Online Intervention to Prevent Perinatal Depression and Promote Breastfeeding

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THESIS

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I dedicate this thesis to my family. To my partner, Matt, who never stops encouraging me to pursue my dreams. To my children, Rosalyn and Margot, for your endless love and for grounding me always. To my parents, who have loved me unconditionally. Mom, thank you for listening and hearing me. To my sister and her family for the simple reminders of goodness and joy.

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LBP

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LIST OF ABBREVIATIONS

BF	Breastfeeding
BMI	Body mass index
BSE	Breastfeeding self-efficacy
CDC	Centers for Disease Control and Prevention
COVID-19	Coronavirus disease 2019
HM	Human milk
HMO	Human milk oligosaccharides
MG	Mammary gland
NICU	Neonatal intensive care unit
OT	Oxytocin
PHQ-8/9	Patient Health Questionnaire-8/9
PP	Postpartum
PPD	Postpartum depression
PRL	Prolactin
RCT	Randomized controlled trial
U.S.	United States

SUMMARY

Despite extensive benefits and high intentions, few women breastfeed exclusively for the recommended duration. At the same time, depression and anxiety are among the most common complications during the perinatal period. Maternal mental health is an important underlying factor associated with barriers and reduced rates of breastfeeding (BF) intent, initiation, exclusivity, and continuation. Black women are more likely to report depressed mood in late pregnancy and early postpartum and have the lowest rates of BF, compared to all other racial groups in the United States. Given the strong evidence of a bidirectional association between maternal mental health and BF, it is important to consider both factors when designing and examining the efficacy of interventions to improve these outcomes.

Findings from the systematic review and pilot trial outlined in this document highlight the intersection of maternal mental health and BF. Results from the systematic review on the efficacy of behavioral interventions (n=35) to improve maternal mental health *and* BF outcomes suggest interventions that extend across pregnancy and postpartum and offer individualized support from both professionals and peers who collaborate through a continuum of settings are most successful. By acknowledging and addressing that mental health and BF both occur in complex settings affected by many factors, we move into a whole-person approach to preventative and supportive services.

Internet interventions offer potential in extending preventative and supportive services since they address key barriers, especially for those navigating the complex and vulnerable early postpartum period. At the same time, cognitive behavioral therapy (CBT) has been shown to be effective at preventing perinatal depression. Therefore, an online CBT-based intervention, with and without BF education and support, was developed. To further acknowledge and address racial disparities in maternal mental health and BF, we developed the pilot study using components shown to improve mental health and BF outcomes among Black women. Additionally, many of the suggestions gleaned from the systematic review were also incorporated into the pilot study design.

Results from the pilot study (n=22) suggest that Black women at-risk for perinatal depression were receptive to and satisfied with the online CBT-based internet intervention, with and without BF education and support, spanning from mid-pregnancy through six weeks postpartum. Preliminary findings indicate that both Sunnyside and Sunnyside Plus (with BF support) interventions have a positive impact on symptoms of depression and anxiety and on BF outcomes across pregnancy and the first 12 weeks postpartum. Larger-scale, longer-term randomized controlled trials are needed to better understand the intersection between maternal mental health and BF.

I. INTRODUCTION

1. Background and rationale

Breastfeeding (BF) is considered the ideal form of infant feeding due to the extensive benefits for the mother and infant; however, overall BF rates within the United States (U.S.) continue to be low.[1] Black mothers have the lowest rates of initiation (60%) and any BF at six (28%) and 12 months (13%) compared to all other racial groups in the U.S.[2,3]

Mental health disorders are among the most common complications during pregnancy and the first 12 months after childbirth.[4–6] Research suggests the prevalence of perinatal anxiety disorders is at least 17% and that approximately 7-20% of women experience clinical depression at some time during the perinatal period.[7–9] Black women are more likely to report depressed mood in late pregnancy and early postpartum (PP), compared to white women, even after adjusting for income and education, distinguishing between the effects of race and socioeconomic status.[10] Given the high prevalence of mental health disorders within the perinatal period, maternal mental health is an important underlying factor associated with the reduced rates of BF intent, initiation, and continuation.[4–6,11]

In fact, research consistently shows that maternal mental health disorders are associated with poorer BF outcomes. More specifically, prenatal anxiety is associated with reduced BF intention, while PP anxiety is associated with reduced BF initiation and exclusivity, and shorter BF duration.[12,13] There is strong evidence for the association between perinatal depression and reduced BF intention, shorter BF duration, and reduced exclusivity of BF.[14,15]

Many interventions have been developed and implemented to improve BF or mental health outcomes. However, given the strong evidence of a bidirectional association between maternal mental health and BF, it is important to consider both factors when examining the efficacy of interventions to improve these outcomes. Moreover, intervention components shown to improve mental health and BF outcomes among Black women include Black Feminist thought as a theoretical foundation –

acknowledgement that Black women experience life at the intersection of multiple oppressions, positive and nurturing representation of Black women BF, and culturally relevant professional BF support across pregnancy and PP.[16,17]

The Internet offers great potential in extending preventative and supportive services to persons in the perinatal period since they address several key barriers to success. Digital-technology interventions, which include the use of web-based content and interactions, text messaging, and social media, have been effective at reducing depressive symptoms and improving BF outcomes.[18,19] Black mothers report that social media is a practical, convenient, and valuable way to obtain BF information and support, feel connected with like-minded people who look like them, and improve BF self-efficacy (BSE).[20,21] However, there is limited evidence on the feasibility and efficacy of such interventions for preventing perinatal mental health disorders and improving BF outcomes.

2. Specific aims

Specific Aim 1. Conduct a systematic review to examine the efficacy of behavioral interventions to improve maternal mental health and breastfeeding outcomes.

Specific Aim 2. Develop, pilot test, and assess the feasibility of an online intervention (Sunnyside Plus) to improve BF and mental health outcomes among Black individuals in the perinatal period.

Hypothesis 2. Individuals assigned to the Sunnyside Plus intervention group will have similar levels of adherence to the intervention and comparable usability and satisfaction scores compared to individuals in the Sunnyside intervention group.

Specific Aim 3. Compare Sunnyside and Sunnyside Plus interventions on preliminary mental health (anxiety and depressive symptoms) and breastfeeding (intention, knowledge, perception of barriers, self-efficacy, initiation, duration, and exclusivity) outcomes among Black individuals who are pregnant, have

mild to moderate depressive symptoms (PHQ-8 score of 5-14) at enrollment, and who intend to BF their baby.

Hypothesis 3. Individuals assigned to the Sunnyside Plus intervention group will 1) report fewer symptoms of anxiety and depression; 2) be more likely to intend to BF exclusively and for longer duration, have greater levels of BF knowledge and self-efficacy, have more positive attitudes toward barriers to BF, have higher initiation and exclusivity rates, and longer durations of BF compared to individuals in the Sunnyside intervention group.

3. Significance

If the above aims are achieved, these efforts will:

1. Provide a complete, exhaustive summary of the current literature on behavioral interventions to improve maternal mental health and breastfeeding.
2. Offer a potentially unique intervention approach to improve maternal mental health and BF outcomes among Black women.

II. LITERATURE REVIEW

1. History of breastfeeding in the United States

Through most of history, human milk (HM) was the only available food for infants. The industrial revolution (1760-1840) and subsequent urbanization of western society led to more separation of women from their babies. In many cultures, close friends or family members would nurse each other's babies (cross-nursing), and if financially feasible, a wet-nurse might be hired to care for and breastfeed the baby.[22] At the same time, enslaved African American women were *forced* to wet-nurse; either to nurse the children of their slave owners or as a commodity to be bought and sold.[23,24] Lactating slaves were rented out to breastfeed other children, many times having their own nursing infants taken from them.[23]

In the early 1900s, most babies were still breastfed; however, for the small percentage of babies who needed an alternative to HM, formula provided an important solution.[25] Originally, individual physicians created their own recipes that they would provide to families to make at home. Companies then started to brand recipes and manufacture them for sale, calling them "formula."[25] By the early 1920s, mothers increasingly began to bottle feed using these commercial formulas.[22,25] However, formula was costly and therefore became a status symbol for wealthy families.[22,24] Black families were less likely to be able to afford formula, due to historical and continued oppression, so would have to breastfeed or use other lesser quality products, continuing the negative experience of BF.[24,26]

In the 1940s, more women joined the workforce, but public policies weren't supportive of BF, so many families used formula to feed their infants.[27] Formula companies now began to target low-income families by giving free samples and products to hospitals, and partnering with the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) to provide free formula to low-income families, where Black women are disproportionately represented.[24,26] By the 1960s, BF was considered "out of step" for the modern woman's lifestyle and not encouraged by medical establishments.[28]

Formula was touted as "liberation in a can," since it allowed for women to work and led to more household equality.[28]

In the 1970s, overall BF rates reached their lowest, with only 22% of U.S. babies given any HM.[29] This marked a turning point. Organizations such as the Infant Formula Action Coalition and the National Council of Churches' Interfaith Center on Corporate Responsibility initiated campaigns on the importance of BF.[22] Although Le Leche League had already been around for almost 15 years (founded in 1956), the organization started to gain national recognition.[30] However, Black women continued to be excluded from the conversation and were not included in the representation of "good parenting."[26] Importantly, many Black women didn't *want* to BF because of the trauma of slavery and wet nursing.[31]

In response to the declining BF rates and the growing evidence of the benefits and importance of BF, the World Health Organization (WHO) and UNICEF issued the Innocenti Declaration on the Protection, Promotion and Support of BF in 1990, which the U.S. signed into.[27] The Baby Friendly Hospital Initiative was then implemented in 1991, promoting adherence to the Ten Steps to Successful BF;[32] however, fewer baby friendly hospitals existed in primarily Black communities.[26]

In 1999, the Surgeon General requested a formal policy on BF, and the Health and Human Services Blueprint for Action on BF was then released in 2000, establishing a comprehensive BF policy for the U.S.[33] Although BF rates have been steadily improving over the past two decades, there are still significant disparities in rates among Black women compared to all other racial groups (discussed further in Section 5).[2,3] Black women continue to receive differential BF information and support, stemming from racism and rooted in the history of slavery, segregation, and continued oppression.[26]

2. Lactation physiology

2.1 Human milk composition

Since the early 2000s, much research on lactation physiology has emerged. As new technology allows, we continue to learn more about the complex biological system that HM is, noting that

composition changes rapidly by time and by situation. HM contains the macronutrients, micronutrients, immune factors, and hormones required by the infant, and the composition of the milk evolves with the growth and development needs of the child.[34–36] Outside of severe malnutrition, micronutrient concentrations seem to be resilient to changes in maternal nutrition status, ensuring that the growing infant receives the nutrients that they need.[37] However, under- and over-nutrition may affect milk volume and/or composition, but available evidence is limited.

Lipid concentration gradually increases over all of lactation and provides the largest source of energy (40-50%) in HM. Most HM lipids are in the form of triacylglycerides, and there are over 200 fatty acids that have been identified.[38] The over 400 different types of proteins found in HM function as nutritional components, stimulate nutrient absorption, provide antimicrobial and immunomodulatory activities, and promote gut development. HM contains casein, whey, and mucin proteins, but has the lowest concentration (~13%) of casein of any studied species, which corresponds to the slow growth rate of humans. Over the course of lactation, protein concentration gradually decreases, and then levels off starting around 7 months PP.[38]

Also unique to HM is the high concentration of the carbohydrate lactose, which is required for the high energy demands of the human brain and the development of the central nervous system.[38] Additionally, human milk oligosaccharides (HMO) make up a significant portion of carbohydrates in HM. Over 200 different HMOs have been identified thus far, and interestingly, the specific composition of HMOs is thought to be affected by maternal genetic factors. While HMOs are indigestible by the infant, they function as prebiotics to nourish the microbiota of the gastrointestinal tract. They are also absorbed into the blood and are thought to aid in the development of other organs via additional modulatory functions.[38]

There is a large variety (with many still unknown) of immune factors in HM, including immunoglobulins, growth factors, cytokines, and chemokines. Immune factors in HM offer protection to the child while their immune system is developing, with concentration decreasing over time as the

immune system becomes more functional.[38] Secretory Immunoglobulin A (SIgA) is the most common immunoglobin found in HM and has been shown to prevent bacterial and viral infections by neutralizing the toxins and enzymes that they produce. Transforming growth factor beta (TGF-B), a central cytokine for the regulation and development of the immune system, is also found in large amounts in HM.[38,39] Non-immune cells, such as stem cells, are also present in HM and have become of more interest in research since their discovery in 2007.[40] Additionally, HM contains hormones, such as insulin, leptin, adiponectin, and ghrelin, that modulate metabolism and body composition within the child. Interestingly, leptin concentration in HM is directly correlated to maternal body mass index (BMI) status,[34] although it is still unclear how leptin levels may impact infant growth and body composition.[41]

There are time-associated changes in HM composition, with notable changes across the course of lactation, across the day, and even during one feeding session, allowing HM to provide individually adapted nourishment.[34,38] Over the course of lactation, HM is classified as colostrum (~first 4 days), transitional milk, and mature milk. The gradual changes that occur in HM adapt to the changing needs of the child. Colostrum contains high concentrations of protein (primarily whey), secretory immunoglobulins, HMOs, and growth factors, but low concentrations of lipids and carbohydrates. The volume of colostrum produced is very small due to the low levels of lactose, which is the most osmotically active component in HM. For these reasons, colostrum's primary function is likely immunological rather than nutritional, and even small volumes consumed by the infant meets their needs. Over time, concentrations of carbohydrates (mostly lactose) and lipids (mostly triacylglycerides) increase, and levels of protein and immune factors decrease.[34,38] Throughout the day, milk fat content peaks during midmorning and reaches its lowest levels overnight. HM composition also changes over the course of a feeding session. From the beginning of the feed to the end, there is a gradual increase in fat content and decrease in lactose content. The longer the interval between feeds, the lower the fat concentration in the milk, which can negatively impact infant growth.[38]

2.2 Maternal mental health and human milk composition

Maternal psychological condition can impact the composition of HM. In a study of PP women in Japan, researchers found that worse mood and anxiety were correlated with lower levels of SIgA in HM at two weeks PP. Given the protective nature of SIgA for the infant, this reduced transmission of immune factors is concerning. From these findings, it has been suggested that SIgA could be used as a marker for mental stress in the PP period.[42] Further showing the compositional changes associated with maternal mental health, researchers in Iran found that TGF-B levels in HM significantly increase with increasing level of anxiety and depression, which may alter the infants immune function.[39]

Studies have shown that sodium concentration in HM can also vary depending on psychological state due to MG permeability. Specifically, researchers have found high sodium concentration to be associated with negative maternal psychological state. In a study of Mexican women at 12 weeks PP, depression and low BF confidence were associated with increased permeability, and therefore, higher sodium levels in the milk.[43] High sodium levels and a high sodium-potassium ratio in HM have also been found to be associated with high PPD and anxiety scores.[44] Depressed mothers tend to nurse less frequently throughout the day and for shorter lengths of time at each session. It is thought that when there is inadequate removal of milk from the ducts, this can lead to increased permeability and therefore an increase in sodium levels crossing into the milk. The baby may then refuse to breastfeed as the milk can become unpalatable, adding to the adverse cycle.[44]

2.3 Mammary gland biology and the production of milk

The mammary gland (MG), a complex exocrine gland, is responsible for the production, secretion, and delivery of milk to the infant. Although the breast tissue is mostly formed by the onset of pregnancy, the MG does not complete its development until this time and does not become fully functional until shortly after childbirth (parturition). During early pregnancy, the rise in estrogen, progesterone, prolactin (PRL), and placental lactogen lead to the transition of the MG from a non-

secreting organ to a secreting organ that contains a network of lobes, ducts, and alveoli. At around 15-20 weeks' gestation, proliferation of lactocytes (milk-secreting cells), upregulation of PRL receptors, and synthesis of milk-specific components begins to take place, and is referred to as lactogenesis I. The transition to lactogenesis II begins after birth, when the absence of the placenta leads to a steep decline in circulating progesterone levels. The fall of progesterone levels then leads to an increase in PRL and oxytocin (OT). Tight junctions within the MG begin to close and this limits the passage of small molecules and ions (e.g., sodium, potassium, chloride), which is important for the onset and continuation of lactation.[45,46]

While lactogenesis I and II are under endocrine control (hormonally driven), lactogenesis III, the ongoing and continued milk production (galactopoesis), is under local autocrine control at the breast and is driven by milk removal.[47] Milk removal soon after birth increases the efficiency of milk secretion by stimulating the development of more PRL receptors. After establishment of lactation, the volume of milk production is determined by the baby's demand (removal). Suckling is sensed by mechanoreceptors on the nipple and areola that communicate with the hypothalamus, via nerve pathways, to stimulate release of PRL (from the anterior pituitary) and OT (from the posterior pituitary). As the principle lactogenic hormone, PRL is episodically released in response to suckling and stimulates milk production. OT regulates the milk ejection reflex (let-down reflex) by acting on the myoepithelial cells in the MG to generate contractile force, which is necessary for efficient milk removal.[45–47] Insulin is also an essential lactogenic hormone; research has shown that the MG becomes sensitive to insulin during lactation and that insulin is necessary for the production of milk.[48] Together these lactogenic hormones and the removal of milk lead to a steady milk supply for the infant.

Overall, we know very little about how the human breast develops and the impact of those developmental states and how they impact lactation. Further, it is unknown if or how the MG changes from one pregnancy and birth to the next.

2.4 Dysregulation of lactogenesis

Successful BF relies on appropriate regulation of the neurohormones associated with lactation, adequate glandular breast tissue, early milk removal, correct attachment of the baby to the nipple and areola, and frequent and efficient suction. Issues with any of these elements can lead to difficulties with lactation.

In rare cases, pituitary insufficiency, resulting in low PRL and OT secretion, or insufficient glandular tissue can lead to delayed or failed lactation.[47] A more common cause of difficult or failed lactation is delayed lactogenesis II. The delay of lactogenesis II is becoming more common as the conditions that can lead to its delay are becoming more common. These include diabetes, polycystic ovary syndrome, thyroid dysfunction, excessive gestational weight gain, obesity, placental retention, cesarean birth, stress or trauma during childbirth, and supplementation with formula in the hospital. Most of these conditions involve a dysregulation of lactogenic hormones. For instance, diabetes, polycystic ovary syndrome, thyroid dysfunction, and obesity can involve delayed secretory activation, PRL resistance, and decreased insulin sensitivity, all of which can lead to insufficient glandular development and reduced milk volume.[45,47,49] Obesity, in particular, is also associated with increased plasma leptin, which inhibits the effect of OT on myoepithelial contraction necessary for milk ejection, and increased estrogen production, which can downregulate PRL signaling and suppress lactation.[45,47]

The release of OT can also be inhibited by stress, pain, fear, embarrassment, or anxiety, and this can lead to a decrease in milk output.[47] MG function can be disrupted by environmental factors, such as chemicals found in herbicides, plastics, soaps, pesticides, cleaning products, and heavy metals exposure.[45] Genetic modifiers, such as alterations in PRL signaling, can also affect milk production and composition, although this is a newer area of research.[45]

3. Breastfeeding and human milk benefits

Breastfeeding is considered the ideal form of infant feeding due to the extensive benefits for the

mother and infant. For mothers, BF offers short and long-term health benefits, including longer periods of amenorrhea and therefore the possibility for improved interpregnancy intervals, decreased PP weight retention, reduced risk of developing depression, obesity, diabetes mellitus, hyperlipidemia, hypertension, cardiovascular disease, breast cancer, ovarian cancer, and mortality over the next decade.[14,50,51] For infants, HM and the nurturing act of BF promotes emotional, cognitive, and sensory development, increases intelligence, provides protection against infectious diseases, including respiratory and ear infections, and reduces the risk of overweight and obesity in both childhood and adulthood, type 1 and 2 diabetes, hypertension, sudden unexplained infant death syndrome, asthma, childhood leukemia, and mortality.[50]

4. Breastfeeding recommendations

Given the benefits of BF for the mother and infant, exclusive BF for the first six months of a child's life is recommended by all major health and professional organizations.[52–54] Recommendations for the duration of BF in combination with appropriate complementary foods range from at least one year to at least two years, as long as desired by both the mother and child.[52,53]

5. Epidemiology of breastfeeding

5.1 Current United States rates

According to the Centers for Disease Control and Prevention's (CDC) 2020 Breastfeeding Report Card, based on data among all infants born in the U.S., 84.1% (4 out of 5) initiated BF, 58.3% (over half) were BF at six months, and 35.3% (one-third) were BF at 12 months.[55] Further, 46.9% of infants were exclusively breastfed through three months and 25.6% through six months.[55] These rates are increased from that reported in the CDC 2016 and 2018 Breastfeeding Report Cards.[1,56]

High BF initiation rates indicate that most mothers want to breastfeed and are attempting to do so; however, many do not continue BF as is recommended. While exclusivity remains relatively high at

6 weeks PP, rates drop by 6 months.[57] This suggests that women may not be getting the professional, social, and policy-driven support that is necessary for continuity of BF.

5.2 Disparities among Black women

National surveillance data for BF outcomes suggests that compared to all other racial groups in the U.S., Black mothers have the lowest rates of initiation (60%) and any BF at six (28%) and 12 months (13%).[2,3] While there are certainly racial disparities, these data may not be representing the complexity. Historically, duration and exclusivity of BF has been reported among all infants, regardless of whether they had initiated BF. However, when examining rates among infants who had initiated BF, the Black-white disparities in BF were smaller.[58] Therefore, duration of BF may be a better indicator of racial disparities and importantly, much effort should be given to increase BF initiation among Black women as a way to improve rates.

