29*(5), 399–406. https://doi.org/10.1016/j.wombi.2016.04.004

Letourneau, N., Secco, L., Colpitts, J., Aldous, S., Stewart, M., & Dennis, C. L. (2015). Quasi-experimental evaluation of a telephone-based peer support intervention for maternal depression. *Journal of Advanced Nursing*, *71*(7), 1587–1599. https://doi.org/10.1111/jan.12622

Letourneau, N., Stewart, M., Dennis, C.-L., Hegadoren, K., Duffett-Leger, L., & Watson, B. (2011). Effect of home-based peer support on maternal-infant interactions among women with postpartum depression: A randomized, controlled trial. *INTERNATIONAL JOURNAL OF MENTAL HEALTH NURSING*, *20*(5), 345–357. https://doi.org/10.1111/j.1447-0349.2010.00736.x

Lusby, C. M., Goodman, S. H., Bell, M. A., & Newport, D. J. (2014). Electroencephalogram patterns in infants of depressed mothers. *DEVELOPMENTAL PSYCHOBIOLOGY*, *56*(3), 459–473. https://doi.org/10.1002/dev.21112

MacQueen, G. M., Frey, B. N., Ismail, Z., Jaworska, N., Steiner, M., Lieshout, R. J. V., Kennedy, S. H., Lam, R. W., Milev, R. V., Parikh, S. V., & Ravindran, A. V. (2016). Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 clinical guidelines for the management of adults with major depressive disorder: Section 6. Special populations: Youth, women, and the elderly. *Canadian Journal of Psychiatry*, *61*(9), 588–603. https://doi.org/10.1177/0706743716659276

Mead, S., Hilton, D., & Curtis, L. (2001). Peer support: A theoretical perspective. *Psychiatric Rehabilitation Journal*, *25*(2), 134–141. https://doi.org/10.1037/h0095032

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-Face Paradigm: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001

Miller, J. G., Vrtička, P., Cui, X., Shrestha, S., Hosseini, S. M. H., Baker, J. M., & Reiss, A. L. (2019). Inter-brain synchrony in mother-child dyads during cooperation: An fNIRS hyperscanning study. *Neuropsychologia*, *124*(December 2018), 117–124. https://doi.org/10.1016/j.neuropsychologia.2018.12.021

Montgomery, P., Mossey, S., Adams, S., & Bailey, P. H. (2012). Stories of women involved in a postpartum depression peer support group. *International Journal of Mental Health Nursing*, *21*(6), 524–532. https://doi.org/10.1111/j.1447-0349.2012.00828.x

Moore, G. A., & Calkins, S. D. (2004). Infants’ vagal regulation in the still-face paradigm is related to dyadic coordination of mother-infant interaction. *Developmental Psychology*, *40*(6), 1068–1080. https://doi.org/10.1037/0012-1649.40.6.1068

Morawetz, C., Bode, S., Baudewig, J., & Heekeren, H. R. (2017). Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. *Social Cognitive and Affective Neuroscience*, *12*(4), 569–585. https://doi.org/10.1093/scan/nsw169

Müller, B. C. N., Kühn-Popp, N., Meinhardt, J., Sodian, B., & Paulus, M. (2015). Long-term stability in children’s frontal EEG alpha asymmetry between 14-months and 83-months. *International Journal of Developmental Neuroscience*, *41*, 110–114. https://doi.org/10.1016/j.ijdevneu.2015.01.002

Netsi, E., Evans, J., Wulff, K., O’Mahen, H., & Ramchandani, P. G. (2015). Infant outcomes following treatment of antenatal depression: Findings from a pilot randomized controlled trial. *Journal of Affective Disorders*, *188*, 252–256. https://doi.org/10.1016/j.jad.2015.08.055

NICE. (2015). Antenatal and postnatal mental health: clinical management and service guidance. *Essentially MIDIRS*, *6*(1), 14. www.nice.org.uk/guidance/cg192%0Ahttp://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2012910556&site=ehost-live

Nusslock, R., Walden, K., & Harmon-Jones, E. (2015). Asymmetrical frontal cortical activity associated with differential risk for mood and anxiety disorder symptoms: An RDoC perspective. *International Journal of Psychophysiology*, *98*(2), 249–261. https://doi.org/10.1016/j.ijpsycho.2015.06.004

Panari, C., Tonelli, M., & Mazzetti, G. (2020). Emotion regulation and employability: The mediational role of ambition and a protean career among unemployed people. *Sustainability (Switzerland)*, *12*(22), 1–13. https://doi.org/10.3390/su12229347

Porges, Stephen W., Furman, S. A. (2011). The Early Development of the Autonomic Nervous System Provides a Neural Platform for Social Behaviour: A Polyvagal Perspective. *Infant and Child Development*, *20*, 106–118. https://doi.org/10.1002/icd

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology*, *42*(2), 123–146. https://doi.org/10.1016/S0167-8760(01)00162-3

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*(2), 116–143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Prevatt, B. S., Lowder, E. M., & Desmarais, S. L. (2018). Peer-support intervention for postpartum depression: Participant satisfaction and program effectiveness. *Midwifery*, *64*(May), 38–47. https://doi.org/10.1016/j.midw.2018.05.009

Propper, C., & Moore, G. A. (2006). The influence of parenting on infant emotionality: A multi-level psychobiological perspective. *Developmental Review*, *26*(4), 427–460. https://doi.org/10.1016/j.dr.2006.06.003

Reindl, V., Gerloff, C., Scharke, W., & Konrad, K. (2018). Brain-to-brain synchrony in parent-child dyads and the relationship with emotion regulation revealed by fNIRS-based hyperscanning. *NeuroImage*, *178*(November 2017), 493–502. https://doi.org/10.1016/j.neuroimage.2018.05.060

Resnick, S. G., & Rosenheck, R. A. (2008). Integrating peer-provided services: A quasi-experimental study of recovery orientation, confidence, and empowerment. *Psychiatric Services*, *59*(11), 1307–1314. https://doi.org/10.1176/ps.2008.59.11.1307

Reznik, S. J., & Allen, J. J. B. (2018). Frontal asymmetry as a mediator and moderator of emotion: An updated review. *Psychophysiology*, *55*(1). https://doi.org/10.1111/psyp.12965

Rothbart, M. K. (2007). Temperament , Development, and Personality. *Current Directions in Psychological Science*, *16*(4), 207–212.