Differing BF rates between racial groups in the U.S. likely contribute to further health disparities for infants. The infant mortality rate is more than double for Black infants, compared to white infants.[59] In an analysis of data from the National Survey of Family Growth, BF and low birth weight both accounted for the racial differences in infant mortality rates at similar levels.[60]

In light of this data, it is essential to understand and internalize that race is a social category linked to social factors known to affect disease risk.[61] The categories we use to discuss race do not represent biologic differences. The context in which BF disparities occur – historical and continued racism, gender oppression – must be discussed in order to better understand the health disparity that we see.[61]

5.3 Factors associated with breastfeeding outcomes

Research has consistently shown that certain sociodemographic factors are more likely to explain poorer BF outcomes. Results from two reviews specifically found that mothers with lower rates of BF tend to be young, low-income, unmarried, less educated, participants in WIC, individuals with overweight or obesity before pregnancy, more likely to report their pregnancy as unintended, and not

having been breastfed themselves as a child.[3,62] Psychological factors, such as history of or current symptoms of depression or anxiety, and birth-related fear, are also associated with lower rates of BF.[62] Many of these characteristics are more common among Black mothers, again stemming from deep roots of systemic racism and oppression, which is thought to help explain the racial disparities seen in BF outcomes.[3]

6. Barriers to reaching breastfeeding goals

6.1 General barriers

Multiple factors influence an individual's intention and ability to start and continue BF, and low BF rates may be due to the many reported barriers. Medical interventions during birth (e.g., excess intravenous fluids, epidural anesthesia, and cesarean birth), neonatal intensive care unit (NICU) admission of the newborn, pain or discomfort, difficulty with latch, concerns of milk supply, lack of professional lactation support, embarrassment, inconvenience, lack of time, employment, unaccommodating childcare environments, unsupportive social and cultural norms, and adverse mental health make it difficult for mothers to meet their BF goals.[2,60,62–64] Studies have shown that one of the most common factors that contributes to early BF cessation is maternal concern of inadequate milk supply, which may be associated with lack of confidence in BF, decreased BSE, and maternal mental health.[65–67]

6.2 Experiences and barriers unique to Black women

Certain barriers are disproportionately experienced by Black women, many of which stem from historical, cultural, social, economic, political, and psychosocial factors. Black women often receive limited education and differential treatment from providers in regards to BF information and encouragement.[2] Lack of exposure or access to supportive BF conditions is another barrier. In a study of hospital support for BF, facilities in locations where there were higher percentages of Black residents

were less likely to offer supportive BF practices (e.g., early initiation of BF, limited supplementation, rooming-in, limited use of pacifiers, and post-discharge support).[63]

Black women are more likely to provide formula supplementation to their baby by two days of life, compared to other racial groups.[1,2] Studies show that Black women are more likely to receive formula-feeding advice from WIC counselors,[2] experience in-hospital formula introduction (found to be the strongest predictor of BF duration),[3] have a preference for bottle feeding (the most common reason cited by Black women for not BF),[60,68] and practice combination feeding.[69]

The necessity to return to work is also a barrier. Jones and colleagues found that Black women typically return to work earlier than white women and are more likely to have jobs that are unsupportive to BF.[2] Some Black mothers have concern of spoiling their baby by BF, fearing it will lead to dependence and difficulty for other caregivers when they return to work.[70] Social and cultural norms can also play a large role. Lack of BF role models, multigenerational influences, desire for shared child rearing, limited *positive* representation in the media, reluctance to breastfeed in public, and negative sexual perceptions are all reported barriers to BF in the Black community.[17,69,70]

Consistent themes of racism, social injustices, and structural violence are present in these barriers and are likely at the core of whether a Black woman will be able to breastfeed. When considered in this context, it's not just the individual mother making the "choice" to not breastfeed, but rather the day-to-day constraints and discriminations outside of their individual control that leads to their "decision" to formula feed instead.[23,26,71–73]

7. Mental Health and breastfeeding

7.1 Perinatal mental health

Mental health disorders are among the most common complications during pregnancy and the first 12 months after childbirth.[4–6] It's estimated that up to 85% of women experience some form of mood disturbance during this time.[11] Psychiatric symptoms in the perinatal period are varied, and can

range from mild and temporary (i.e., baby blues) to more severe (i.e., psychosis). Pregnancy and PP are generally considered periods for increased vulnerability to psychiatric disorders due to hormonal fluctuations, environmental factors, and life stress events.[7,74]

Racial disparities in mental health outcomes also exist. In a large sample (n=26,877) of women residing in Iowa, Black women were more likely to report depressed mood in late pregnancy and early PP, compared to white women. Importantly, this remained the case even after adjusting for income and education, distinguishing between the effects of race and socioeconomic status.[10] Given the high prevalence of mental health disorders within the perinatal period, maternal mental health is an important underlying factor associated with the reduced rates of BF intent, initiation, and continuation.

7.2 Anxiety and breastfeeding

Data on the prevalence of perinatal anxiety is limited despite some data showing higher reported prevalence rates of perinatal anxiety compared to perinatal depression.[75] Research shows the prevalence of perinatal anxiety disorders is at least 17% and even higher among Black individuals.[76] More specifically, women who experience everyday discrimination are more than twice as likely to have symptoms of anxiety compared to women who don't.[77]

Findings from two systematic reviews indicate an association between prenatal anxiety and BF outcomes.[13,78] Specifically, those with high levels of prenatal anxiety in early pregnancy were more likely to intend to formula feed; however, prenatal anxiety was not associated with initiation or any BF. There were mixed results for the association between prenatal anxiety and BF exclusivity and duration.[13,78]

Other studies, including results from two systematic reviews, have also examined the association between PP anxiety and BF outcomes. Women with symptoms of PP anxiety are less likely to initiate, breastfeed exclusively, and continue to breastfeed.[12,13,79] Furthermore, PP anxiety was associated with decreased BSE and increased difficulties with BF.[12]

Overall, research shows an association between anxiety during pregnancy and reduced BF intention. However, the results are inconclusive for the association with initiation, exclusivity, and duration of BF. On the other hand, PP anxiety has consistently been shown to be associated with reduced BF initiation and exclusivity, and shorter BF duration. Some research suggests that PP anxiety may result from early cessation of BF, with concern of milk supply being an important factor.

7.3 Depression and breastfeeding

Depression is among the most researched mental health disorders in pregnancy and during the PP period, and the relationship between BF and depression has been studied extensively. It is estimated that approximately 7-20% of women experience clinical depression at some time during the perinatal period.[7–9] Despite the high prevalence of perinatal depression, a large proportion of pregnant women suffer silently throughout their pregnancy due to low rates of detection and treatment. In a study of nearly 400 pregnant women, only 26% of the symptomatic depressed women received a diagnosis and subsequent treatment.[80] Moreover, detection can be lacking due to the similarities between somatic symptoms of depressive disorders and those commonly reported during the normal course of pregnancy (i.e., fatigue, sleep disturbances, appetite changes).[81]

Depression during pregnancy is one of the strongest predictors for depression during the PP period.[15,82,83] Results from a large systematic review and meta-analysis indicate that PPD affects approximately 13-19% of women in the months following childbirth,[74] and is the leading cause of non-obstetric hospitalization in the U.S. among women aged 18-44 years.[84] Symptoms of PPD are similar to depressive symptoms occurring at other times in a woman's life, and include persistent low mood, feelings of sadness, hopelessness, and/or worthlessness. The physiological changes that occur in the perinatal period may lead to the increased susceptibility to PPD.[74]

Depression and BF both occur in complex settings that can be affected by physiological, emotional, social, psychological, personal, cultural, and physical factors.[2,3] Therefore, the relationship between the two must take into consideration these complexities. In a longitudinal study of perinatal

depression in minority and economically disadvantaged women, 39% of the women had depression at preconception, 36% during pregnancy, and 33% in the PP period.[85] Further, African American and Hispanic women are less likely than white women to seek perinatal mental health services due to stigma, lack of awareness of the disorder, and lack of resources.[86–88]

7.3.1 Pregnancy depression and breastfeeding

Research shows that depression during pregnancy negatively impacts BF outcomes including intent, initiation, duration, and exclusivity of BF.

Women who are depressed during pregnancy are less likely to intend to breastfeed**.** In a prospective cohort study in the U.S. (n=1436), those with prenatal depressive symptoms were twice as likely to intend to formula feed rather than breastfeed, compared to those without depressive symptoms.[89] In this same study, depressive symptoms during pregnancy were not associated with the failure to initiate BF.[89] In a prospective cohort study of Hispanic women in the U.S., those with high levels of anxiety and depression in both early and mid-pregnancy were less likely to intend to breastfeed, compared to those with low symptoms severity.[90] Conversely, in a prospective study in the U.S. (n=168) of predominately white women, neither major depressive disorder or depressive symptom severity during pregnancy were associated with BF intention. However, the intent to breastfeed exclusively was the most significant predictor of initiation and duration of BF.[91]

The association between depression during pregnancy and BF initiation is less clear. In a longitudinal study of women in Sweden, high depression scores during pregnancy resulted in significantly fewer women initiating BF, compared to those with low depression scores.[92] In a large sample using data from the 2010-2011 Pregnancy Risk Assessment Monitoring System, 13.4% (n=76,658) of women reported pre-pregnancy anxiety or depression and these women were less likely to initiate BF compared to those who did not have pre-pregnancy anxiety or depression.[93] On the other hand, Bogen and colleagues, who assessed depression using both a clinical interview and validated questionnaire, found that depression during pregnancy was not associated with BF initiation.[91]

Much research has been done to examine the association between pregnancy depression and BF duration. One study found no association between major depressive disorder or depression symptom severity during pregnancy with duration at 2 and 12 months PP.[91] However, most others have found that women who are depressed during pregnancy are less likely to maintain BF. In 2015, a systematic review (n=48 studies) examining the associations between pregnancy depression and BF found that those with depression during pregnancy did not continue to breastfeed as long as those who did not have depression during pregnancy.[14] In a longitudinal study of U.S. women (n=205), depressive symptoms in pregnancy predicted lower rates of BF and earlier BF cessation (an average of 2.3 months earlier) at 3 months PP.[94] Stuebe and colleagues also recently found that symptoms of depression in the third trimester of pregnancy was associated with earlier introduction of formula and cessation of BF.[95] This research overwhelmingly suggests that pregnancy depression predicts a shorter BF duration.

Depression during pregnancy may also negatively affect exclusivity of BF. In a prospective cohort study of Portuguese women, depression scores during pregnancy, but not PP, were significant predictors of exclusive BF at 3 months PP and exclusive BF duration. More specifically, depression scores in the first trimester were the best predictors of exclusivity and depression scores in the third trimester were the best predictors of exclusive BF duration.[82] Further, in a recent longitudinal population-based study in Sweden (n=1,217), both depressive symptoms during pregnancy and not initiating BF within the first 2 hours after birth were associated with not exclusively BF at 6 weeks PP. When women experienced both factors, there was a 4-fold increased odds of not exclusively BF at 6 weeks PP.[96]

Overall, research shows that while there is a less clear association between pregnancy depression and BF initiation, there is strong evidence for the association between pregnancy depression and reduced BF intention, shorter BF duration, and reduced exclusivity of BF.

7.3.2 Postpartum depression and breastfeeding

The causal relationship between BF and PPD is complex and difficult to study. Several studies have examined and support the reciprocal relationship or bidirectional hypothesis, whereby PPD can lead to early BF cessation, but the discontinuation of BF can also lead to symptoms of PPD.[14,82,97,98] A prospective study of Arab women (n=137) conducted by Hamdan and colleagues demonstrated this relationship well. Breastfeeding at both 2 and 4 months PP resulted in lower reported depressive symptoms, but depressive symptoms at 2 months predicted lower rates of BF at 4 months.[99] Hahn-Holbrook and colleagues also found that depressive symptoms in pregnancy predicted lower rates of BF and earlier BF cessation; however, frequent BF (measured by the number of feedings per day) at 3 months was associated with greater subsequent declines in depressive symptoms through 2 years PP.[94] In a recent systematic review, Dias and colleagues suggested that depression during pregnancy predicts a shorter BF duration, and this may consequently increase PPD symptoms.[14] In the text that follows, the evidence on the different directions of association is discussed further.

Many studies have found an association between symptoms of PPD and early BF cessation. In most cases, PPD symptoms may precede the cessation of BF, and this has been found across many time points within the first year PP, in a variety of populations, using a range of measures.[92,100–105] Further, a review published in 2013 found PPD to be associated with worse BF outcomes even when different sociocultural contexts were considered. Mothers with perinatal depressive symptoms were less likely to initiate, continue, and exclusively breastfeed compared to those with no depressive symptoms.[15] Importantly, while depression during either pregnancy or PP has been found to have detrimental effects for BF, continuity or persistence of depressive symptoms from pregnancy into PP is associated with even worse BF outcomes, compared to women who had depressive symptoms in only one of these periods of time.[106,107]

The extent to which feeding practices influence PPD is not as clear. Some studies suggest that PPD may result from not engaging in or early cessation of BF.[92,99,108–114] In a randomized controlled trial

(RCT) in Canada (n=1,403), not BF (when attempted) predicted an increased risk of PPD at 8 weeks PP.[115] In a study of women of Mexican origin (n=150), not BF resulted in the highest level of depressive symptoms at 6 months PP, while BF non-exclusivley resulted in the lowest level.[116]

Pope and colleagues were specifically interested in whether a sample (n=2,848) of Canadian women who did not intend to or attempt to breastfeed were at greater risk of PPD, compared to women who did breastfeed.[117] In contrast with previous research, BF intention and attempt was not associated with PPD. However, lower household income, lower perceived social support, and higher perceived stress were all significantly related to PPD, and the authors offered a unique argument that these risk factors may play a larger role than BF on depression status.[117] In a large cohort study in Australia, early BF cessation was significantly associated with PPD; depressed women had a 1.25 times greater risk of BF cessation than nondepressed women. However, for most women, the onset of PPD occurred before BF cessation, suggesting that hormonal changes associated with BF or the cessation of BF were unlikely to be responsible for the development of depression.[104]

Importantly, even though engaging in BF may offer some protection against PPD, that may only be the case if the BF experience is going well. Watkins and colleagues conducted a secondary analysis of data from the Infant Feeding Practices Study II (IFPS-II), consisting of a large sample of U.S. women (n=2,586), to examine the association between early BF experiences and PPD at 2 months PP. Pain associated with BF within the first two weeks and the dislike of BF was associated with an increased odds of having PPD 2 months after childbirth.[110] In a cross-sectional analysis of women who initiated BF but discontinued before 6 months PP (n=217), shorter BF duration was associated with higher depression scores. However, the only significant predictors of PPD symptoms were pain or physical difficulties (e.g., insufficient milk supply, exhausting) with BF. The authors suggest that specific BF experiences rather than the duration of BF may actually be what is predicting depressive symptoms.[118]

Da Silva Tanganhito and colleagues recently conducted a qualitative review (n=6 articles) that provided further insights into the BF experiences and perspectives of women with PPD.[98] Across

studies, most women intended to breastfeed and had a strong desire to do so. In some cases, women breastfed even if their mental health was negatively affected; they often felt they had "no choice". This persistence was often driven by the desire to be a "good mother" and avoid having "failed as mothers". Pressure to breastfeed, from health care professionals and/or society, also influenced mothers to breastfeed, although this was negatively perceived. Although many women did not expect that BF would involve so many difficulties, these struggles were negatively associated with their mental health. Some women thought that their failure to breastfeed led to their development of PPD, and they described feelings of failure and guilt. Others indicated that physical BF difficulties were the culprit. In other words, not BF when you intended to do so, or BF but having a negative experience, might both lead to PPD.[98]

On the other hand, engaging in a BF may offer protective benefits against PPD. In a small cross-sectional study of women in Iran who did not have anxiety or depression before pregnancy, symptoms of anxiety and depression during pregnancy and PP were less common in women who breastfed exclusively compared to those who did not exclusively breastfeed.[119] Analysis of national U.S. data concluded that BF initiation predicted lower rates of PPD. Interestingly, this effect was only seen in multipara, and not in primipara individuals.[109] In a longitudinal study in England (n=14,676), women who were not depressed during pregnancy had a lower risk of PPD if they had intended to breastfeed and went on to initiate BF. Women who intended to breastfeed, but did not go on to initiate BF, had the highest risk of developing PPD.[120] Results from a study by Mezzacappa and Katkin provide further support that BF offers a protective effect on PPD symptoms. In this study, mothers who were both BF and bottle-feeding formula were assessed for mood ratings before and after both a BF and a bottle-feeding session. This within-subjects design showed that BF was associated with decrease in negative mood, while bottle-feeding was associated with a decrease in positive mood in these same women.[108]

Some research suggests there is a dose-response effect of BF on PPD. That is, differences in the levels of depressive symptoms may occur between women who are exclusively, partially, or not BF. In a

cross-sectional study of Icelandic women (n=1,058), those who exclusively breastfed had lower mean depressive symptom scores at 2 to 3 months PP, compared to women who partially breastfed.[121] Ystrom also found that partial BF and formula feeding were significantly related to higher levels of anxiety and depressive symptoms at 6 months PP, compared to exclusive BF.[122] Possible factors associated with BF that may act to protect against PPD include improved sleep and awake patterns,[123] increased BSE,[124,125] enhanced emotional involvement with the infant,[113,126] and improved regulation of the hypothalamic-pituitary-adrenal (HPA) axis.[127–129]

Overall, BF is less common among women who have PPD, but the direction of the association is complex. As discussed above, the presence of PPD symptoms may negatively affect BF outcomes. At the same time, not engaging in BF may increase the risk of PPD symptoms, while engaging in BF may protect against and/or ameliorate these symptoms. Importantly, even if a mother is engaging in BF, negative experiences around BF may be a risk factor for PPD.

Studies suggest a number of underlying reasons by which BF is affected by or affects PPD. BSE, which is defined as the confidence in one's ability to effectively breastfeed, is thought to play important role in the relationship between PPD and BF.[14,57,94,105,130] Not only is high BSE associated with lower levels of depressive symptoms,[57,130,131] but it is also associated with longer BF duration.[57,130] Given that BSE is a potentially modifiable factor, efforts to strengthen BSE could improve both mental health and BF outcomes.

Additionally, negative perceptions of BF,[105,110,132] lower BF confidence,[43] BF difficulties,[92,118,133,134] BF pain,[110] issues with mother-infant interactions and bonding,[133] and prenatal and PP weight status[116] may also play a role in the relationship between BF and PPD. Ultimately, it is thought that a combination of these factors increases a woman's vulnerability to depressive symptoms and/or worse BF outcomes.[105]

From a physiological standpoint, PPD and failed lactation – defined by Stuebe and colleagues as "weaning earlier than the mother desires because of physiologic difficulties, such as pain, difficult latch,

or concerns about milk supply"[135] – share overlapping mechanisms, which may be why they frequently occur together. During the transition into motherhood, there are complex neuroendocrine and behavioral changes taking place, any of which can become dysregulated.

Soon after birth, progesterone and estrogen levels fall, which in some women can cause baby blues and can lead to difficulty navigating early BF challenges.[135] At the same time, PRL and OT levels are increasing to stimulate milk production and ejection. In normal physiological conditions, OT and PRL have mood-ameliorating effects; promoting feelings of relaxation during nursing.[136] However, disruptions in OT or PRL homeostasis (i.e., low levels) can affect mood and BF success. Pain, chronic and acute stress, anxiety, and depression are all associated with diminished OT release and reduced PRL response to suckling.[135,137,138] Further, low OT levels are associated with weakened pain thresholds and reduced enjoyment of BF which can result in early cessation.[135] Interestingly, OT and PRL release is greater in multiparous women compared to primiparous women, indicating that parity may be an important factor in the relationship between PPD and BF.[109]

Physical and/or emotional stress is known to increase levels of salivary and plasma cortisol. Higher cortisol levels can interfere with the regulation of OT and PRL,[135] and have been associated with decreased milk volume.[12] However, BF is thought to lessen the cortisol stress responses and enhance maternal mood. Research has shown that salivary and plasma cortisol responses to stress are suppressed in lactating women in situations of physical and psychological stress. This hyporesponsiveness and reduced activation of the HPA axis may provide protection against inhibition of lactation caused by stress and lessen the exposure to cortisol that the infant receives through the milk.[128,135] If stress is associated with the development of PPD symptoms, and lactation is associated with a decreased response to stress, then BF may decrease the likelihood of developing depression in the PP period.

Pain or stress associated with BF can also decrease levels of serotonin, which can lead to higher reported symptoms of depression and anxiety.[139] This has been further demonstrated through rare cases of antidepressant use inducing lactation (galactorrhea), which is thought to occur through interactions

between serotonin and PRL.[82] Additionally, BF has been found to offer psychoneuroimmunological benefit to mothers, further explaining the protective effect of BF against poor mental health. In mothers with low mood and/or high stress, levels of immunity enhancing cytokines, including interferon-gamma and interleukin-10, were found to be low (consistent with decreased immunity) in mothers who formula-feed; however this was not seen in BF mothers even when low mood or high stress were present.[127]

More recently, researchers have suggested a new approach to understanding the relationship between depression and BF. While it was previously thought that inflammation was only one of the risk factors associated with depression, it is now believed that inflammation may be *the* risk factor that underlies all others.[140,141] Depression may be caused by high levels of inflammation, and since inflammation levels naturally rise in late pregnancy, this increases a new mother's susceptibility to depression. While physical and psychological stressors increase inflammation, BF is thought to be anti-inflammatory and stress reducing, which may explain some of the protective effects of BF on PPD.[140,141]

8. Mental health and breastfeeding interventions

8.1 Overview of interventions

Many interventions have been developed and implemented to improve BF or mental health outcomes. However, given the strong evidence of a bidirectional association between maternal mental health and BF, it is important to consider both factors when examining the efficacy of interventions to improve these outcomes. Based on a recent systematic review (Pezley et al., 2021, unpublished data), interventions which extend across pregnancy and PP and offer individualized support from professionals and peers who collaborate through a continuum of settings are most successful in improving both mental health and BF outcomes. In addition, results from a qualitative review of BF experiences among women with PPD, mothers indicated that non-judgmental, encouraging, timely, and individualized support from professionals that are competent in BF counseling is essential in their decision and ability to

breastfeed.[98] Research also suggests that communication and collaboration between providers from various disciplines can improve mental health and BF outcomes.[142]

8.2 Interventions engaging Black mothers

Several studies highlight intervention components that improve mental health and BF outcomes among Black mothers. A systematic review of psychosocial inventions, organized using a social ecological framework, showed that effective interventions should span from community engagement and peer-support during pregnancy, to adequate and timely BF support at the place of birth, and continue on with professional support during the PP period.[16] Black women routinely voice that peer-support during pregnancy and professional lactation support during PP would be the most important in helping them meet their BF goals. Importantly, this continuity of care is most beneficial when the impact of discrimination and racism is acknowledged and assessed.[16]

Results from another systematic review showed BF-specific clinic appointments, group prenatal care, and hospital and WIC policy changes improved rates of BF initiation, duration, and exclusivity. It was further indicated that family and friend support is very influential in an Black mother's infant feeding decisions and that this should be capitalized on by including close family and friends in education and counseling discussions.[2] Exposure to and normalization of BF is an important factor in promoting BSE among Black women.[68,70] Having a family member or friend who breastfed provides a positive impact on the initiation and duration of BF.[17] Black women indicate that advertisements and social marketing campaigns that represent positive images of Black mothers BF and promote BF as nurturing and normal would improve BF rates.[2,17]

Intrinsic motivation, self-determination, and confident commitment to breastfeed are all important factors in an Black woman's ability to overcome challenges and meet her BF goals.[17] Several influential interventions use Black feminist thought as the theoretical framework for their efforts, understanding and addressing the fact that Black women experience life at the intersection of multiple oppressions including gender, sex, class, and race.[17,20,21] When the issues and challenges surrounding

infant feeding practices are considered in the context of these factors, beyond the choice of the individual, BF interventions among Black women may have the most positive impact.[68,73]

8.3 Digital-technology interventions

The Internet offers great potential in extending preventative and supportive services to persons in the perinatal period since they address several key barriers to success. Digital-technology interventions, which include the use of web-based content and interactions, text messaging, and social media, have been effective at reducing depressive symptoms and improving BF outcomes.[18,19] Black mothers report that social media is a practical, convenient, and valuable way to obtain BF information and support, feel connected with like-minded people who look like them, and improve BSE.[20,21] Additional strengths of a digital approach to interventions for perinatal women include efficiency of time and resources, individualized care, ability to reach geographically and racially diverse populations, and improved social support. However, there is limited evidence on the feasibility and efficacy of such interventions for preventing perinatal mental health disorders and improving BF outcomes.

9. Development and implementation of Sunnyside

The original idea of Sunnyside, a cognitive behavioral therapy-based, interactive online intervention, came about to address the many barriers that interfere with an individual's ability to seek care for perinatal depression. The first step in the development of the intervention was collecting survey data on access to the internet and general interest in an internet intervention. In 2012, a total of 99 women at Northwestern University and University of Iowa obstetrics/gynecology clinics completed surveys. Most respondents (92%) reported access to the internet and 72% reported interest in a perinatal internet intervention.

In 2014, three (one online, two in-person) user-centered design focus groups engaged individuals who were pregnant or PP in the intervention-building process. Discussion questions were formulated along three lines of inquiry: 1) pregnancy topics of interest (topics about which women might be seeking

more information); 2) motifs for the intervention (visual themes and look and feel of the internet site); and 3) use of the intervention (how, when, and why they might interact with the intervention).

From this formative design and usability data, the Sunnyside website was built and pilot tested in a sample of 25 people in the perinatal period.[143] Participants were randomized to either the Share (group) or Control (individual) condition. In this 2015 pilot trial, participants with none to moderate depressive symptoms (PHQ-9 score of 0-14) began the 8-week online prevention intervention between 20-28 weeks gestation. The Sunnyside website consisted of 16 core didactic lessons (plus three PP booster sessions) and five associated tools. Results from this pilot work showed that in both groups intervention use was high, user experience was satisfactory, and symptoms of depression decreased from baseline to PP.

Next, Sunnyside was tested in a RCT of 210 women. Participants were randomized to either the Share (group) or Control (individual) condition. Symptoms of depression and anxiety did not differ between intervention groups; however, in both groups, symptoms decreased across time from baseline to six weeks PP. Additionally, as prevalence estimates for PPD in the general population range from 13%-20%; women who completed the Sunnyside intervention had a 4% rate of PPD.

After Sunnyside was tested in the pilot trial and RCT, the antenatal portion of the online intervention was shortened from eight to six weeks based on data from the digital mental health field suggesting that shorter length digital interventions can be effective with better adherence than longer interventions. To ensure content and cultural relevance, Sunnyside then went through further expert review and user testing from 2018-2019. The website was reviewed by healthcare professionals who routinely worked with perinatal patients and by a diverse group of women with a history of perinatal depression. Based on results of this effort, modifications were made to the content, language, and media of the intervention, creating a more inclusive and relevant user experience.

In 2019, an extension of Sunnyside was created to promote and support BF given the strong bi-directional relationship between maternal mental health and lactation. In this new arm, called Sunnyside

Plus, education and skill-promotion for BF was provided during the antenatal lessons, and written, text message, and video call lactation support was provided during the first six weeks PP. Although originally set to be pilot tested in early 2020, Sunnyside Plus research efforts were halted due to the coronavirus disease 2019 (COVID-19) pandemic. During this pause, additional modules specific to anxiety and BF during the time of COVID-19 were created by specialists in the respective fields and added to the intervention content. In the summer of 2020, the Sunnyside Plus pilot RCT (n=22) commenced, comparing Sunnyside (individual) to Sunnyside Plus (individual).

III. MANUSCRIPT 1

Title: Efficacy of behavioral interventions to improve maternal mental health and breastfeeding outcomes: a systematic review

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1. Abstract

Background: Despite extensive benefits and high intentions, few women breastfeed exclusively for the recommended duration. Maternal mental health is an important underlying factor associated with barriers and reduced rates of breastfeeding intent, initiation, and continuation. Given the strong evidence of a bidirectional association between maternal mental health and breastfeeding, it is important to consider both factors when examining the efficacy of interventions to improve these outcomes.

Objective: The purpose of this manuscript is to review the literature on the efficacy of behavioral interventions which focused on both maternal mental health and breastfeeding outcomes, examining the intersection of the two.

Materials and Methods: This systematic review was completed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines. Relevant articles were identified from PubMed, CINAHL, Embase, and PsycINFO from database inception to April 23, 2020.

Results: Thirty-five interventions reported in 36 articles were identified, representing 18 different countries. Fifteen studies reported a statistically significant positive effect of the intervention on both maternal mental health and breastfeeding; most showing a decrease in self-report depressive and/or anxiety symptoms in parallel to an increase in breastfeeding duration and/or exclusivity.

Conclusions: Interventions that extend across pregnancy and postpartum and offer individualized support from both professionals and peers who collaborate through a continuum of settings (i.e., health system, home, and community) are most successful in improving both mental health and breastfeeding outcomes. The benefits of improving these outcomes warrant continued development and implementation of such interventions.

2. Background

Breastfeeding (BF) is considered the ideal form of infant feeding due to the extensive benefits for the mother and infant. For mothers, BF offers short and long-term health benefits, including longer periods of amenorrhea and therefore the possibility for improved interpregnancy intervals, decreased postpartum weight retention, reduced risk of developing depression, obesity, diabetes mellitus, hyperlipidemia, hypertension, cardiovascular disease, breast cancer, ovarian cancer, and mortality over the next decade.[14,50,51] For infants, human milk and the nurturing act of BF promotes emotional, cognitive, and sensory development, increases intelligence, provides protection against infectious diseases, including respiratory and ear infections, and reduces the risk of overweight and obesity in both childhood and adulthood, type 1 and 2 diabetes, hypertension, sudden unexplained infant death syndrome, asthma, childhood leukemia, and mortality.[50]

Despite these benefits, few women breastfeed for the recommended duration. All major health and professional organizations, including the World Health Organization, American Academy of Pediatrics, and the United States (U.S.) Departments of Agriculture and Health and Human Services (i.e., Dietary Guidelines for Americans)[52–54] recommend exclusive BF for the first six months of a child's life. Recommendations for the continued duration of BF, in combination with appropriate complementary foods, range from at least one year to at least two years, as long as desired by both the mother and child.[52,53] However, epidemiological data show that few women breastfeed to 1 year. According to the Centers for Disease Control and Prevention's (CDC) 2020 Breastfeeding Report Card, while 84% (4 out of 5) initiated BF, 58% were BF at six months, and only 35% were BF at 12 months.[55] Importantly, these low BF rates at 1 year persist despite high rates of intention to breastfeed. In the U.S., 80% of women intend to breastfeed in some capacity, and of those, more than 85% intend to exclusively breastfeed for at least 3 months; however, only one third (32%) of mothers achieve their intended BF goals.[144]

Discrepancies between BF recommendations and actual BF duration have been explored. Reported barriers include: neonatal intensive care unit (NICU) admission of the newborn, pain or discomfort when BF, difficulty with latching, concerns with adequate milk supply, lack of professional lactation support, employment circumstances, unaccommodating childcare environments, and unsupportive social and cultural norms.[2,62–64] These barriers are further complicated by mental health disorders, which are common both during pregnancy and the first 12 months after childbirth.[4–6] Specifically, research suggests that the prevalence of perinatal anxiety disorders is at least 17%, that approximately 7-20% of women experience clinical depression at some time during the perinatal period,[7,8] and that up to 1 in 3 (34%) women report experiencing childbirth trauma, often leading to postpartum depression[145] and post-traumatic stress disorder (PTSD).[146] Given the high prevalence of mental health disorders within the perinatal period, maternal mental health has been considered an important underlying factor associated with barriers and reduced rates of BF intention, initiation, exclusivity, and continuation.[4–6]

Research consistently shows that maternal mental health disorders are associated with poorer BF outcomes. Prenatal anxiety is associated with reduced BF intention, while postpartum anxiety is associated with reduced BF initiation and exclusivity, and shorter BF duration.[12,13] Childbirth trauma negatively affects initiation and continuation of BF.[65,147] Further, a strong association exists between perinatal depression and reduced BF intention, shorter BF duration, and reduced exclusivity of BF.[14] Not engaging in BF may increase the risk of postpartum depressive symptoms,[122] while engaging in BF may protect against or ameliorate these symptoms.[108,109] Importantly, negative experiences around BF may increase risk for developing postpartum depression.[98,105] Therefore, the relationship between maternal mental health and BF outcomes are bidirectional; mental health disorders may impede BF success and difficulty with BF may predict depression and/or anxiety.

Given the strong evidence of a bidirectional relationship between maternal mental health and BF, it is important to consider both factors when examining the efficacy of interventions to improve these

outcomes. Indeed, many interventions have been developed and implemented to improve mental health and/or BF outcomes. To our knowledge, there are no published systematic reviews that examine the efficacy of behavioral interventions that focus on *both* maternal mental health and BF outcomes. In this review, behavioral interventions, rather than medical, were included in order to hone in on behavioral components that can be applied in future intervention efforts. Therefore, the purpose of this manuscript was to systematically review the literature on the efficacy of behavioral interventions which included outcomes of both maternal mental health (depression, anxiety, and childbirth trauma) *and* BF (i.e., intention, initiation, duration, exclusivity, knowledge, and self-efficacy), examining the intersection of the two. Examination of these behavioral intervention types considers a more wholistic approach to care, improving our understanding of how to create and reform best practices which can improve the short and long-term health of the mother, child, and family unit.

3. Methods

This systematic review was completed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines. We used the Covidence[148] software to manage title and abstract screening, full-text screening, quality assessment, and data extraction processes. The team consisted of five reviewers (B.L., J.P., K.C., L.P., and M.C.). At every phase, each publication was independently evaluated by two reviewers. Discrepancies were discussed until all authors agreed.

3.1 Data Sources and Search Methodology (Identification)

Using an a priori research protocol, relevant articles were identified from PubMed, CINAHL, Embase, and PsycINFO from database inception to April 23, 2020 in consultation with a senior research librarian at the University of Illinois at Chicago. The general search terms used included variants of BF, depression, anxiety, and trauma. The full search strategy can be found in supplementary file 1. The

search terms were organized by database and included both database-specific Subject Heading and Keyword searches. A total of 6177 studies were identified using this search strategy.

3.2 Study Selection (Screening and Eligibility)

After automatic deduplication was completed in Covidence, a total of 3,963 studies were available to be screened at the title and abstract level. For the purpose of this systematic review, empirical studies that assessed the effectiveness of behavioral interventions for improving maternal mental health and BF outcomes were included; the intervention itself did not have to focus on both factors, but inclusion of both outcomes was required. Maternal mental health outcomes were depression, anxiety, and childbirth trauma. Various aspects of BF were considered, including intention, initiation, duration, exclusivity, milk onset and volume, perceived milk supply, knowledge, and self-efficacy. Only articles available in English, those with primary experimental or quasi-experimental research design, and studies which used a behavioral intervention type were considered. Studies were included regardless of sample size or measurement type. 129 full-text studies were assessed for eligibility, of which, 36 studies were included. A PRISMA flow diagram of the search strategy and study selection was generated (Figure 1).

3.3 Quality Assessment and Data Extraction

The quality of each study was independently assessed in Covidence using the Cochrane Risk of Bias[149] template or the Joanna Briggs Institute (JBI) Critical Appraisal Checklist.[150] Risk was assessed for each of the following domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, and selective outcome reporting. Using an a priori data extraction protocol and the Covidence software, independent reviewers extracted pertinent data including authors and country, research design, participant characteristics (i.e., age, race/ethnicity, income, parity, mode of delivery, past BF experience, and mental health history), intervention description, BF outcomes (i.e., intention, initiation, duration, exclusivity, milk onset and

volume, knowledge, self-efficacy), and mental health outcomes (i.e., depression, anxiety, childbirth trauma) when available.

3.4 Data Synthesis

Relevant data from the publications were extracted and organized into table format (Table I).

4. Results

4.1 General Description

A total of 36 articles met the criteria for inclusion in this review. Two articles[151,152] describe data from the same study, for a total of 35 unique interventions. Table I provides a summary of sample characteristics, intervention components, and mental health and BF outcomes of the studies included. Overall, 32 of the studies were randomized controlled trials (RCT) and three studies were quasi-experimental (e.g., crossover trial, retrospective cohort).[153–155] Studies were published between 1993-2020, with 72% (n=26) being published in the past 10 years.

Of the studies included in this review, nine were conducted in the U.S.[19,151–153,156–161] four in China,[162–165] three in India,[155,166,167] two each from South Africa,[168,169] Norway,[154,170] Iran,[171,172] and the United Kingdom,[173,174] and one each from Canada,[175] Switzerland,[176] Australia,[177] Turkey,[178] New Zealand,[179] Nigeria,[180] Mexico,[181] Malaysia,[182] Sweden,[183] Spain,[184] and Croatia.[185] Of the studies conducted in the U.S., 67% (n=6) had a sample of primarily white non-Hispanic participants,[19,151–153,157,159,161] two studies had primarily Hispanic and/or Spanish-speaking participants,[158,160] and one study had primarily Black and Hispanic participants.[156]

Sample size varied greatly across studies from 18 to 1,324 participants. Eight interventions were conducted in first-time parents only.[163–165,171–173,177,182] Nine studies did not state the parity of the sample.[153,155,158,159,166,168,178,183,185] Sixteen of the studies did not report mode of birth as a sample characteristic. Of the remaining studies, three reported 100% of participants had a vaginal birth[161,183,184]

and three reported 100% of participants had a cesarean birth.[162,163,172] Income level varied greatly among study samples and was reported differently from study to study; household vs. individual and annual vs. monthly. A total of 17 studies did not report income as a sample characteristic.

4.2 Successful Interventions for Mental Health and Breastfeeding Outcomes

Fifteen of the 35 studies reported statistically significant positive effect of the intervention on both maternal mental health and BF outcomes. Successful interventions included psychoeducational group programs,[165,177] relaxation therapy,[166,185] skin-to-skin contact between mother and infant,[175] music therapy,[155] psychological nursing,[163] health and infant care education programs,[162,170] stepped-care psychological treatment,[180] peer support with[160,173] and without[168] home visits, BF training with home visits,[178] risk-based treatment with home visits.[151,152]

Six of the interventions occurred across both pregnancy and the postpartum period,[151,152,160,168,173,177,180] four occurred during the hospital stay at or around the time of birth,[162,163,170,175] four occurred during the postpartum period only,[155,166,178,185] and one occurred during pregnancy only.[165] Six interventions were delivered by hospital staff,[155,162,163,166,170,175] three by multidisciplinary teams of mental health and lactation specialists,[165,177,180] three by peer support,[160,168,173] and one each by a lactation specialist,[178] home healthcare provider,[151,152] and research staff.[185] Two-thirds (n=10) of the successful interventions for both mental health and BF outcomes were conducted individually, four were offered in a group setting,[166,168,177,185] and one was a combination of individual and group settings.[160] Over half (n=8) of the successful interventions focused on both BF and maternal mental health,[151,152,155,160,165,166,170,177,178] four focused primarily on BF,[162,163,175,185] and three focused primarily on mental health.[168,173,180]

Nine studies reported BF exclusivity as an outcome and all nine indicated a statistically significant increase in exclusivity in the intervention group compared to the control, with assessment time points ranging from three days to six months postpartum.[160,162,165,168,175,177,178,180,185] BF duration was measured in seven studies, five of which indicated a statistically significant increase in duration at

three, six, or nine months postpartum in the intervention group compared to the control.[151,152,170,175,178,185] Milk output/volume was measured in four studies and all four indicated a statistically significant increase in volume within the first three days to two weeks postpartum in the intervention group versus control.[155,162,163,166] Initiation of BF was measured in four studies, three of which indicated a statistically significant increased rate of initiation among the intervention participants compared with control.[152,163,165] Breastfeeding self-efficacy was measured in three studies, two of which indicated a statistically significant enhanced self-efficacy between three days to six months postpartum in intervention versus control participants.[160,165] Earlier milk onset,[162] decreased breast swelling,[162] greater levels of effective BF behavior (i.e., noticing changes in breast fullness, visualizing and hearing baby swallowing, etc.)[165] and increased mother-infant bonding[173] were reported among intervention versus control participants in these studies as well.

Most studies reported depressive symptoms as an outcome (n=11). Symptoms of depression were measured by Edinburgh Postpartum Depression Scale (EPDS) (n=8), Center for Epidemiological Study-Depressive Symptomatology Scale (CES-D) (n=2), or Scale of Depression Score (n=1). All studies indicated a statistically significant decrease in the level of depressive symptoms at time points ranging from birth to 12 months postpartum among the intervention compared to the control participants. One study reported more depressive symptoms at 30 months postpartum in the intervention group compared to control.[152] Symptoms of anxiety were measured in four studies using the State Trait Anxiety Inventory (STAI) (n=3) or Perinatal Anxiety Screening Scale (PASS) (n=1), with these studies reporting lower levels across time points of three days to six months postpartum.[162,166,178,185] One study also reported a dose response of BF frequency, where the higher the frequency, the lower maternal anxiety levels became.[178] Stress was reported in three studies using Perceived Stress Scale (PSS), Parenting Stress Index (PSI), and salivary cortisol. These studies indicated a lower level of stress across time points of one day to six months postpartum among the intervention participants.[155,160,166]

Three studies delivered interventions to postpartum mothers who delivered preterm infants cared for in the NICU.[155,166,170] Two of these studies, featuring music therapy and relaxation therapy, reported increased milk volume and decreased levels of stress.[155,166] Dabas and colleagues reported fewer symptoms of anxiety for mothers of preterm infants at around two weeks postpartum in the intervention group compared to control.[166] The third study among mothers of preterm infants reported an increase in BF duration at nine, but not 12 months postpartum and lower levels of depressive symptoms.[170]

4.3 Successful Interventions for Breastfeeding Outcomes Only

Seven studies reported statistically significant positive effect of the intervention on BF, but not maternal mental health outcomes. Successful interventions included doula support,[156,181] early hospital discharge with home-based postpartum care,[184] massage therapy,[172] an online interactive BF monitoring system with real-time support from a lactation specialist,[19] BF education group sessions,[171] and Person Environment Occupation model (therapy to enhance understanding of individual environmental barriers to BF and infant care).[167]

Three of the interventions occurred during the postpartum period only,[19,167,184] two occurred during the hospital stay at or around the time of birth,[172,181] one occurred during pregnancy only,[171] and one occurred across pregnancy, birth, and postpartum.[156] Two interventions were delivered by doulas[156,181] and one each was delivered by a lactation specialist,[19] mental health provider,[167] massage therapist,[172] home healthcare provider,[184] and hospital staff.[171] Most (n=6) of the interventions were offered in an individual setting and one occurred in a group setting.[171] Over half (n=4) of the interventions focused on both BF and maternal mental health,[156,167,181,184] two focused primarily on BF,[19,171] and one focused primarily on mental health.[172]

Two studies reported BF exclusivity as an outcome and both indicated a statistically significant increase in exclusivity in the intervention group compared to the control, with time points ranging from one to three months postpartum.[19,181] BF duration was measured in two studies, with one indicating a statistically significant increase in duration at three months postpartum among the intervention

participants, but not at one week, one, six, or greater than nine months postpartum.[184] One study found no difference between groups for BF duration at three months postpartum.[156] Frequency of BF was reported in two studies. One showed increased daily frequency status post cesarean birth[172] and the other from one to three months postpartum[19] among intervention versus control participants. Two studies measured BF knowledge and found an increase at time points ranging from birth to three months postpartum.[171,181] Greater rate of BF initiation among intervention compared to control participants was found in one study.[156]

One of the interventions was delivered to postpartum mothers of preterm infants cared for in the NICU.[167] Higher BF self-efficacy was seen at 15 days postpartum among intervention participants; however, there was no difference between groups for depressive symptoms or stress at 15 days postpartum.