Shannon, K. E., Beauchaine, T. P., Brenner, S. L., Neuhaus, E., & Gatzke-Kopp, L. (2007). Familial and temperamental predictors of resilience in children at risk for conduct disorder and depression. *Development and Psychopathology*, *19*(3), 701–727. https://doi.org/10.1017/S0954579407000351

Singla, D. R., Lawson, A., Kohrt, B. A., Jung, J. W., Meng, Z., Ratjen, C., Zahedi, N., Dennis, C. L., & Patel, V. (2021). Implementation and Effectiveness of Nonspecialist-Delivered Interventions for Perinatal Mental Health in High-Income Countries: A Systematic Review and Meta-analysis. *JAMA Psychiatry*, *78*(5), 498–509. https://doi.org/10.1001/jamapsychiatry.2020.4556

Slomian, J., Honvo, G., Emonts, P., Reginster, J. Y., & Bruyère, O. (2019). Consequences of maternal postpartum depression: A systematic review of maternal and infant outcomes. In *Women’s Health* (Vol. 15). https://doi.org/10.1177/1745506519844044

Smith, C. L., Diaz, A., Day, K. L., & Bell, M. A. (2016). Infant frontal electroencephalogram asymmetry and negative emotional reactivity as predictors of toddlerhood effortful control. *Journal of Experimental Child Psychology*, *142*, 262–273. https://doi.org/10.1016/j.jecp.2015.09.031

Sockol, L. E. (2015). A systematic review of the efficacy of cognitive behavioral therapy for treating and preventing perinatal depression. *Journal of Affective Disorders*, *177*, 7–21. https://doi.org/10.1016/j.jad.2015.01.052

Sockol, L. E. (2018). A systematic review and meta-analysis of interpersonal psychotherapy for perinatal women. *Journal of Affective Disorders*, *232*(February), 316–328. https://doi.org/10.1016/j.jad.2018.01.018

Stein, A., Netsi, E., Lawrence, P. J., Granger, C., Kempton, C., Craske, M. G., Nickless, A., Mollison, J., Stewart, D. A., Rapa, E., West, V., Scerif, G., Cooper, P. J., & Murray, L. (2018). Mitigating the effect of persistent postnatal depression on child outcomes through an intervention to treat depression and improve parenting: a randomised controlled trial. *The Lancet Psychiatry*, *5*(2), 134–144. https://doi.org/10.1016/S2215-0366(18)30006-3

Swingler, M. M., Perry, N. B., Calkins, S. D., & Bell, M. A. (2014). Maternal sensitivity and infant response to frustration: The moderating role of EEG asymmetry. *Infant Behavior and Development*, *37*(4), 523–535. https://doi.org/10.1016/j.infbeh.2014.06.010

Taft, A. J., Small, R., Hegarty, K. L., Watson, L. F., Gold, L., & Lumley, J. A. (2011). Mothers’ AdvocateS in the Community (MOSAIC)-non-professional mentor support to reduce intimate partner violence and depression in mothers: A cluster randomised trial in primary care. *BMC Public Health*, *11*, 1–10. https://doi.org/10.1186/1471-2458-11-178

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*(3), 201–216. https://doi.org/10.1016/S0165-0327(00)00338-4

Tottenham, N. (2015). Social scaffolding of human amygdala-mPFCcircuit development. *Social Neuroscience*, *10*(5), 489–499. https://doi.org/10.1080/17470919.2015.1087424

Tottenham, N. (2019). Early Adversity and the Neotenous Human Brain. *Biological Psychiatry*, *16*, 1–10. https://doi.org/10.1016/j.biopsych.2019.06.018

Tronick, Edward. (1989). Emotions and emotional communication in infants. *American Psychologist*, 112–119. https://doi.org/10.4324/9780429478154-5

Weinberg, M. K., Beeghly, M., Olson, K. L., & Tronick, E. (2008). Effects of maternal depression and panic disorder on mother-infant interactive behavior in the Face-to-Face Still-Face paradigm. *Infant Mental Health Journal*, *29*(5), 472–491. https://doi.org/10.1002/imhj.20193

Wen, D. J., Soe, N. N., Sim, L. W., Sanmugam, S., Kwek, K., Chong, Y.-S., Gluckman, P. D., Meaney, M. J., Rifkin-Graboi, A., & Qiu, A. (2017). Infant frontal EEG asymmetry in relation with postnatal maternal depression and parenting behavior. *Translational Psychiatry*, *7*(3), e1057. https://doi.org/10.1038/tp.2017.28

Wheelock, M. D., Culver, J. P., & Eggebrecht, A. T. (2019). High-density diffuse optical tomography for imaging human brain function. *Review of Scientific Instruments*, *90*(5), 1–24. https://doi.org/10.1063/1.5086809