4.4 Successful Interventions for Mental Health Outcomes Only

Three studies reported statistically significant positive effect of the intervention on maternal mental health, but not BF outcomes. Successful interventions included relaxation therapy,[182] in-home postpartum support,[174] and prenatal psycho-educational group support.[164]

Two of the interventions occurred during the postpartum period only[174,182] and one occurred during pregnancy only.[164] Two interventions were delivered by research team members[164,182] and one by community midwives and postpartum support workers.[174] Two of the interventions were offered in an individual setting[174,182] and one occurred in a group setting.[164] Two of the interventions focused on both BF and maternal mental health[174,182] and one focused primarily on mental health.[164]

Two studies reported depressive symptoms as an outcome measured by EPDS. Both studies indicated a statistically significant decrease in the level of depressive symptoms at time points ranging from six weeks to six months postpartum among the intervention compared to the control participants.[164,174] Symptoms of anxiety were measured in one study using the Beck Anxiety Inventory (BAI) and they reported a decrease at two weeks postpartum among intervention participants, but not at

six and 12 weeks postpartum.[182] Stress was reported in one study using PSS and milk cortisol.[182] At two weeks postpartum, there were lower levels of stress as indicated by a decrease in hindmilk cortisol. Lower levels of stress were reported at six and 12 weeks postpartum according to the PSS among intervention participants.

4.5 Interventions with No Effect

Of the studies included in this review, 10 reported no statistically significant difference between intervention and control groups for mental health or BF outcomes. These interventions included home-based postpartum care,[153,157,161,176] in-home antenatal support,[158] group prenatal care,[159] sleep intervention,[179] audiovisual postpartum BF education,[169] skin-to-skin contact between mother and infant,[183] and early hospital discharge.[154] Six of the interventions occurred during the postpartum period only,[153,154,157,161,169,176] two occurred during pregnancy only,[158,159] one during the hospital stay,[183] and one across both pregnancy and the postpartum period.[179] Three interventions were delivered by home healthcare providers,[153,157,161] three by perinatal care providers,[154,159,176] two by hospital staff,[169,183] one by sleep and lactation specialists,[179] and one by peer support.[158] Most (n=7) of the interventions were conducted individually,[153,154,157,158,169,176,183] two were a combination of individual and group settings,[161,179] and one was offered in a group setting only.[159] Most (n=7) of the interventions focused on both maternal mental health and BF[154,157–159,161,179,183], while three focused primarily on BF.[153,169,176]

4.6 Risk of Bias

For the RCTs (n=32), the Cochrane Risk of Bias tool[149] was used to assess seven domains of bias (Table II).

1. *Random sequence generation (selection bias)*

Adequate generation of a randomized sequence (low risk of selection bias) was described in 25 of the 32 RCTs. Three studies were at high risk for this bias.[159,168,178] The method of randomization was not adequately described in four of the studies.[156,158,183,185]

2. *Allocation concealment (selection bias)*

Adequate concealment of allocations prior to assignment (low risk of selection bias) was described in 19 of the 32 RCTs. Two studies were at high risk for this bias.[175,178] The method used to conceal the allocation sequence was not described in sufficient detail in 11 of the studies.

3. *Blinding of participants and personnel (performance bias)*

Blinding was not always possible due to the nature of behavioral interventions. However, blinding of participants and personnel was ensured or it was determined that the outcomes were not likely to be influenced by lack of blinding (low risk of performance bias) in 22 of the 32 RCTs. Three studies were at high risk for performance bias due to no or incomplete blinding.[158,166,180] The method of blinding was not adequately described in seven of the studies.[151,152,164,169–171,173,185]

4. *Blinding of outcome assessment (detection bias)*

Blinding of the outcome assessment was ensured (low risk of detection bias) in 14 of the 32 RCTs. Two studies were at high risk for this bias.[162,175] The method used to blind the outcome assessment was not described in sufficient detail in 16 of the studies.

5. *Incomplete outcome data addressed (attrition bias)*

The amount, nature, and handling of incomplete outcome data was appropriate (low risk of attrition bias) in 22 of the 32 RCTs. Five studies were at high risk for this bias.[158,163,168,169,177] The method of blinding was not described in sufficient detail in five of the studies.[162,171,179,183,185]

6. *Selective reporting (reporting bias)*

Adequate description of the study's pre-specified and expected outcomes (low risk of reporting bias) was provided in 24 of the 32 RCTs. Two studies were at high risk for this bias.[171,179] This information was unclear or inadequate in six of the studies.[156,169,172,178,180,184]

7. Other sources of bias

Additional sources of potential bias assessed included protocol adherence, other interventions avoided, sample size sufficiently large, eligible participants enrolled, and funding and sponsorship bias. Low risk of other bias was found in 25 of the 32 RCTs. No studies were at high risk for this bias. This information was unclear or inadequate in seven of the studies.[151,152,158,163,167,172,184,185]

The JBI Critical Appraisal Checklist[150] was used to assess quality of the quasi-experimental studies (n=3) (Table III). All studies had appropriate cause-effect design, presence of a control group, multiple measurements of the outcome(s), and consistently and reliably measured outcomes. Two of the three studies had minimal group difference; this was unclear in one study. In all three studies, it was unclear if comparison groups received similar treatment or care outside of the intervention. Two of the three studies reported follow-up completion, while one study reported incomplete follow-up. The use of appropriate statistical analysis (i.e., statistical power) was unclear for one study.[153]

5. Discussion

This review examined 36 articles which sought to test the effect of 35 unique interventions on both maternal mental health and BF outcomes. Almost half (n=15, 42%) of the interventions were successful at improving both mental health and BF outcomes, seven (20%) reported positive effects on BF, but not mental health, three (9%) reported positive effects on mental health, but not BF, and over one quarter (n=10, 29%) of interventions had no effect on mental health or BF outcomes.

Consistent with the strong evidence of a bidirectional association between maternal mental health and BF, most successful interventions showed an increase in BF duration and/or exclusivity in parallel to a decrease in self-report depressive and/or anxiety symptoms. Physical and/or emotional stress is known to increase levels of salivary and plasma cortisol.[12,135] Higher cortisol levels can interfere with the regulation of lactogenic hormones,[135] and have been associated with decreased milk volume.[12]

Consistent with this mechanism, three studies in this review reported increased milk volume with concurrent reduced levels of stress or anxiety.[155,162,166] It is important to note that while *perceived* concern of milk supply is one of the most common factors associated with early BF cessation and postpartum anxiety,[65–67] none of the studies in this review assessed perceived milk supply.

Interventions that improved both mental health and BF outcomes were more likely to span across pregnancy and the postpartum period, including at or around birth, while interventions demonstrating no effect mostly occurred in either pregnancy or the postpartum period. Successful interventions were also more likely to be delivered by a combination of hospital staff, mental health and lactation specialists, and peer support. These findings are consistent with evidence indicating that support that is provided concurrently throughout a continuum of settings (i.e., health system, home, and community) result in the largest positive impact BF outcomes.[186] Research also suggests that communication and collaboration between providers from various disciplines can improve both maternal mental health and BF outcomes.[142]

Across all outcome categories, most (n=25, 71%) interventions were in an individual rather than group setting. However, four of the seven group-based interventions improved both mental health and BF outcomes. In a qualitative review of BF experiences among those with postpartum depression, mothers indicated that non-judgmental, encouraging, timely, and individualized support from professionals that are competent in BF counseling is essential in their decision and ability to breastfeed.[98]

5.1 Limitations

Several limitations of this review should be noted. Interventions in this review took place across 18 different countries which makes it difficult to make direct comparisons given the varying policies and social environments that can affect maternal mental health and BF outcomes. Additionally, the majority (67%) of U.S.-based samples in this review included white non-Hispanic participants, making it difficult to consider the intersectional complexities of race, mental health, and BF. Future research must take an

intersectional approach to understand how varying identities and compounding experiences of discrimination and oppression impact outcomes of mental health and BF. Previous BF experience, which could impact outcomes, was only reported in three articles.[19,157,161] In addition, parity was not consistent across studies and was not reported in many articles. Lactogenic hormone release is greater in multiparous women compared to primiparous, indicating that parity may be an important factor in the relationship between mental health and BF.[109] Many articles (n=23) did not report current or past history of mental health difficulties within the study sample, which is a potential for unknown confounding. The varying follow-up time points and measurement strategies used across studies make it difficult to make direct comparisons as well. Childbirth experience continues to be underrepresented in the literature. Nearly half of the studies did not report mode of birth. Further, no studies were found examining childbirth-related trauma as an outcome. It is likely that the events that occur during labor and birth have an impact on BF outcomes, mostly due to the delay of lactogenesis II and the disruption of normal physiologic processes.[47] Childbirth trauma is also associated with increased risk of postpartum depression and PTSD.[145,146] Lastly, under- and over-nutrition may affect milk volume and composition. More specifically, there is data suggesting that obesity is associated with insufficient glandular development, reduced milk volume, dampened milk ejection reflex, suppressed lactation, and elevated depressive symptoms,[47,187] however, only 3 articles reported body mass index (BMI) as a sample characteristic.[158,172,173]

While not a limitation, it should be noted that only one intervention used digital-technology.[19] The Internet offers great potential in extending preventive services to individuals in the perinatal period since they address several key barriers to success such as limited access to professional support and lack of social support. Digital-technology interventions, which include the use of web-based content and interactions, text messaging, and social media, have been effective at reducing depressive symptoms and improving BF outcomes.[18,98] Strengths of a digital approach to interventions for perinatal women

include efficiency of time and resources, ability to reach geographically and racially diverse populations, and improved social support.

6. Conclusions

This systematic review highlights the intersection of maternal mental health and BF. Both occur in complex settings that affect and can be affected by physiological, emotional, social, psychological, personal, cultural, and physical factors. Based on this review, interventions that extend across pregnancy and postpartum and offer individualized support from both professionals and peers who collaborate through a continuum of settings are most successful in improving both mental health and BF outcomes. The benefits of improving these outcomes warrant continued development and implementation of interventions that acknowledge and support the whole person and their community.

7. Acknowledgements

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Supplementary File 1: Search Strategy

PubMed Search

(("Breast Feeding"[mesh] OR "Lactation"[mesh] OR "Breast Feeding"[tiab] OR "Breastfeeding"[tiab] OR "Lactation"[tiab] OR "Lactating"[tiab]) **AND** ("Mental Disorders"[mesh:NoExp] OR "Anxiety Disorders"[mesh] OR "Depressive Disorder"[mesh] OR "Depression"[mesh] OR "Trauma and stressor related disorders"[mesh] OR "Depression"[tiab] OR "Depressive"[tiab] OR "PPD"[tiab] OR "PND"[tiab] OR "Anxiety"[tiab] OR "Trauma"[tiab] OR "Traumatic"[tiab] OR "PTSD"[tiab]) **AND** ("Epidemiologic studies"[mesh] OR "Statistics and numerical data"[sh] OR "Controlled clinical trial"[pt] OR "randomized"[tiab] OR "randomised"[tiab] OR "randomly"[tiab] OR "placebo"[tiab] OR "case control"[tiab] OR "cohort"[tiab] OR "cross sectional"[tiab] OR "follow up"[tiab] OR "observational"[tiab] OR "longitudinal"[tiab] OR "prospective"[tiab] OR "retrospective"[tiab] OR "investigated"[tiab] OR "analysis"[tiab] OR "statistics"[tiab] OR "data"[tiab])) **NOT** ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))

CINAHL Search

((MH "Breast Feeding+") OR (MH "Lactation+") OR AB("Breast Feeding") OR TI("Breast Feeding") OR AB("Breastfeeding") OR TI("Breastfeeding") OR AB("Lactation") OR TI("Lactation") OR AB("Lactating") OR TI("Lactating")) **AND** ((MH "Behavioral and Mental Disorders") OR (MH "Anxiety Disorders+") OR (MH "Depression+") OR (MH "Psychological Trauma+") OR AB("Depression") OR TI("Depression") OR AB("Depressive") OR TI("Depressive") OR AB("PPD") OR TI("PPD") OR AB("PND") OR TI("PND") OR AB("Anxiety") OR TI("Anxiety") OR AB("Trauma") OR TI("Trauma") OR AB("Traumatic") OR TI("Traumatic") OR AB("PTSD") OR TI("PTSD")) **AND** ((MH "research by type and subject+") OR AB("randomized") OR TI("randomized") OR AB("randomised") OR TI("randomised") OR AB("randomly") OR TI("randomly") OR AB("placebo") OR TI("placebo") OR AB("case control") OR TI("case control") OR AB("cohort") OR TI("cohort") OR AB("cross sectional") OR TI("cross sectional") OR AB("follow up") OR TI("follow up") OR AB("observational") OR TI("observational") OR AB("longitudinal") OR TI("longitudinal") OR AB("prospective") OR TI("prospective") OR AB("retrospective") OR TI("retrospective") OR AB("investigated") OR TI("investigated") OR AB("analysis") OR TI("analysis") OR AB("statistics") OR TI("statistics") OR AB("data") OR TI("data"))

Embase Search

('Breast Feeding'/exp OR 'Lactation'/exp OR 'Breast Feeding':ti,ab OR 'Breastfeeding':ti,ab OR 'Lactation':ti,ab OR 'Lactating':ti,ab) **AND** ('Mental Disease'/de OR 'Anxiety Disorder'/exp OR 'Depression'/exp OR 'Psychotrauma'/exp OR 'Depression':ti,ab OR 'Depressive':ti,ab OR 'PPD':ti,ab OR 'PND':ti,ab OR 'Anxiety':ti,ab OR 'Trauma':ti,ab OR 'Traumatic':ti,ab OR 'PTSD':ti,ab) **AND** ('methodology'/exp OR 'randomized':ti,ab OR 'randomised':ti,ab OR 'randomly':ti,ab OR 'placebo':ti,ab OR 'case control':ti,ab OR 'cohort':ti,ab OR 'cross sectional':ti,ab OR 'follow up':ti,ab OR 'observational':ti,ab OR 'longitudinal':ti,ab OR 'prospective':ti,ab OR 'retrospective':ti,ab OR 'investigated':ti,ab OR 'analysis':ti,ab OR 'statistics':ti,ab OR 'data':ti,ab) **NOT** ([animals]/lim NOT [humans]/lim)

PsycINFO Search

(MAINSUBJECT.EXACT.EXPLODE("breast feeding") OR MAINSUBJECT.EXACT.EXPLODE("Lactation") OR AB,TI("breast feeding") OR AB,TI("breastfeeding") OR AB,TI("Lactation") OR AB,TI("Lactating")) **AND** (MAINSUBJECT.EXACT("mental disorders") OR MAINSUBJECT.EXACT.EXPLODE("anxiety disorders") OR MAINSUBJECT.EXACT.EXPLODE("major depression") OR MAINSUBJECT.EXACT.EXPLODE("stress and trauma related disorders") OR AB,TI("depression")

OR AB,TI("depressive") OR AB,TI("PPD") OR AB,TI("PND") OR AB,TI("anxiety") OR AB,TI("trauma") OR AB,TI("traumatic") OR AB,TI("PTSD")) **AND** (MAINSUBJECT.EXACT.EXPLODE("empirical methods") OR AB,TI("randomized") OR AB,TI("randomised") OR AB,TI("randomly") OR AB,TI("placebo") OR AB,TI("case control") OR AB,TI("cohort") OR AB,TI("cross sectional") OR AB,TI("follow up") OR AB,TI("observational") OR AB,TI("longitudinal") OR AB,TI("prospective") OR AB,TI("retrospective") OR AB,TI("investigated") OR AB,TI("analysis") OR AB,TI("statistics") OR AB,TI("data"))

Figure 1. PRISMA Flow Diagram of Search Strategy and Study Selection

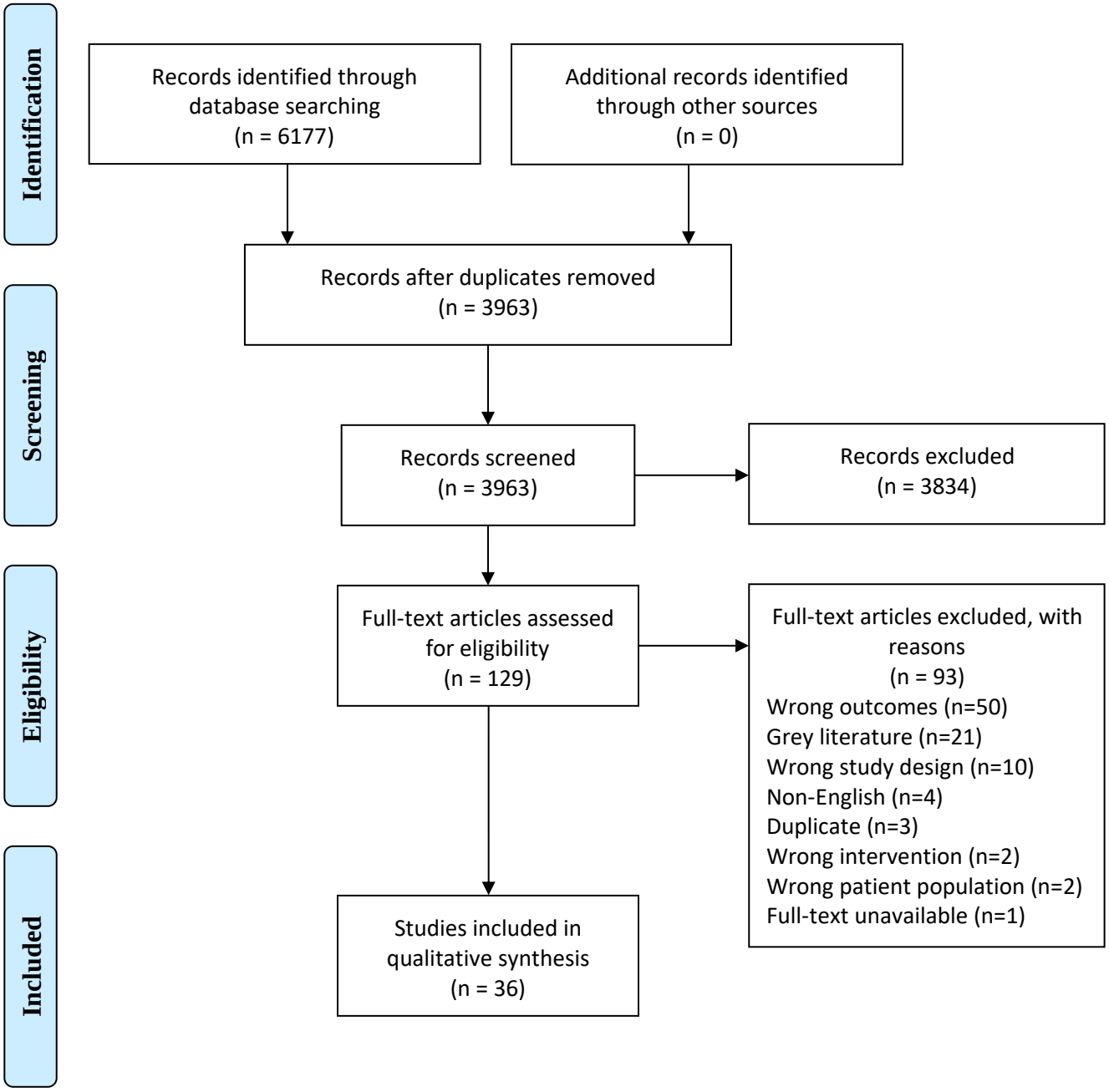

TABLE I. SUMMARY OF PUBLISHED BEHAVIORAL INTERVENTIONS

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
Ahmed et al. (2016), United States	RCT	N=49 (I); 57 (C) Age (mean): 29.9 (I); 29.2 (C) Race/ethnicity: White: 73.5% (I); 67.9% (C) Black: 18.4% (I); 28.3% (C) Hispanic: 2% (I); 5.3% (C) Income (individual, annual): <10000: 8.2% (I); 19.3% (C) ≥ 50000: 71.4% (I); 47.4% (C) Parity: 42.9% (I); 57.9% (C) primiparous Mode of birth: 73.5% (I); 73.7% (C) vaginal MH status/history: NR			x	I: online interactive BF monitoring system with automatic feedback via notifications for any reported BF issues within the first mos. PP C: standard care	Lactation Specialist Individual BF	**Exclusivity:** No difference between groups at discharge; ↑ at 1, 2, and 3 mos. PP* **Daily Frequency (Intensity):** ↑ at 1, 2, and 3 mos. PP*	**Depressive Symptoms:** No difference between groups at 1, 2, and 3 mos. (EPDS)
AK et al. (2015), India	Crossover Trial	N=29 Age (mean): 24 Race/ethnicity: NR Income: NR Parity: NR Mode of birth: Vaginal: 27.5% Vaginal with vacuum: 27.5% Cesarean: 45% MH status/history: NR			x	I: music therapy via 30 min. rendition of the raga Malkauns and Yaman played on the flute for PP persons of preterm infants (<34 wks.) in NICU C: no music therapy	Hospital Staff Individual BF, MH	**Milk volume production:** ↑ at day 1, 2, 3, and 4 PP*	**Stress:** ↓ at day 1 and 4 PP* (PSS and salivary cortisol)
Akbarzadeh et al. (2017), Iran	Semi-experimental	N=50 (I); 50 (C) Age (mean): 23.9 (I); 24.4 (C) Race/ethnicity: NR Income: NR Parity: 100% primiparous Mode of birth: NR MH status/history: NR	x			I: Behavior-Change Model involving 4 weekly group BF educational sessions (90 min.) based on BASNEF in late pregnancy C: standard care	Hospital Staff Group BF	**Knowledge:** ↑ immediately, 1 and 3 mos. after the intervention*	**Depressive Symptoms:** No difference between groups at 1 and 3 mos. after intervention (Zung Self-Rating Depression Scale)
Bigelow et al. (2014), Canada	RCT	N=26 (I); 51 (C) Age (mean): 32.1 (I); 28.8 (C) Race/ethnicity: 100% (I); 98% (C) non-Hispanic White Income: NR Parity (mean): 1.1 (I); 1.2 (C) Mode of birth: NR MH status/history: NR		x		I: skin-to-skin contact 6 hrs. per day during infant's first week of life, then 2hrs. per day through 1 mos. PP (>4000 min. total) C: <4000 min. total skin-to-skin in the 1st mos. PP	Hospital Staff Individual BF	**Duration:** ↑ at 1, 2, and 3 mos. PP* **Exclusivity:** ↑ at 1, 2, and 3 mos. PP*	**Depressive Symptoms:** ↓ at 1 wk. PP*; no difference between groups at 1, 2, and 3 mos. PP (EPDS)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
Boulvain et al. (2004), Switzerland	RCT	N= 228 (I); 231 (C) Age (mean): 29 (I and C) Race/ethnicity: 31% (I); 30% (C) Swiss origin Income (household, annual) [CHF (US$)]: <50000 (<$55000) 27% (I); 24% (C) ≥ 50000 (≥$55000) 57% (I and C) Parity: 60% (I); 57% (C) nulliparous Mode of birth: Spontaneous vaginal: 72% (I); 65% (C) Instrumental vaginal: 18% (I); 24% (C) Cesarean: 11% (I); 12% (C) MH status/history: no history of PP depression			x	I: home-based PP care by a midwife after shortened hospital stay (24-48 hrs.) C: hospital-based PP standard care lasting 4-5 days PP	Midwives Individual BF	**Duration:** No difference between groups at 7 days, 28 days, and 6 mos. PP	**Depressive Symptoms:** No difference at 7 and 28 days PP (EPDS)
Buultjens et al. (2018), Australia	Alternate-Allocation Study	N=10 (I); 8 (C) Age (mean): 32.6 (I); 31.9 (C) Race/ethnicity: 90% (I); 62.5% (C) White Income (household, annual) [AUD (US$)]: <$50000-99999 ($35654-71308): 30% (I); 62.5% (C) >$100000 ($71309): 70% (I); 37.5% (C) Parity: 100% primiparous Mode of birth: NR MH status/history: 70% (I); 75% (C) with no history of MH difficulties	x		x	I: psycho-educational group program met weekly for 2 hrs. from 3rd trimester through 8 wks. PP C: standard care with addition of a weekly phone call	Multidisciplinary Team Group BF, MH	**Exclusivity:** No difference at 2-5 wks. PP; ↑ 12-14 wks. PP*	**Depressive Symptoms:** No difference between groups at 34-36 wks. gestation; ↓ at 38-40 wks. gestation, 2-5 wks., 5-8 wks., and 12-14 wks. PP* (EPDS)
Çiftçi and Arikan (2011), Turkey	RCT	N=32 (I); 30 (C) Age: NR Race/ethnicity: NR Income: NR Parity: NR Mode of birth: NR MH status/history: NR			x	I: one-on-one BF training (1 hr.) + 5 in-home visits from 2 wks. before returning to work through 6 mos. PP C: 5 in-home visits, but no BF training	Lactation Specialist Individual BF, MH	**Duration:** ↑ at 6 mos. PP* **Duration per feeding:** ↑ at 6 mos. PP* **Exclusivity:** ↑ at 3, 4, 5, and 6 mos. PP* **Frequency per day/night:** ↑*	**Anxiety Symptoms:** ↓ at 6 mos. PP* (STAI)
Dabas et al. (2019), India	RCT	N=25 (I); 25 (C) Age (mean): 30 (I); 29 (C) Race/ethnicity: NR Income (household, monthly) [Rs (US$)]: <10000-20000 ($135-270): 56% (I); 84% (C) 20001->50000 ($270->677): 44% (I); 16% (C) Parity: NR Mode of birth: NR MH status/history: NR			x	I: audio assisted relaxation technique (30 min.) for 10 consecutive days starting on 4±2 days PP in persons of preterm infants (26-33 wks.) in NICU C: standard care	Hospital Staff Group BF, MH	**Milk output:** ↑ at 10 days after enrollment of participants (within the first week PP)*	**Anxiety Symptoms:** ↓ at 10 days after enrollment (PASS)* **Stress:** ↓ at 10 days after enrollment* (PSS:NICU)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
Escobar et al. (2001), United States	RCT	N=508 (I); 506 (C) Age (mean): 29 (I); 29.1 (C) Race/ethnicity: White: 48.8% (I); 50.6% (C) Hispanic: 21.7% (I); 21.2% (C) Asian/Pacific Islander: 23.2% (I); 22.4% (C) Income (household, annual): >$60000: 50.2% (I); 53.3% (C) Parity 1: 46.6% (I); 45.4% (C) Mode of birth: 100% vaginal MH status/history: NR			x	I: home health nurse visits (60-90 min.) starting 48 hrs. after hospital discharge C: hospital-based follow-up anchored in group visits	Home Health Nurse Individual and Group BF, MH	**Duration:** No difference between groups at 2 wks. PP	**Depressive Symptoms:** No difference between groups at 2 wks. PP (CES-D)
Galland et al. (2017), New Zealand	RCT	N=802 Age (mean): 32 Ethnicity: 77.9% European Income (household, annual) [NZD(US$)]: >$70000 ($46645): 50.6% Parity: 48% primiparous Mode of birth: NR MH status/history: EPDS within normal range at baseline	x		x	I: sleep intervention with a single antenatal education group session (1 hr.) followed by a home visit at 3 wks. PP with an infant sleep training specialist I: Food, Activity and BF (FAB) intervention with BF education and support antenatally and at 1 wk. and 4 mos. PP provided by an IBCLC; physical activity support at 3 mos. PP I: combined sleep and FAB intervention C: standard care	Sleep Specialist, IBCLC Individual and Group BF, MH	**Exclusivity:** No difference between groups at 4 and 6 mos. PP	**Depressive Symptoms:** No difference between groups at 4 mos. PP (EPDS)
Gureje et al. (2019), Nigeria	Cluster RCT	N=452 (I); 234 (C) Age (mean): 24.5 (I); 24.9 (C) Race/ethnicity: NR Income: NR Parity: 56% (I); 49% (C) primiparous Mode of birth: NR MH status/history: EPDS score ≥ 12, but no psychotic symptoms, bipolar disorder, or suicidality	x		x	I: stepped-care treatment using a manualized psychological intervention package; 8 psychological sessions during pregnancy; 4-8 weekly interventions sessions starting at 6 wks. PP; pharmacotherapy as needed C: basic specifications of MH Gap Action Program; no structured sessions; no stepped-care procedure	OB Care Providers Individual MH	**Exclusivity:** ↑ at 6 mos. PP*	**Depressive Symptoms:** No difference between groups at 6 mos. PP; ↓ 12 mos. PP* (EPDS)
Hans et al. (2018), United States	RCT	N=156 (I); 156 (C) Age (mean): 18.5 (I); 18.3 (C) Race/ethnicity: African American: 43.6% (I); 46.2% (C) Latina/Hispanic: 39.1% (I); 35.9% (C) Income: 100% low income (I and C) Parity: 97.4% (I); 98.7% (C) primiparous Mode of birth: 23.2% (I); 21.5% (C) cesarean MH status/history: CES-D score of 14.2 (I); 13.8 (C) at baseline	x	x	x	I: doula-home-visiting program with weekly prenatal home visits by a home visitor and/or community doula; doula support during labor and birth, and through 6 wks. PP C: case management	Community Doulas and Peers Individual BF, MH	**Initiation:** ↑ at the hospital stay* **Duration:** No difference between groups at 3 mos. PP	**Depressive Symptoms:** No difference between groups at 3 wks. and 3 mos. PP (CES-D)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
Jaywant et al. (2020), India	RCT	N=52 Age: 75% between 20-25 Race/ethnicity: NR Income: NR Parity: 57.7% primiparous Mode of birth: NR MH status/history: EPDS score >10 at baseline			x	I: Person Environment Occupation model; therapy tool used daily for 15 days to enhance understanding of individual environmental barriers to BF and infant care, and subsequent solutions among PP persons of preterm infants (28-36 wks.) in NICU C: daily counseling on BF and infant handling and positioning for 15 days	MH provider Individual BF, MH	**Self-Efficacy:** ↑ at 15 days PP* (BSES)	**Depressive Symptoms: :** No difference between groups at 15 days PP (EPDS) **Stress:** No difference between groups at 15 days PP (PSS:NICU)
Johnston et al. (2004, 2006), United States	Cluster RCT	N=439 (2004); 239 (I); 104 (C) Age (mean): NR (2004); 32.5 (I); 30.9 (C) Race/ethnicity: NR (2004); 78.6% (I); 80.6% (C) White Income (household, annual): NR (2004) <40000: 17.1% (I); 13.6% (C) 40000-75000: 45.7% (I); 38.8% (C) >75000: 37.2% (I); 47.6% (C) Parity: 53.4% primiparous (2004); 52.9% (I and C) primiparous Mode of birth: NR MH status/history: NR	x		x	I: risk-based intervention (Healthy Steps) focused on developmental and behavioral services starting at 1 wk. PP; includes home visits and phone support I: Healthy Steps plus 3 additional antenatal home visits and phone support starting between 16-20 wks. gestation (PrePare) C: standard care	Healthcare Provider Individual BF, MH	**Initiation:** No difference between groups (2004); ↑ for all intervention groups* (2006) **Duration:** ↑ at 3 and 6 mos. PP for all intervention groups*	**Depressive Symptoms:** ↓ at 3 mos. PP, but ↑ at 30 mos. PP for all intervention groups* (modified CES-D)
Kenyon et al. (2016), United Kingdom	RCT	N=662 (I); 662 (C) Age (mean): 21.8 (I); 21.5 (C) Ethnicity: 48% (I and C) British Income: NR Parity: 100% nulliparous Mode of birth: NR MH status/history: 15% with clinical diagnosis of past or present mental illness (I and C)	x		x	I: pregnancy outreach worker service providing individual case management with home visits offered from <28 wks. gestation through 6 wks. PP. Prenatal services supported healthy lifestyle choices and social/emotional/mental difficulties. PP services supported BF and infant care. C: standard UK care	Peer Support Individual MH	**Duration:** No difference between groups at 6-8 wks. PP **Self-efficacy:** No difference between groups at 8-12 wks. PP (Pearlin Mastery Scale) **Bonding:** ↑ at 8-12 wks. PP*	**Depressive Symptoms:** No difference between groups; ↓ at 8-12 wks. PP for those with more severe baseline symptoms* (EPDS)
Langer et al. (1998), Mexico	RCT	N= 361 (I); 361 (C) Age (mean): 22.5 (I and C) Race/ethnicity: NR Income: NR Parity: 93.1% (I); 90.6% (C) primiparous; no previous vaginal birth Mode of birth: Vaginal with forceps: 2.8% (I); 3.4% (C) Cesarean: 23.8% (I); 27.2% (C) MH status/history: NR		x		I: doula support involving continuous emotional, informational, and physical support through active labor; BF support during the immediate PP C: standard care	Doula Individual BF, MH	**Exclusivity:** ↑ at 1 mos. PP* **Knowledge:** ↑ behaviors that promote BF at 1 mos. PP*	**Anxiety Symptoms:** No difference between groups at immediate PP (STAI)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
Lieu et al. (2000), United States	RCT	N= 580 (I); 583 (C) Age (mean): 27.9 (I); 27.8% (C) Race/ethnicity: White: 62.9% (I); 58.8% (C) Hispanic: 13.4% (I); 11.5% (C) Income (household): 71.1% (I); 72.7% (C) above 200% of federal poverty level Parity: 39% (I); 39.3% (C) primiparous Mode of birth: NR MH status/history: NR			x	I: home visits (60-90 min.) starting within 48 hrs. after discharge C: standard individual PP clinic follow-up	Home Health Nurse Individual BF, MH	**Duration:** No difference between groups at 2 and 12 wks. PP	**Depressive Symptoms:** No difference between groups at 2 wks. PP (CES-D)
Liu et al. (2018), China	RCT	N=130 (I); 130 (C) Age: 40.8% (I); 41.9% (C) between 18-34 Race/ethnicity: NR Income (household, annual): ≤4000: 20% (I and C) >4000: 30% (I and C) Parity: 34.2% (I); 36.5% (C) primiparous Mode of birth: 100% (I and C) cesarean MH status/history: NR		x		I: health education intervention developed according to the Health Belief Model that encouraged milk expression within 1 hr. after cesarean birth; expressed milk via hospital grade electric double pump every 2-3 hrs. for 20-30 min. C: standard education by obstetric nurses	Hospital Staff Individual BF	**Milk Onset:** Earlier lactation time* **Milk Volume:** ↑ during 24, 24 to 48, and 48 to 72 hours* **Exclusivity:** ↑ at 42 days PP* **Breast Swelling:** ↓ at 3 days PP*	**Anxiety Symptoms:** ↓ at 3 days PP* (STAI)
Lutenbacher et al. (2018), United States	RCT	N=91 (I); 87 (C) Age (mean): 30.4 (I); 28.7 (C) Race/ethnicity: 100% Hispanic Income (household, annual): <$15000: 96.7% (I); 96.5% (C) Parity: median of 2 children in home Mode of birth: NR MH status/history: NR	x		x	I: Maternal Infant Health Outreach Worker model consisting of monthly home visits (1 hr.) and periodic group gatherings focusing on maternal concerns, healthy lifestyle, child development and attachment, and BF offered from <26 wks. gestation through 6 mos. PP C: distribution of printed educational material about maternal and infant health and development	Peer Support Individual and Group BF, MH	**Initiation:** No difference between groups **Duration:** No difference between groups through 6 mos. PP **Exclusivity:** ↑ through 6 wks. PP* **Self-efficacy:** ↑ at 2 wks., 2 and 6 mos. PP* (BSES-SF)	**Depressive Symptoms:** ↓ at 2 wks., 2 and 6 mos. PP* (EPDS) **Stress:** ↓ at 2 wks., 2 and 6 mos. PP* (PSI)
Mohd Shukri et al. (2019), Malaysia	RCT	N=33 (I); 31 (C) Age: 51.5% (I); 67.7% (C) between 26-30 Race/ethnicity: 90.9% (I); 96.8% (C) Malay Income (household, monthly) [RM(US$)]: 1500-5000 (360- 1202): 54.5% (I); 54.8% (C) 5001- >10000 (1202- >2405): 45.5% (I); 45.3% (C) Parity: 100% (I and C) primiparous Mode of birth: 75% (I and C) vaginal MH status/history: NR			x	I: relaxation therapy via audio-guided imagery protocol designed for BF persons provided in-home at 2, 6, and 12 wks. PP; instructed to listen during the subsequent 2 wks. C: no relaxation therapy	Research Staff Individual BF, MH	**Milk Intake:** No difference between groups	**Anxiety Symptoms:** ↓ at 2 wks. PP*; no difference between groups at 6-8 wks. and 12-14 wks. PP (BAI) **Stress:** No difference between groups at 2 wks. PP; ↓ at 6-8 wks. and 12-14 wks. PP* (PSS) **Stress:** ↓ at 2 wks. PP* (hindmilk cortisol); no

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
									difference between groups at 6-8 wks. PP (milk cortisol)
Mörelius et al. (2015), Sweden	RCT	N=18 (I); 19 (C) Age (mean): 31 (I); 33 (C) Race/ethnicity: NR Income: NR Parity: NR Mode of birth: 100% (I and C) vaginal MH status/history: NR		x		I: almost continuous skin-to-skin contact from birth until discharge from the NICU for late preterm infants (32-35 wks.) C: standard care	Hospital Staff Individual BF, MH	**Duration:** No difference between groups at discharge, 1 and 4 mos. PP	**Depressive Symptoms:** No difference between groups at 4 mos. PP (EPDS) **Stress:** No difference between groups at 1 and 4 mos. PP (SPSQ and salivary cortisol)
Morrell et al. (2000), United Kingdom	RCT	N=311 (I); 312 (C) Age (mean): 27.5 (I); 28 (C) Race/ethnicity: NR Income: 30% (I); 29% (C) receiving housing benefit Parity (mean): 1.9 (I); 1.8 (C) Mode of birth: Spontaneous vaginal: 68% (I); 73% (C) Elective cesarean: 8% (I); 7.7% (C) Emergency cesarean: 9.6% (I); 10.2% (C) Twin birth: 2.9% (I); 0.32% (C) MH status/history: NR			x	I: PP care at home by community midwives plus up to 10 in-home visits from a support worker for up to 3 hrs./day in the first 28 days PP C: PP care at home by community midwives	Community Midwife and PP Support Worker Individual BF, MH	**Exclusivity:** No difference between groups at 6 wks. and 6 mos. PP	**Depressive Symptoms:** ↓ at 6 wks. PP*; no difference between groups at 6 mos. PP (EPDS)
Nikodem et al. (1993), South Africa	RCT	N=83 (I); 79 (C) Age (mean): 25.4 (I); 24.5 (C) Race/ethnicity: NR Income (monthly) [ZAR(US$)]: <R1000-00 ($68.25): 75.3% (I); 69.5% (C) Parity: 37.3% (I); 48.1% (C) primigravida Mode of birth: NR MH status/history: NR			x	I: audiovisual intervention featuring BF and health education videos within 72 hrs. after birth C: no audiovisual intervention	Hospital Staff Individual BF	**Duration**: No difference between groups at 6 wks. PP **Exclusivity:** No difference between groups at 6 wks. PP	**Depressive Symptoms:** No difference between groups at 6 wks. PP (Pitt's Depression Questionnaire)
Pugh et al. (2001), United States	Quasi-experimental	N=10 (I); 10 (C) Age (mean): 23.8 (I); 24.9 (C) Race/ethnicity: White: 60% (across all groups) African American: 30% (across all groups) Income: 100% low income on medical assistance			x	I: BF support team; in-hospital visit with a community health nurse, at least 3 home visits at 1, 2, and 4 wks. PP with a community nurse, and in-home or telephone support with a peer counselor twice weekly through 8 wks. and weekly through 5 mos. PP	Community health nurse and peer counselor Individual BF	**Duration:** No difference between groups through 5 mos. PP **Nipple Discomfort**: No difference between groups through 5 mos. PP	**Depressive Symptoms:** No difference at 3 and 5 mos. PP (CES-D) **Anxiety Symptoms:** No difference at 3 and 5 mos. PP (STAI)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
		Parity: NR Mode of birth: 80% (I and C) vaginal MH status/history: NR				C: standard care			
Ravn et al. (2012), Norway	RCT	N=56 (I); 50 (C) Age (mean): 31 (I) 30.8 (C) Race/ethnicity: 25% (I); 10% (C) non-Norwegian origin Income: NR Parity: 60.7% (I); 78% (C) primiparous Mode of birth: 55.4% (I); 68% (C) cesarean MH status/history: NR		x	x	I: Mother–Infant Transaction Program; 7 intervention sessions (1 hr.) occurring 7-10 days before hospital discharge from the NICU and 4 in-home visits within the first 3 month PP in persons with preterm infants (born at 30-36 wks.); supports parents in understanding infants temperament, developmental potential, and physiological and social cues C: standard care	Hospital Staff Individual BF, MH	**Duration:** ↑ at 9 mos. PP*; no difference between groups at 12 mos. PP	**Depressive Symptoms:** ↓ at 1 mos. PP* (CES-D Somatic/Depressed Affect domain; Total CES-D score); no difference between groups at 1, 6, and 12 mos. PP (CES-D Positive Affect and Interpersonal /Depressed Affect domains)
Rotheram-Borus et al. (2014), South Africa	Cluster RCT	N=544 (I); 656 (C) Age (mean): 26.5 (I and C) Race/ethnicity: NR Income: NR Parity: NR Mode of birth: NR MH status/history: 48.5% (I); 41.9% (C) with EPDS >12 at baseline	x		x	I: peer mentor session on the day of their HIV diagnosis plus invitation to attend 4 antenatal and 4 PP meetings with HIV-positive peers C: standard care	Peer Support Group MH	**Exclusivity:** ↑ at 6 mos. PP*	**Depressive Symptoms:** ↓ at birth through 12 mos. PP* (EPDS)
Rotheram-Fuller et al. (2017), United States	RCT	N=99 (I); 104 (C) Age (mean): 28.5 (I); 27.8 (C) Race/ethnicity (language at home): 80% (I); 87% (C) Spanish Income (household, monthly): <$1000: 43.5% (I); 47.1% (C) $1001–2000: 42.4% (I); 41.3% (C) Parity: NR Mode of birth: NR MH status/history: 13.1% (I); 11.5% (C) with EPDS >13 at baseline	x			I: home visiting or telephone support addressing maternal daily habits, BF, and depression; offered as needed during pregnancy C: standard care	Peer Support Individual BF, MH	**Duration:** No difference between groups at 1 wk. through 6 mos. PP	**Depressive Symptoms:** No difference between groups at 6 mos. (EPDS)
Saatsaz et al. (2016), Iran	RCT	N=52 (foot); 52 (hand+foot); 52 (C) Age (mean): 27 (foot); 26.7 (hand+foot); 27.8 (C) Race/ethnicity: NR		x		I: foot massage (5 min./limb) given 4 hrs. after the last dose of analgesic following cesarean birth	Massage Therapist Individual MH	**Frequency:** ↑ after cesarean birth in all intervention groups compared to control*	**Anxiety Symptoms:** No difference between groups after cesarean birth (STAI)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
		Income: NR Parity: 100% primiparous Mode of birth: 100% cesarean MH status/history: NR				I: hand and foot massage (5 min./limb) given 4 hrs. after the last dose of analgesic following cesarean birth C: no massage			
Sainz Bueno et al. (2005), Spain	RCT	N= 213 (I); 217 (C) Age: 54.9% (I); 53.1% (C) between 20-30 Race/ethnicity: NR Income: NR Parity: 18.2% (I); 19% (C) primiparous Mode of birth: 100% (I and C) vaginal MH status/history: NR			x	I: early hospital discharge (24 hrs.), monitored at home by a nurse for 24-48 hrs., in-clinic follow up at 7-10 days PP, and telephone consultation at 1, 3, and 6 mos. PP C: standard hospital discharge (48+ hrs.), in-clinic follow up at 7-10 days PP, and telephone consultation at 1, 3, and 6 mos. PP	Home Health Nurse Individual BF, MH	**Duration:** ↑ at 3 mos. PP*; no difference at 1 wk., 1 mos., 6 mos., or >9 mos. PP	**Depressive Symptoms:** No difference between groups at 1wk. and 1 mos. PP (HAD)
Song et al. (2017), China	RCT	N=60 (I); 60 (C) Age (mean): 30.8 (I); 31.3 (C) Race/ethnicity: NR Income: NR Parity: 100% (I and C) primiparous Mode of birth: 100% (I and C) cesarean MH status/history: NR		x		I: psychological nursing care consisting of appropriate and timely support was offered before, during, and after cesarean birth C: standard nursing care	Hospital Staff Individual BF	**Initiation:** ↑ at 1 day before discharge* **Lactation yield:** ↑ at 3 days PP*	**Depressive Symptoms:** ↓ at 1 day before discharge* (Scale of Depression Score)
Tubay et al. (2019), United States	RCT	N=61 (I); 68 (C) Age (mean): 28.1 (I); 27.8 (C) Race/ethnicity: White: 61% (I); 59% (C) Hispanic: 23% (I); 12% (C) Asian: 13% (I); 18% (C) African American: 10% (I); 15% (C) Income: E1-E5 Enlisted military rank: 35.7% (I); 31.8% (C) Parity: NR Mode of birth: 15% (I); 18% (C) unplanned cesarean MH status/history: NR	x			I: group prenatal care (CenteringPregnancy) starting ~16 wks. gestation; 10 sessions (2 hrs.) across pregnancy C: standard prenatal care	OB provider Group BF, MH	**Duration:** No difference between groups at 6 wks. PP	**Depressive Symptoms:** No difference between groups at 6 wks. PP (CES-D) **Anxiety Symptoms:** No difference between groups at 6 wks. PP (STAI)
Verpe et al. (2019), Norway	Retrospec-tive Cohort	N=64 (I); 95 (C) Age (mean): 29.3 (I); 28.9 (C) Race/ethnicity: 95% (I); 94% (C) not from an ethnic minority Income: NR			x	I: early hospital discharge (<48 hrs.) with in-home follow-up with community midwives	Community Midwives Individual BF, MH	**Duration:** No difference between groups at 6 wks. and 6 mos. PP	**Depressive Symptoms:** No difference between groups at 6 wks. and 6 mos. PP (EPDS)

Reference (year), Country	*Research Design*	*Sample Characteristics*	*Timing of Intervention*			*Intervention Components*	*Method of Intervention Delivery / Focus of Intervention*	*Breastfeeding Results*	*Mental Health Results*
			Pregnancy	*During Hospital Stay*	*PP*				
		Parity (mean): 0.8 (I and C) Mode of birth: 93.8% (I); 86% (C) vaginal MH status/history: EPDS score of 4.6 (I); 4.1 (C) in early pregnancy				C: early hospital discharge (<48 hrs.) with standard in-hospital follow-up			
Vidas et al. (2011), Croatia	RCT	N=50 (I); 50 (C) Age: NR Race/ethnicity: NR Income: NR Parity: NR Mode of birth: NR MH status/history: NR			x	I: autogenic training as a relaxation technique taught for 12 wks. in small groups from 2 to 6 mos. PP in BFing persons C: no autogenic training	Research Staff Group BF	**Duration:** ↑ at 6 mos. PP* **Exclusivity:** ↑ at 6 mos. PP*	**Depressive Symptoms:** ↓ at 6 mos. PP* (EPDS) **Anxiety Symptoms:** ↓ at 6 mos. PP* (STAI)
Zhao et al. (2017), China	RCT	N=176 (I); 176 (C) Age (mean): 30.4 (I); 30.6 (C) Race/ethnicity: NR Income (household, monthly) [RMB (US$)]: <4000-7999 ($598-1196): 16% (I); 15.4% (C) 8000-≥10,000 ($1197-≥1495): 84% (I); 84.6% (C) Parity: 100% (I and C) primiparous Mode of birth: 54.3% (I); 43.1% (C) vaginal MH status/history: 98.9% (I); 99.4% (C) with no depression history	x			I: prenatal couple-separated psycho-educational group sessions (6 at 90 min. each) focused on maternal MH and family support; sessions 1-5 were for high-risk pregnant persons, while session 6 was for their partner C: standard obstetrical care	Research Staff Group MH	**Exclusivity:** No difference between groups at 42 days PP	**Depressive Symptoms:** ↓ at 42 days PP* (EPDS)
Zhao et al. (2020), China	RCT	N=91 (I); 89 (C) Age (mean): 30.7 (I); 29.9 (C) Race/ethnicity: NR Income (household, monthly) [RMB (US$)]: < 6000-7999 ($898-1196): 18.7% (I); 27% (C) 8000–≥10,000 ($1197-≥1495): 81.3% (I); 73% (C) Parity: 100% (I and C) primiparous Mode of birth: 67% (I); 66.3% (C) vaginal MH status/history: 98.9% (I); 97.8% (C) with no depression history	x			I: individualized mixed management intervention consisting of 4 in-person psycho-educational sessions (1 hr.) focused on perinatal MH and BF C: standard obstetric care	Psychiatrist and IBCLC Individual BF, MH	**Initiation:** ↑ at 3 days PP* **Exclusivity**: ↑ at 3 days PP* **Self-Efficacy:** ↑ at 3 days PP* (BSES) **Effective BF Behavior:** ↑ at 3 days PP*	**Depressive Symptoms:** ↓ at 3 days PP* (EPDS)

Abbreviations: BAI, Beck Anxiety Inventory; BASNEF, beliefs, attitudes, subjective norms and enabling factors; BF, breastfeeding; BSES-SF, Breastfeeding Self-Efficacy Scale-Short Form; C, Control; CES-D, Center for Epidemiological Study-Depressive Symptomatology Scale; EPDS, Edinburgh Postpartum Depression Scale; HAD, Hospital Anxiety and Depression Scale; IBCLC, International Board Certified Lactation Consultant; I, Intervention; MH, mental health; PASS, Perinatal Anxiety Screening Scale; PSI, Parenting Stress Index-Short Form; PP, postpartum; PSS, Perceived Stress Scale; PSS:NICU, Parental Stress Scale: Neonatal Intensive Care Unit; RCT, randomized controlled trial; SPSQ, The Swedish Parenthood Stress Questionnaire; s/p, status post; STAI, Spielberger State Trait Anxiety Inventory.

*Indicates statistical significance with outcome direction according to the intervention group(s) relative to the control group.

TABLE II. COCHRANE RISK OF BIAS FOR RANDOMIZED CONTROLLED TRIALS

Author/Year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data addressed	Selective reporting	Other sources of bias*
Ahmed et al (2016)	+	?	+	?	+	+	+
Akbarzadeh et al. (2017)	+	?	?	?	?	-	+
Bigelow et al. (2014)	+	-	+	-	+	+	+
Boulvain et al. (2004)	+	+	+	?	+	+	+
Buultjens et al (2018)	+	+	+	?	-	+	+
Çiftçi and Arikan (2011)	-	-	+	+	+	?	+
Dabas et al. (2019)	+	+	-	?	+	+	+
Escobar et al. (2001)	+	+	+	?	+	+	+
Galland et al. (2017)	+	+	+	+	?	-	+
Gureje et al (2019)	+	+	-	+	+	?	+
Hans et al. (2018)	?	+	+	+	+	?	+
Jaywant et al. (2020)	+	?	+	?	+	+	?
Johnston et al. (2004, 2006)	+	?	?	+	+	+	?
Kenyon et al. (2016)	+	+	?	+	+	+	+
Langer et al. (1998)	+	+	+	+	+	+	+
Lieu et al. (2000)	+	+	+	?	+	+	+
Liu et al. (2018)	+	+	+	-	?	+	+
Lutenbacher et al. (2018)	+	+	+	+	+	+	+
Mohd Shukri et al. (2019)	+	+	+	?	+	+	+
Mörelius et al. (2015)	?	?	+	?	?	+	+
Morell et al. (2000)	+	+	+	+	+	+	+
Nikodem et al (1993)	+	+	?	+	-	?	+
Ravn et al. (2012)	+	+	?	+	+	+	+
Rotheram-Borus et al. (2014)	-	?	+	?	-	+	+

Author/Year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data addressed	Selective reporting	Other sources of bias*
Rotheram-Fuller et al. (2017)	?	?	-	?	-	+	?
Saatsaz et al. (2016)	+	+	+	+	+	?	?
Sainz Bueno et al. (2005)	+	+	+	?	+	?	?
Song et al. (2017)	+	?	+	?	-	+	?
Tubay et al. (2019)	-	+	+	?	+	+	+
Vidas et al. (2011)	?	?	?	+	?	+	?
Zhao et al. (2017)	+	?	?	+	+	+	+
Zhao et al. (2020)	+	?	+	?	+	+	+

*Other sources of bias may include: protocol adherence, other interventions avoided, sample size sufficiently large, eligible participants enrolled, funding and sponsorship bias.

TABLE III. JBI CRITICAL APPRAISAL CHECKLIST FOR QUASI-EXPERIMENTAL STUDIES

Author/Year	Appropriate cause-effect design	Minimal group differences	Similar treatment/care outside of intervention	Presence of a control group	Multiple measurements of the outcome	Follow-up completion	Outcomes consistently measured	Outcomes reliably measured	Appropriate statistical analysis
AK et al. (2015)	+	?	?	+	+	+	+	+	+
Pugh et al. (2001)	+	+	?	+	+	+	+	+	?
Verpe et al. (2019)	+	+	?	+	+	-	+	+	+

IV. MANUSCRIPT 2

Title: Feasibility of an Online Intervention to Prevent Perinatal Depression and Promote Breastfeeding

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1. Abstract

Background: Depression and anxiety are among the most common complications during the perinatal period and are considered important underlying factors associated with barriers and reduced rates of breastfeeding (BF) outcomes. Although BF is considered the ideal form of infant feeding due to the extensive benefits for the mother and infant, overall rates within the United States (U.S.) are low. Black women are more likely to report depressed mood in late pregnancy and early postpartum and have the lowest rates of BF, compared to all other racial groups in the U.S. Due to the bi-directional relationship between maternal mental health and BF, it is important to consider both when designing interventions to improve these outcomes. Internet interventions offer potential in extending preventative and supportive services since they address key barriers, especially for those navigating the complex and vulnerable early postpartum period. However, there is limited evidence on the feasibility and efficacy of such interventions for preventing perinatal mental health disorders and improving BF outcomes.

Objectives: This study aimed to describe the design and components of a cognitive behavioral therapy (CBT)-based internet intervention, with and without BF education and support, to prevent perinatal depression and promote BF and to examine preliminary site usage and adherence, maternal mental health, and BF outcomes.

Methods: Participants enrolled in this pilot study were Black individuals between 20-28 weeks pregnant, who intended to breastfeed their child, and who reported mild to moderate depressive symptoms (Patient Health Questionnaire scores of 5-14). Using a comparative effectiveness research approach, participants were randomized to Sunnyside, a six-week CBT-based online intervention, or Sunnyside Plus, which built upon Sunnyside and included additional education and support to promote BF. Assessments took place at baseline, 3rd trimester (end of antenatal treatment), six weeks postpartum (end of postpartum treatment) and 12 weeks postpartum.

Results: A total of 22 participants were randomized. Although data collection is still underway, 15 participants have completed the intervention thus far. Mean number of logins across the six-week

intervention plus booster sessions was 7.3 for Sunnyside and 13.8 for Sunnyside Plus. Scores of depression and anxiety measures remained below the clinical threshold for referral for treatment in both groups. All participants initiated BF and reported any BF at six and 12 weeks postpartum. By 12 weeks postpartum, 75% of participants reported continued exclusive BF in both intervention groups.

Conclusions: Results suggest that Black women at-risk for perinatal depression were receptive to and satisfied with an online CBT-based internet intervention, with and without BF education and support, spanning from mid-pregnancy through six weeks postpartum. Preliminary findings indicate that both Sunnyside and Sunnyside Plus interventions have a positive impact on symptoms of depression and anxiety and on BF outcomes.

Trial Registration:

ClinicalTrials.gov NCT04128202; https://www.clinicaltrials.gov/ct2/show/NCT04128202

2. Background

Mental health disorders are among the most common complications during pregnancy and the first 12 months after childbirth.[4–6] Research suggests the prevalence of perinatal anxiety disorders is at least 17% and that approximately 7-20% of women experience clinical depression at some time during the perinatal period.[7–9] Perinatal mental health disorders make it difficult to function and care for oneself and for an infant. In fact, maternal mental health is considered an important underlying factor associated with barriers and reduced rates of breastfeeding (BF) intent, initiation, exclusivity, and continuation.[4–6,11]

Breastfeeding is considered the ideal form of infant feeding due to the extensive benefits for the mother and infant. All major health and professional organizations recommend exclusive BF for the first six months of a child's life, with continued BF in combination with appropriate complementary foods for at least one to two years.[52–54] However, despite the benefits, recommendations, and high rates of intention to BF, overall rates within the United States (U.S.) continue to be low.[55] There are many known barriers to reaching BF goals including painful or difficult latch, concerns of milk supply, lack of professional lactation support, unsupportive social and cultural norms and policies, and maternal mental health difficulties.[2,60,62–64]

Certain barriers are disproportionately experienced by Black women, many of which stem from historical and continued oppression, systematic racism, social injustices, and structural violence. For example, Black women often receive limited education and differential treatment from providers regarding BF information and encouragement.[2] National data show that non-Hispanic Black women have the lowest rates of initiation (73.7%), and continuation at six (47.8%) and 12 months (26.1%) postpartum compared to all other racial groups in the U.S.[55] In addition, Black women are more likely to report depressed mood in late pregnancy and early postpartum, compared to white women, even after adjusting for income and education, distinguishing between the effects of race and socioeconomic status.[10]

The relationship between maternal mental health and BF outcomes is bidirectional; mental health disorders may make BF more challenging and difficulty with BF may predict depression and anxiety.[12,14,98,108,122] Therefore, it is important to consider both intricacies when designing interventions to improve these outcomes. Cognitive behavioral therapy (CBT), which focuses on identifying and changing unhelpful thoughts and behaviors, has been shown to be effective at preventing perinatal depression.[188] Further, based on a recent systematic review (Pezley et al., 2021, unpublished data), interventions which extend across pregnancy and postpartum and offer individualized support from professionals and peers are most successful in improving both mental health and BF outcomes. In addition, intervention components shown to improve these outcomes among Black women include positive representation that enhances and normalizes BF in an encouraging way, content that addresses gaps in support (e.g., building a support network, advocating for oneself in the hospital, preparing for successful return to work, enhancing BF self-efficacy), and professional and timely BF support that continues into the postpartum period.[2,16,17,70] While many effective intervention strategies exist, access to these programs can be a barrier, especially for those navigating the complex and vulnerable early postpartum period.

The Internet offers great potential in extending preventative and supportive services to individuals in the perinatal period since they address several key barriers to success. Digital-technology interventions, which include the use of web-based content and interactions, text messaging, and social media, have been effective at reducing depressive symptoms and improving BF outcomes.[18,19] Black mothers report that social media is a practical, convenient, and valuable way to obtain BF information and support, feel connected with like-minded people who look like them, and improve self-efficacy.[20,21] Additional strengths of a digital approach to interventions for perinatal women include efficiency of time and resources, individualized care, ability to reach geographically and racially diverse populations, and improved social support. However, there is limited evidence on the feasibility and efficacy of such interventions for preventing perinatal mental health disorders and improving BF outcomes.

Therefore, the objectives of this study are two-fold. First, to describe the design and components of a CBT-based internet intervention, with and without BF education and support, to prevent perinatal depression and promote BF. Second, to examine the preliminary site usage and adherence, maternal mental health, and BF outcomes.

3. Methods

3.1 Study Design and Participants

This randomized pilot trial used a comparative effectiveness research (CER) approach to compare two active treatments Sunnyside[143] and the newly developed Sunnyside Plus on maternal mental health and BF outcomes among Black women with mild to moderate depressive symptoms upon study enrollment, who intended to breastfeed their child.

Subjects were recruited through advertisements placed on Ovia,[189] a nationwide online pregnancy forum and internet-based application. Inclusion criteria were: 1) pregnant and between 20-28 weeks gestation, 2) 18 years of age or older, 3) Black or African American, 4) intend to breastfeed their child, 5) self-report mild to moderate depressive symptoms (PHQ-8 score of 5-14), 6) access to a broadband internet connection, and 7) English language proficiency. Exclusion criteria were: 1) pregnant with multiples, 2) visual, hearing, voice, or motor impairment that would prevent completion of study procedures, 3) diagnosed with a major depressive episode, psychotic disorder, bipolar disorder, dissociative disorder, substance use disorder or other diagnosis for which participation in this trial was either inappropriate or dangerous based on self-report; or 4) were currently receiving treatment (medication or psychotherapy) and had an intention to resume antidepressant medication after birth (i.e., those who discontinued their medication during pregnancy). Those interested were directed to a brief online screener to assess eligibility. Qualifying individuals provided electronic consent to participate. All procedures were approved by the University of Illinois at Chicago (UIC) Institutional Review Board.

3.2 Study Procedures

Following consent, qualifying individuals were immediately directed to complete the baseline assessment surveys that were provided via a REDCap link; all study data were collected and managed using REDCap electronic data capture tools hosted by UIC.[190,191] Participants were then randomized in a 2:1 allocation ratio to either Sunnyside or Sunnyside Plus using a block randomization method with online randomization service provider, Sealed Envelope.[192]

All participants, regardless of group allocation, completed an initial engagement session to review components and expectations of the study, and ensure access to the treatment websites. The engagement session took place through Cisco WebEx Meeting Center, a HIPAA compliant videoconferencing web application. Once complete, the online intervention began. Follow-up assessments using REDCap took place following the completion of six weeks of online lessons during pregnancy (third trimester), and at six and 12 weeks postpartum. A brief assessment of BF continuation and exclusivity (yes or no reply) was measured on a weekly basis via text messaging (SimpleTexting)[193] from one to six weeks postpartum. Participants received a $20 Amazon gift certificate after completing each assessment.

Starting between 20-28 weeks gestation, participants began the six-week online intervention (Sunnyside or Sunnyside Plus). After the birth of their baby, the intervention continued through six weeks postpartum. The intervention components for each group are listed in Table IV and described below.

3.3 Sunnyside

The Sunnyside intervention is an online intervention (an interactive website with didactic material and interactive tools) targeting skills to manage mood during and after pregnancy.[143] Sunnyside consists of six weeks of online lessons during pregnancy and online booster sessions at two, four, and six weeks postpartum. The intervention website was based on CBT and Interpersonal Therapy (IPT) principles and consisted of 12 learning modules covering basic skills (e.g., behavioral activation,

cognitive restructuring). Interactive tools to assist in learning and implementing skills was associated with each of the learning modules. In this study, participants were given unlimited access to the web intervention content that consisted of lessons and tools and were encouraged to use the site at least twice weekly as new modules became available (every 3-4 days). The online lessons to be completed during pregnancy required approximately 40-60 minutes per week for six weeks. The online lessons completed during the first six weeks postpartum required approximately 10-20 minutes per week for six weeks. The UIC CCTS Technology Core was responsible for hosting and maintaining the site.

3.4 Sunnyside Plus

Sunnyside Plus built upon Sunnyside, but added additional education and support to promote BF. Education and skill-promotion for BF was provided during the six weeks of online lessons during pregnancy and then continued through six weeks postpartum. This postpartum support involved weekly online lessons, text support messages, and video support calls with a Lactation Specialist. The research team requested that at least two lactation support calls take place, but beyond that, virtual support was provided on an as-needed basis determined by the participant. Text support messages were sent using SimpleTexting,[193] a user-friendly text marketing software. Frequency of messages tapered from three down to one message per week across the first six weeks postpartum. Text message content included BF encouragement and a reminder of the virtual lactation support.

Intervention components shown to improve mental health and BF outcomes among Black women were central to the intervention design and development. These included Black Feminist thought as a theoretical foundation – acknowledgement that Black women experience life at the intersection of multiple oppressions; positive and nurturing representation of Black women BF; and culturally relevant professional BF support across pregnancy and PP.[16,17] For both groups, modules specific to anxiety and to BF during the time of COVID-19 were included in the intervention content.

3.5 Measures

The primary focus of this randomized pilot trial was feasibility (adherence to and satisfaction with the intervention) and preliminary outcomes on depression and anxiety symptom severity and BF initiation, continuation, and exclusivity. Secondary outcomes included BF intention, knowledge, self-efficacy, and perception of barriers. Participant socio-demographic data, parity, pregnancy-related variables, BF history, mental health history, birth-related variables, social support, resilience, and discrimination were also measured. The outcomes were largely assessed with standardized measures or established questions from national sources (e.g., Centers for Disease Control and Prevention (CDC) National Immunization Survey, CDC Pregnancy Risk Assessment Monitoring System questionnaire). Self-reported participant anthropometric measures were also assessed and confirmed through medical record release processes when possible (4 participants). See Table V for a list of data collection instruments by assessment time point.

Adherence to the online intervention was measured by the number of logins to the site during the intervention period, lessons read, and tools completed. Adherence to text and video call interaction was measured by number of weekly text question responses and number of lactation video calls completed within the first six weeks postpartum.

The Usefulness, Satisfaction, and Ease of Use Questionnaire (USE)[194] was designed to measure satisfaction, usefulness, ease of use, and ease of learning on a Likert scale ranging from "strongly disagree" (1) to "strongly agree (7). Higher scores indicate greater usability and satisfaction.

The Patient Health Questionnaire-9 (PHQ-9)[195] is composed of 9 scored items and 1 unscored item which reflect overall functioning and impairment due to depressive symptoms. The PHQ-9 uses a Likert scale to determine the frequency of experienced depressive symptoms over the past 2 weeks ranging from "not at all" (0), "several days" (1), "more days than not" (2), and "nearly every day" (3). Higher values correspond with greater frequency. Scoring the PHQ-9 is simple and efficient; the measure yields only one score which is determined by summing the positively endorsed items (1-3) at

the noted values. PHQ-9 scoring interpretations are as follows: 1-4: minimal; 5-9: mild; 10-14: moderate; 15-19: moderately severe: 20-27: severe depressive symptoms.

The Inventory of Depression and Anxiety Symptoms (IDAS)[196] is a 64-item measure of depression (including a 20-item general depression scale [GD]) and anxiety symptoms that has been validated with postpartum women. The IDAS was developed specifically in response to an NIMH initiative to provide more sensitive measurement of depression and its symptom dimensions (e.g., dysphoria, lassitude, insomnia, suicidality, appetite loss) for use in clinical trials. The IDAS uses a Likert scale ranging from "not at all" (1) to "extremely" (5). The 20-item general depression scale was used for this study, with an overall range from 20-100. Higher scores represent greater depressive symptoms.

The Generalized Anxiety Disorder questionnaire-7 (GAD-7)[197] is a 7-item measure to assess anxiety symptom severity using a frequency Likert scale. The scale ranges from "not at all" (0), "several days" (1), "more than half the days" (2), and "nearly every day" (3). Higher values correspond with greater frequency. The measure yields only one score (0-21) which is determined by summing the positively endorsed items (1-3) at the noted values. GAD-7 interpretations are as follows: 0-4: minimal; 5-9: mild; 10-14: moderate; 15-21: severe anxiety symptoms.

The Infant Feeding Practices Study II (IFPS-II)[198] was developed by the Food and Drug Administration (FDA), in collaboration with the CDC, in order to collect data on infant feeding practices used by U.S. women. For the purposes of this project, we used the Prenatal Questionnaire to assess infant feeding intent, BF knowledge, and self-efficacy.

The Breastfeeding Knowledge, Self-Efficacy, and Perception of Barriers survey[199] was assessed in the antenatal period using a face and content-validated questionnaire that was developed and pilot tested with a sample of 30 WIC clients. For this study, four indices were constructed representing BF knowledge and the barriers of embarrassment, time and social constraints, and lack of social support. Each index included 3-4 true/false items. Each item was scored as desired response (1) or undesired

response (0). A composite score for each index was computed by summing the score of the relevant items. Composite scores on the BF knowledge index range from 0-3. Composite scores range from 0-4 for embarrassment barriers, 0-4 for time and social constraint barriers, and 0-3 for social support barriers. Higher composite score represent greater knowledge and positive attitudes toward the barriers.

The Prenatal Breastfeeding Self-Efficacy Scale (PBSES)[200] was developed by Wells and colleagues in 2006 to assess perceived BF self-efficacy during pregnancy. The scale comprises 20 items with ranges on a 5-point Likert-type scale from "not at all sure" (1) to "completely sure" (5), with an overall range from 20 to 100. Higher scores indicate greater levels of prenatal BF self-efficacy.

The Breastfeeding Self-Efficacy Scale – Short Form (BSES-SF)[131] was developed by Dennis and Faux to measure postpartum mothers' BF self-efficacy using theoretical framework from Bandura's Social Cognitive Theory. The instrument has 14 items and uses a 5-point Likert-type scale with responses from "not at all confident" (1) to "always confident" (5), with overall scores ranging from 14-70. Higher scores indicate greater levels of BF self-efficacy.

Initiation, exclusivity, and duration of BF was assessed in the postpartum period using questions, in-part, from the CDC National Immunization Survey. Weekly assessment of duration and exclusivity was also assessed via text message.

The Brief Resilience Scale (BRS)[201] is a 6-item survey to assess the ability to bounce back or recover from stress. The survey utilizes a 5-point Likert scale (1= strongly disagree, 5=strongly agree), giving an item average score of 1-5. Higher scores represent greater level of psychological resilience.

The Medical Outcomes Study (MOS) Social Support Survey[202] is a 19-item scale that consists of four separate social support subscales and an overall functional social support index. The survey utilizes a 5-point Likert scale (1=not at all, 5=all of the time), giving an item average score of 1-5. A higher score for an individual scale or for the overall support index indicates more support.

The Everyday Discrimination Scale (EDS)[203] is a 9-item measure of subjective experiences of discrimination. Response categories ranges from 1 (never) to 6 (experience discrimination almost every day), giving a summed score of 9-54. Higher scores indicate greater perceived discrimination.

3.6 Statistical Analyses

Statistical analysis was performed with R.[204] This study used a repeated measures design with two intervention groups (Sunnyside and Sunnyside Plus). Data were examined to assess for outliers. Descriptive statistics were obtained by computing means and standard deviations for the continuous variables and frequencies for the categorical variables. Differences for the baseline characteristics between the intervention groups were assessed using independent two-sample t-test (continuous variables) and Fisher's exact test (categorical variables). Intervention feasibility data, including adherence to the intervention, usability, and acceptability, were assessed using descriptive statistics. Independent samples t-tests were used to compare mean scores between groups.

Between group differences were assessed using two approaches. First, we used independent samples t-tests applied to the mean values for each group. Second, we created a mean change score from baseline to each follow-up assessment timepoints for each outcome and tested group differences using an independent samples t-test. Using paired t-tests, within group mean change scores were used to examine if the change score at each follow-up timepoint was significantly different than zero. For all statistical analyses, effects with a p-value <0.05 were considered significant.

4. Results

4.1 Eligibility Screening

In total, 1,618 individuals completed the online screener across a three-month period (June 12, 2020 to September 15, 2020). The mean age of respondents was 30.9 years. Most respondents identified as white (54.1%) and one-third (33.4%) identified as Black or African American. Approximately 39% of respondents had an estimated gestational age (EGA) between 20 to 28 weeks which was the inclusion

criteria for this study; most had an EGA less than 20 weeks (60.3%). A majority (72.5%) of respondents intended to BF exclusively for at least the first few weeks postpartum. The mean PHQ-8 score was 6.2 (mild depressive symptoms) and half (50.8%) reported mild to moderate depressive symptoms (PHQ-8 score of 5-14) which was the inclusion criteria for this study. Similar to national rates, a total of 16.6% of respondents reported having a current diagnosis of depression. Data are provided in Table VI.

Most respondents were excluded during the online screening process, as discussed above (n=1546). Of those who qualified based on the eligibility screener, 30.6% (22/72) were randomized and received the intervention; those not randomized were ultimately not interested in participating, unable to contact, or lost to follow-up. See Figure 2 for more information.

4.2 Participants

A total of 22 Black pregnant individuals in their second trimester (mean EGA of 22.6 [SD 2.5]) participated in this study. The mean age of participants was 30.4 years (SD 3.9). A majority of participants were married or partnered and cohabitating (N=17, 77.3%), employed full-time (N=13, 59.1%), and had private health insurance (N=16, 72.7%). All participants attended at least some college (N=12, 54.5%) or held a graduate or professional degree (N=10, 45.5%). Just over half (N=12, 54.5%) of participants reported an annual household income of ≥ $51,000, with the average household size being 2.5 (SD 1). Maternal pre-pregnancy BMI (kg/m^2) was calculated from self-reported height and pre-pregnancy body weight. When data from medical records were available, we explored differences between self-reported and medical record data and found none. Over half of the participants (N=14, 63.6%) had obesity. Mean PHQ-9 scores at baseline were 6.6 (SD 2.9), with most participants having mild depressive symptoms (N=15, 68.2%). Mean GAD-7 scores were 6.05 (SD 4.7), with most having none to mild symptoms of anxiety (N=16, 72.7%). Mean BRS scores were 3.6 (SD 0.8), EDS were 22.5 (SD 10), and MOS social support scores were 4.1 (SD 0.7). A majority of participants were nulliparous at enrollment (N=14, 63.6%). Regarding BF-related variables, about one quarter of participants reported being breastfed themselves as an infant (N=6, 27.3%), a majority had no prior BF experience (N=17,

77.3%), and most intended to breastfeed exclusively for at least the first few weeks postpartum (N=19, 86.4%). PBSES scores at baseline were 81 (SD 14.1) and the average BF duration goal was 13.7 months (SD 5.7). The participants in the intervention groups did not differ significantly on any baseline characteristics, suggesting that random assignment-generated groups were equivalent at baseline (Table VII).

4.3 Attrition

Two participants (one from each intervention group) withdrew from the study after the baseline assessment. One Sunnyside participant did not complete the 3rd trimester follow-up assessment, but continued on with the study. One participant in the Sunnyside Plus group did not engage in the online intervention or complete assessments and was therefore withdrawn by the research team after the baseline assessment. As data collection is still underway, several participants are pending completion of assessments at a future date. These metrics will be updated for the upcoming peer-reviewed publication. Herein, data will be reported on 18 subjects at the 3rd trimester assessment, 15 at six weeks postpartum, and 12 subjects at 12 weeks postpartum. Re-analysis of the baseline variables showed a significant difference in EGA between those who completed the trial through 12 weeks postpartum and those who dropped out or whose completion is pending at a future date (p=0.005). All other baseline variables were similar between completer and drop-out/pending groups.

4.4 Site use

Adherence to the online intervention was measured by the number of logins to the site during the intervention period, number of lessons accessed, and number of tools completed. Table VIII shows site usage data via these primary adherence variables. Mean number of logins across the six-week intervention plus booster sessions was 7.3 (SD 5.3) for Sunnyside (n=9) and 13.8 (SD 10.5) for Sunnyside Plus (n=12). Within the Sunnyside group, the average number of lessons accessed during pregnancy was 10.1 (SD 3.5) and during postpartum was 1.6 (SD 1.3). Within the Sunnyside Plus group, the average number of lessons accessed during pregnancy was 9.7 (SD 4.1) and during postpartum was

2.5 (SD 3.3). A total of 6 (67%) Sunnyside participants and 7 (58%) Sunnyside Plus participants completed at least 50% of the available lessons. The average number of tools utilized was 11 (SD 6.6) for Sunnyside and 25.8 (SD 27.8) for Sunnyside Plus. Participants in the Sunnyside Plus group utilized the activity tool more than those in the Sunnyside group (p=0.0318). All other site use was similar between groups, with no additional significant differences found.

4.5 Text and video call interactions

Mean number of weekly BF text question responses across the first six weeks postpartum was 5.2 (SD 1.3) for Sunnyside (n=5) and 5.2 (SD 1.3) for Sunnyside Plus (n=10). Three participants in Sunnyside and six in Sunnyside Plus completed all six weekly text questions. Most participants completed at least four of the six weekly questions (Sunnyside 80%; Sunnyside Plus 90%). Response rates were similar between groups, with no significant differences found. Participants in Sunnyside Plus were offered virtual lactation support. Mean number of video calls completed during the first six weeks postpartum was 2.7 (SD 2.1). Number of calls ranged from zero to seven. One participant declined lactation support.

4.6 Usability and acceptability

At the 3rd trimester follow-up (after completion of the 6-week antenatal online intervention), scores on USE subscales ranged from 1 (strongly disagree) to 7 (strongly agree). Sunnyside participants' mean scores were 5.3 (1.3) for usefulness, 5.1 (2.1) for ease of use, 5.1 (2.3) for ease of learning, and 4.9 (1.9) for satisfaction. Sunnyside Plus participants' mean scores were 4.9 (1.2) for usefulness, 5.9 (1.1) for ease of use, 6.2 (1.1) for ease of learning, and 5.3 (1.5) for satisfaction.

At 6 weeks postpartum, scores on USE subscales also ranged from 1 (strongly disagree) to 7 (strongly agree). Sunnyside participants' mean scores were 5.0 (0.5) for usefulness, 4.7 (0.9) for ease of use, 4.9 (1.3) for ease of learning, and 4.6 (0.7) for satisfaction. Sunnyside Plus participants' mean scores were 5.1 (1.4) for usefulness, 5.9 (1.4) for ease of use, 5.7 (1.3) for ease of learning, and 4.9 (1.5)

for satisfaction. The participants in the intervention groups did not differ significantly on any of the USE subscales at either assessment time point. Data are provided in Table IX.

4.7 Birth outcomes

Total gestational weeks at birth did not significantly differ between groups; mean EGA at birth was 38.6 (SD 1.5) and 38.2 (SD 1.8) for Sunnyside and Sunnyside Plus participants respectively. In addition, 60% of participants in both groups had a cesarean birth.

4.8 Depressive and anxiety symptoms

Mental health outcomes are provided in Table X. No significant differences between or within groups were detected on any of the mental health outcome measures. In both intervention groups, mean PHQ-9 scores across all follow-up visits remained below 10, the clinical threshold for referral for treatment.[195] Mean IDAS scores remained relatively consistent across all follow-up visits in Sunnyside and Sunnyside Plus. In both intervention groups, mean GAD-7 scores across all follow-up visits remained below 10, the threshold for moderate to severe symptoms of anxiety.[197]

4.9 Breastfeeding

Prenatal BF outcomes are shown in Table XI. The mean intended BF duration at baseline (mid-pregnancy) was 12.7 months for Sunnyside participants and 14.3 months for Sunnyside Plus participants. The intended duration was slightly lower in both groups in the 3rd trimester of pregnancy – 10 and 13.4 months for Sunnyside and Sunnyside Plus participants, respectively, although not statistically significant. Among all participants, 86% intended to BF exclusively for at least 5-6 months (data not shown). No significant differences between or within groups were detected for BF knowledge. Attitudes toward common BF barriers (i.e., embarrassment, time and social constraints, and social support) remained relatively consistent from baseline to 3rd trimester in both intervention groups. However, there was an increase that approached statistical significance ($p=0.0519$) in positive attitudes toward time and social constraints among participants in Sunnyside Plus. Prenatal BF self-efficacy

(PBSES) scores increased slightly for all participants, but a significant increase was seen in the Sunnyside Plus group only, from baseline to 3rd trimester (p=0.0242).

Postpartum BF outcomes are shown in Table XII. All participants initiated BF. At six weeks postpartum, 60% (N=3 of 5) of Sunnyside and 90% (N=9 of 10) of Sunnyside Plus participants reported BF exclusively. At 12 weeks postpartum, 75% of participants in each group were BF exclusively. The mean number of weeks until formula was introduced was 3.3 (SD 5.9) for Sunnyside and 0.5 (SD 0.5) for Sunnyside Plus. At six and 12 weeks, all participants reported any BF. No significant differences between groups were detected for postpartum BF outcome measures.

5. Discussion

This study describes the components and preliminary findings of a novel CBT-based internet intervention to prevent perinatal depression and promote BF. While both active treatment groups aimed to target skills to manage mood, the newly developed Sunnyside Plus intervention used evidence-based practices to promote and actively support BF as well.

Overall, the recruitment response rate was high with an average of approximately 17 respondents each day during the three-month recruitment period (1,618 respondents/96 days). The major factors for exclusion were race and EGA. Future recruitment efforts should target internet-based applications used by those who identify as Black or African American. In addition, a system to allow for re-screening at a later date might capture those who meet all inclusion criteria except for current EGA.

High adherence to the online intervention indicates that Black individuals who are in the perinatal period are willing to use an individual intervention program which involves engagement with an online website and interactions via text messaging and video calls. Usability scores suggest an overall positive user experience for both the pregnancy and postpartum sections of the intervention.

Participants enrolled in this study were Black individuals in mid-pregnancy, who intended to breastfeed their child, and who reported mild to moderate depressive symptoms. Although difficult to

detect with a small sample size, the preliminary data suggest that the interventions may positively impact mental health and BF outcomes.

After completion of the intervention, at both six and 12 weeks postpartum, no participants in this at-risk sample met criteria for postpartum depression compared with a 13% prevalence rate seen among individuals in the first year postpartum[9] and with a 17% prevalence rate seen among at-risk individuals in the absence of an intervention.[205] This is in line with results from the previously published pilot data on Sunnyside.[143] Overall, levels of perinatal anxiety symptoms remained low among participants as well. Given the adverse impact of perinatal mental health disorders on both the mother and infant, including reduced rates of BF,[6] the overall low levels of depressive and anxiety symptoms among all participants is encouraging.

Intended BF exclusivity and duration was high among all participants at baseline. Interestingly, after completion of the antenatal portion of the intervention, intended BF duration decreased in both intervention groups, although not significantly. In some ways, this decrease might represent a more realistic BF goal which perhaps the intervention components helped to support. Overall, attitudes toward common BF barriers remained consistent in both groups. However, Sunnyside Plus may have a more positive impact on perceived barriers toward time and social constraints compared to Sunnyside.

Postpartum BF self-efficacy, defined as the confidence in one's ability to effectively breastfeed, is thought to play important role in the relationship between postpartum depression and BF.[14,57,94,105,130] Not only is high self-efficacy associated with lower levels of depressive symptoms,[57,130,131] but it is also associated with longer BF duration.[57,130] In this study, prenatal BF self-efficacy improved for all participants after completion of the antenatal portion of the intervention, but a statistically significant increase was seen in the Sunnyside Plus group only.

According to the National Vital Statistics System, the U.S. cesarean birth rate in 2019 was 31.7%.[206] A total of 60% of participants in this study had a cesarean birth, which is almost double the National rate. Medical interventions during birth, including cesarean birth, may make it difficult for

mothers to reach their BF goals.[62] Across both intervention groups, 100% of participants initiated BF compared with a 60% prevalence rate seen among Black individuals in the U.S.[3] At six weeks postpartum, a greater percentage of Sunnyside Plus participants were BF exclusively compared to Sunnyside (90% vs. 60% respectively). National BF reports do not include rates at six weeks postpartum, however, research shows that rates of exclusive BF at six weeks postpartum is approximately 62%.[57] Compared to this data, the Sunnyside Plus intervention may provide a more positive impact on BF exclusivity at six weeks compared to Sunnyside. By 12 weeks postpartum, both intervention groups were BF exclusively at the same rate (75%). According to National data, approximately 47% of infants are exclusively breastfed through 12 weeks,[55] indicating a positive effect of both interventions on BF exclusivity at 12 weeks. Importantly, although exclusivity rates in this project are higher than National data, the decrease from 90% at 6 weeks to 75% at 12 weeks in the Sunnyside Plus group might be related to necessity to return to work. Black women typically return to work earlier than white women and are more likely to have jobs that unsupportive to BF.[2]

Although not statistically significant, participants in Sunnyside Plus had earlier introduction of formula compared to Sunnyside participants. These data are likely picking up on the week-by-week changes in exclusivity that might not be reported by participants when retrospectively reporting infant feeding method over a period of time (i.e., six or 12 weeks). All participants reported at least some BF at both six and 12 weeks postpartum. This rate is higher than other research showing an 81% prevalence rate of any BF at six weeks postpartum.[57] High rates of exclusive and continued BF at six and 12 weeks further underscore the intervention's positive clinical impact.

5.1 Strengths and limitations

There are several strengths of this study. The design of the intervention offers a novel approach for preventative and supportive care within the perinatal period; one that extends across pregnancy and postpartum, involves various interface options (i.e., website, text, video conferencing), and

acknowledges the logistical challenges of physically seeking care as parent with a newborn. In addition, participants consistently utilized all aspects of the intervention in both pregnancy and the postpartum period, suggesting interest and satisfaction with this design of care. In an effort to reduce the race-mediated power differential, the lactation specialist team included Black and white individuals. When support was provided by a white lactation specialist, we acknowledge that race-of-interviewer effects may be present.

This study had several limitations. As a small pilot study, this trial is not powered to reliably detect smaller significant differences or associations. The use of a convenient internet sample may have led to bias toward higher education level. Further, the primary outcome data was based on self-report assessments which may introduce recall bias. Lastly, with no true control group, we relied on outside data to compare rates of mental health and BF outcomes.

6. Conclusions

Results of this study suggest that Black women at-risk for perinatal depression were receptive to and satisfied with an online CBT-based internet intervention, with and without BF education and support, spanning from mid-pregnancy through six weeks postpartum. Preliminary findings indicate that both Sunnyside and Sunnyside Plus interventions have a positive impact on symptoms of depression and anxiety and on BF outcomes. Although difficult to interpret with such a small sample size, Sunnyside Plus may have a more positive impact on symptoms of anxiety and a more *lasting* positive impact on depressive symptoms. Additionally, Sunnyside Plus may have a more positive effect on BF self-efficacy and on exclusivity of BF at six weeks postpartum. Importantly, both interventions resulted in lower prevalence of common mental health disorders and overall higher BF rates, compared to rates seen in the absence of an intervention. Next steps should include a larger sample size and a longer follow-up period to better understand differences between groups and to examine the continued impact across the postpartum period.

7. Acknowledgements

The authors would like thank Jo Ann Allen, RN, MSN, IBCLC for their collaboration and implementation of the virtual lactation support calls. In addition, the authors acknowledge that it was not intended to exclude pregnant, postpartum or lactating individuals who do not identify as mother/woman or as having breasts by the use of gendered language in this article.

TABLE IV. OVERVIEW OF INTERVENTION COMPONENTS

Sunnyside	Sunnyside Plus[a]
Antenatal	
Week 1 Part 1: Your Pregnancy and Your Mood Part 2: Worries About You and Your Baby **Week 2** Part 1: Mood Management Part 2: Challenging Your Thinking **Week 3** Part 1: Stress in Pregnancy Part 2: Positive Activities in Pregnancy **Week 4** Part 1: Communication and Support Part 2: Changing Relationships **Week 5** Part 1: Monitoring Kick Counts and Other Pregnancy Anxieties; BF in the Time of COVID-19 Part 2: Planning for Postpartum and Employment Issues **Week 6** Part 1: Preparing for Birth and After Part 2: Moving Forward and Conclusions	**Week 1** Part 1: BF Benefits, Recommendations, and Safety Part 2: Learning about BF **Week 2** Part 1: BF Basics Part 2: BF Positions **Week 3** Part 1: Realities of BF Part 2: Realities of BF (continued) **Week 4** Part 1: Preparing to Breastfeed by Building Your Support Part 2: Building Your Support Network (continued) **Week 5** Part 1: Feeding and Growth Patterns of a Newborn Part 2: Expressing, Storing, and Feeding Human Milk **Week 6** Part 1: BF Immediately After Birth Part 2: Advocating for Yourself in the Hospital; BF in the Time of COVID-19
Postpartum	
	Week 1: Working Through Early BF Challenges BF text support messages (3) Lactation support calls (at least 1)
Week 2: Baby Blues / Relationships with Family and Friends	**Week 2:** BF Challenges and Solutions BF text support messages (3) Lactation support calls (at least 1)
	Week 3: Feeding and Growth Patterns of a Newborn (booster) BF text support messages (2) Lactation support calls (as needed)
Week 4: Relationships and Unhelpful Thoughts	**Week 4:** Expressing, Storing, and Feeding Human Milk (booster) BF text support messages (2) Lactation support calls (as needed)
	Week 5: Using Your BF Support Network BF text support messages (1) Lactation support calls (as needed)
Week 6: Thoughts and Healthy Activities	**Week 6:** Your BF Journey Continues BF text support messages (1) Lactation support calls (as needed)

[a]Sunnyside Plus content includes all Sunnyside content plus the BF-related content listed.

TABLE V. DATA COLLECTION INSTRUMENTS BY ASSESSMENT TIME

Data Collection Instrument	Baseline (EGA: 20-28 wks.)	3rd Trimester (EGA: 26-34 wks.)	6 Weeks Postpartum	12 Weeks Postpartum
Demographics	✓			
Maternal Anthropometrics	✓	✓	✓	✓
PHQ-9	✓	✓	✓	✓
IDAS	✓	✓	✓	✓
GAD-7	✓	✓	✓	✓
IFPS-II	✓	✓		
Breastfeeding variables (antenatal)	✓	✓		
PBSES	✓	✓		
BSES-SF			✓	✓
Breastfeeding variables (postpartum)			✓	✓
BRS	✓			
MOS	✓		✓	
EDS	✓		✓	
USE		✓	✓	
Neonatal and birth variables			✓	

TABLE VI. ELIGIBILITY SCREENER RESULTS

Variable	**N, % or mean (SD)[a]**
Age (mean years) (n = 1481)	30.9 (5)
Race (n = 1615)	
American Indian/Alaska Native (1)	11, 0.68%
Asian (2)	61, 3.8%
Native Hawaiian or Other Pacific Islander (3)	8, 0.5%
Black or African American (4)	539, 33.4%
White (5)	874, 54.1%
Other race (6)	122, 7.5%
Currently pregnant (n = 1616)	1611, 99.7%
Singleton pregnancy (n = 1611)	1579, 98%
Estimated gestational age (mean weeks) (n = 1611)	17.4 (6.3)
Estimated gestational age category (n = 1611)	
<20 weeks	971, 60.3%
20-28 weeks	622, 38.6%
>28 weeks	18, 1.1%
Planned infant feeding method (first few weeks) (n = 1616)	
Breastfeed only (baby will not be given formula)	1171, 72.5%
Formula feed only	20, 1.2%
Both breast and formula feed	367, 22.7%
I don't know yet	58, 3.6%
PHQ-8[b] (mean score) (n = 1616)	6.2 (4.7)
PHQ-8 category for depressive symptoms (n = 1616)	
None/minimal (0 - 4)	696, 43.1%
Mild (5 – 9)	560, 34.7%
Moderate (10 – 14)	261, 16.2%
Moderately severe (15 – 19)	78, 4.8%
Severe (20 – 27)	21, 1.3%
Current diagnosis of depression (n = 1616)	269, 16.6%
Ever diagnosed with:	
Psychotic disorder (n = 1614)	27, 1.7%
Bipolar disorder (n = 1614)	73, 4.5%
Dissociative disorder (n = 1614)	5, 0.31%
Substance use disorder (n = 1614)	31, 1.9%
Currently receiving treatment for mental health concern (n = 1616)	232, 14.4%
Plan to resume antidepressant medication postpartum (n = 1616)	237, 14.7%
Visual, hearing, voice, or motor impairments (n = 1616)	82, 5.1%

[a]Independent samples t-Test (continuous variables) comparing mean scores between groups or Fisher's exact test (categorical variables) examining independence of variables between groups.
[b]PHQ-8: Patient Health Questionnaire-8.

Figure 2. CONSORT flow diagram

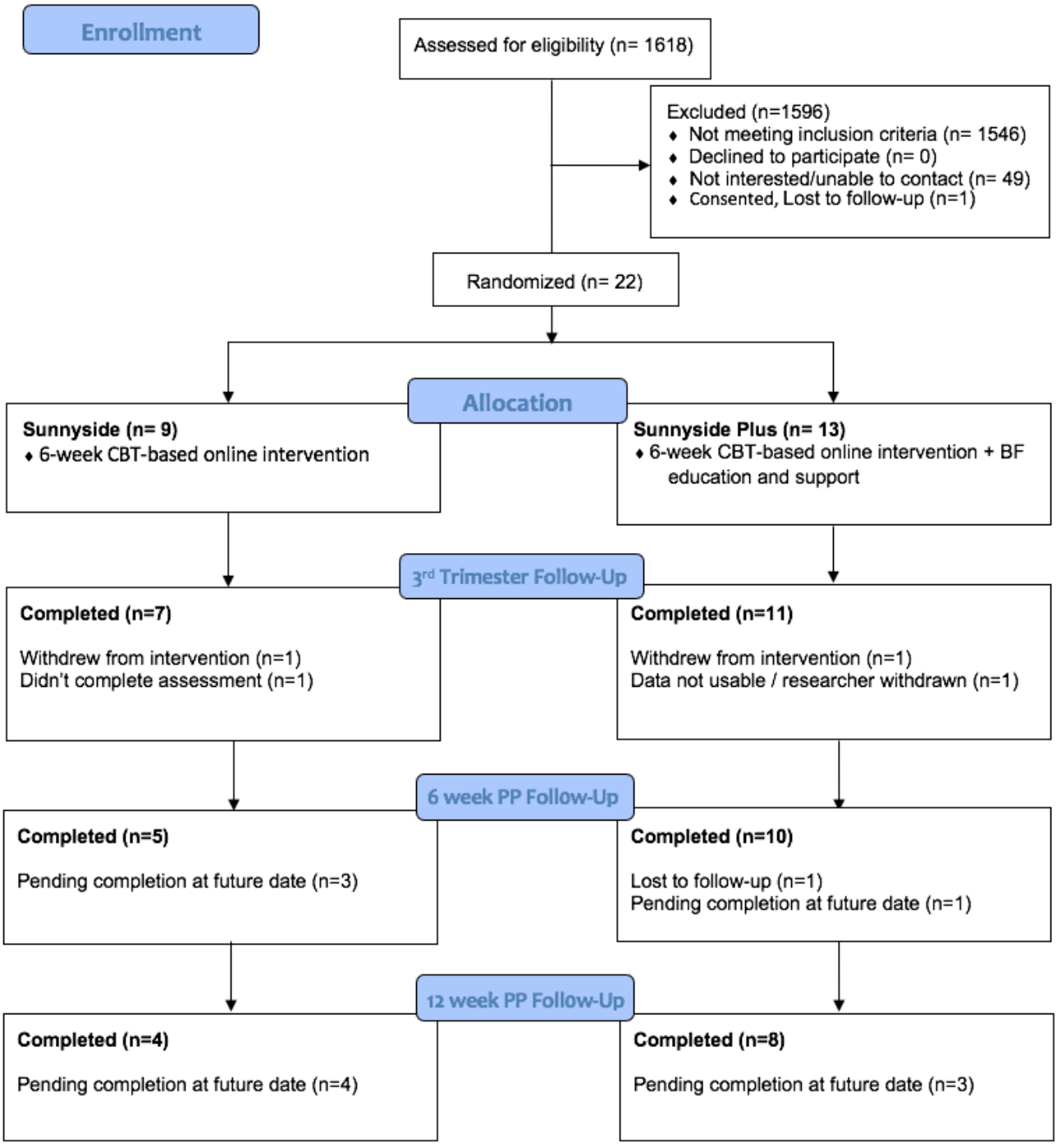


TABLE VII. BASELINE SAMPLE CHARACTERISTICS BY INTERVENTION GROUP

Variables	Overall (n=22)	Sunnyside (n=9)	Sunnyside Plus (n=13)	*P* Value[a]
	N, % or mean ± SD			
Age (years)	30.4 ± 3.9	29.7 ± 4.7	30.9 ± 3.3	0.5351
Race (Black or African American)	22, 100%	9, 100%	13, 100%	1
Ethnicity (non-Hispanic)	21, 95.5%	8, 88.9%	13, 100%	0.4091
Relationship status				0.8189
Single	5, 22.7%	2, 22.2%	3, 23.1%	
Married or partnered (cohabitating	17, 77.3%	7, 77.8%	10, 76.9%	
Household size	2.5 ± 1	2.6 ± 1	2.5 ± 1.1	0.8355
Annual household income				0.5925
≤$50,999	10, 45.4%	5, 55.6%	5, 38.4%	
≥$51,000	12, 54.5%	4, 44.4%	8, 61.5%	
Education				0.8480
Some college, 2- or 4-year college degree	12, 54.5%	5, 55.6%	7, 53.8%	
Graduate / professional degree	10, 45.5%	4, 44.4%	6, 46.2%	
Occupation				0.1375
Homemaker	5, 22.7%	3, 33.3%	2, 15.4%	
Employed part-time	4, 18.2%	3, 33.3%	1, 7.7%	
Employed full-time	13, 59.1%	3, 33.3%	10, 76.9%	
Health insurance				1
Private insurance	16, 72.7%	7, 77.8%	9, 69.2%	
Medicaid	6, 27.3%	2, 22.2%	4, 30.8%	
Pre-pregnancy BMI category				0.0662
Underweight (<18.5 kg/m2)	1, 4.5%	0, 0%	1, 7.7%	
Healthy weight (18.5 – 24.9 kg/m2)	4, 18.2%	4, 44.4%	0, 0%	
Overweight (25 – 29.9 kg/m2)	3, 13.6%	1, 11.1%	2, 15.4%	
Obese (≥30 kg/m2)	14, 63.6%	4, 44.4%	10, 76.9%	
PHQ-9 (mean score)	6.6 ± 2.9	7.3 ± 3.1	6.1 ± 2.7	0.3392
PHQ-9 category for depressive symptoms				
None/minimal (0 - 4)	4, 18.2%	2, 22.2%	2, 15.4%	
Mild (5 – 9)	15, 68.2%	5, 55.6%	10, 76.9%	
Moderate (10 – 14)	3, 13.6%	2, 22.2%	1, 7.7%	
GAD-7 (mean score)	6.05 ± 4.7	5.4 ± 3.8	6.5 ± 5.3	0.6096
GAD-7 category for anxiety symptoms				
None, Mild (0-9)	16, 72.7%	7, 77.8%	9, 69.2%	
Moderate to Severe (10-21)	6, 27.3%	2, 22.2%	4, 30.8%	
Resilience (BRS; mean score)	3.6 ± 0.81	3.6 ± 0.85	3.5 ± 0.81	0.8832
Discrimination (EDS; mean score)	22.5 ± 10	20.4 ± 8	24 ± 11.3	0.3987
Social support (MOS; mean overall score)	4.1 ± 0.70	4.2 ± 0.73	4.0 ± 0.69	0.5178
EGA at enrollment (weeks)	22.6 ± 2.5	23.1 ± 2.9	22.3 ± 2.3	0.4972
Nulliparous at enrollment	14, 63.6%	4, 44.4%	10, 76.9%	0.1125
Participant was breastfed as an infant	6, 27.3%	2, 22.2%	4, 30.8%	1
No past breastfeeding experience	17, 77.3%	6, 67%	11, 84.6%	0.6090
Breastfeeding self-efficacy (PBSES)	81 ± 14.1	77.3 ± 14.3	83.5 ± 14	0.3266
Intend to BF exclusively in the first few weeks PP	19, 86.4%	8, 88.9%	11, 84.6%	1
BF goal duration (months)	13.7 ± 5.7	12.7 ± 6.2	14.3 ± 5.5	0.5225

Abbreviations: BMI, body mass index; BRS, brief resilience scale; EDS, everyday discrimination scale; EGA, estimated gestational age; GAD-7, generalized anxiety disorder assessment-7; MOS, medical outcomes study social support survey; PBSES, prenatal breastfeeding self-efficacy scale; PHQ-9, patient health questionnaire-9.

[a]Independent samples t-Test (continuous variables) comparing mean scores between groups or Fisher's exact test (categorical variables) examining independence of variables between groups.

TABLE VIII. ADHERENCE DATA

	Sunnyside (n=9)		Sunnyside Plus (n=12)		
Program Activity	Mean (SD)	Range	Mean (SD)	Range	*P* value[a]
Total logins	7.3 (5.3)	1-17	13.8 (10.5)	2-39	0.0856
Total days on site	82.9 (62.4)	0-180	79.1 (47.0)	7-160	0.8803
Pregnancy lessons accessed[b]	10.1 (3.5)	5-13	9.7 (4.1)	2-13	0.7909
Postpartum lessons accessed[b]	1.6 (1.3)	0-3	2.5 (3.3)	0-9	0.3848
50% completion of lessons (n, %)	6, 66.6%	--	7, 58.3%	--	1[c]
Tool: activity scheduling/monitoring	0.4 (1.0)	0-3	9.8 (13.1)	0-36	0.0318*
Tool: mood rating	3.9 (2.2)	1-8	6.3 (9.6)	0-35	0.4080
Tool: feelings	2.7 (2.2)	0-5	4.9 (5.1)	0-17	0.1934
Tool: thought record	3.1 (1.5)	0-6	3.4 (2.9)	0-10	0.7596
Tool: goal setting	0.9 (1.2)	0-3	1.4 (3.1)	0-11	0.5984
Total tools used	11.0 (6.6)	4-23	25.8 (27.8)	0-79	0.0992
Text BF question responses	5.2 (1.3)	3-6	5.2 (1.3)	2-6	1
Lactation support calls	--	--	2.7 ± 2.1	0-7	--

[a]Independent samples t-test comparing mean scores between groups.
[b]Both intervention groups were offered a total of 13 lessons during pregnancy. Sunnyside intervention offered 3 lessons during postpartum and Sunnyside Plus offered 9 lessons during postpartum.
[c]Fisher's exact test examining independence of categorical variables between groups.
*$p<0.05$

TABLE IX. USABILITY AND ACCEPTABILITY

	Sunnyside	Sunnyside Plus	
	Mean (SD)	Mean (SD)	*P* value[a]
3rd trimester	N=7	N=11	
Usefulness	5.3 (1.3)	4.9 (1.2)	0.5564
Ease of use	5.1 (2.1)	5.9 (1.1)	0.3964
Ease of learning	5.1 (2.3)	6.2 (1.1)	0.2641
Satisfaction	4.9 (1.9)	5.3 (1.5)	0.6243
6 weeks postpartum	N=5	N=9	
Usefulness	5.0 (0.5)	5.1 (1.4)	0.7922
Ease of use	4.7 (0.9)	5.9 (1.4)	0.0763
Ease of learning	4.9 (1.3)	5.7 (1.3)	0.2744
Satisfaction	4.6 (0.7)	4.9 (1.5)	0.5877

[a]Independent samples t-test comparing mean scores between groups.

TABLE X. MENTAL HEALTH OUTCOMES

	Sunnyside					Sunnyside Plus						
Outcomes		Outcome measure		Change from baseline			Outcome measure		Change from baseline		Significance of difference in mean between groups	Significance of difference in mean change between groups
	N	Mean (SD)	Median (IQR)	Mean (SD)[a]	*P* value[b]	N	Mean (SD)	Median (IQR)	Mean (SD)[a]	*P* value[b]	*P* value[c]	*P* value[d]
PHQ-9[e]												
Baseline	9	7.3 (3.1)	7 (3)			13	6.1 (2.7)	5 (2)			0.3392	
3rd trimester	7	6.4 (3.9)	6 (5)	-0.7 (3.4)	0.5934	11	7.6 (4.8)	8 (5)	1.4 (2.8)	0.1421	0.5675	0.2006
6 weeks PP	5	5.4 (2.5)	4 (3)	-2.0 (5.6)	0.4669	10	6.9 (3.3)	6 (1.5)	0.7 (1.6)	0.2091	0.3527	0.3437
12 weeks PP	4	8.3 (5.2)	10 (5.75)	-0.3 (5.0)	0.9265	8	5.9 (5.6)	4 (6)	-0.1 (3.1)	0.9134	0.4923	0.9656
IDAS[f]												
Baseline	9	44.6 (8.8)	43 (11)			13	42.7 (11.0)	39 (18)			0.6650	
3rd trimester	7	44.1 (8.0)	46 (5)	-0.3 (14.4)	0.9599	11	44.5 (11.3)	42 (11.5)	0.3 (9.8)	0.9286	0.9465	0.9302
6 weeks PP	5	45.0 (7.0)	43 (9)	2.4 (5.2)	0.3585	10	46.2 (12.1)	46.5 (24)	3.8 (13.2)	0.3860	0.8114	0.7739
12 weeks PP	4	43.8 (7.9)	43 (12.75)	-2.0 (8.5)	0.6709	8	43.1 (13.6)	43.5 (19.75)	1.1 (13.7)	0.8227	0.9222	0.6391
GAD-7[g]												
Baseline	9	5.4 (3.8)	5 (5)			13	6.5 (5.3)	6 (7)			0.6096	
3rd trimester	7	5.9 (2.9)	6 (3)	0.9 (2.8)	0.4481	11	7.5 (6.0)	6 (5.5)	0.2 (4.6)	0.8983	0.4350	0.7036
6 weeks PP	5	7.6 (6.0)	10 (7)	3.0 (5.7)	0.3046	10	6.3 (6.1)	5 (7)	-0.4 (3.7)	0.7415	0.7042	0.2732
12 weeks PP	4	6.3 (3.3)	6.5 (2.75)	1.0 (2.2)	0.4228	8	5.5 (5.3)	5 (7.5)	-1.5 (2.7)	0.1635	0.7711	0.1243

[a]Estimated mean change in the difference between the baseline and follow-up means.
[b]Paired t-Test comparing mean change score to zero within groups.
[c]Independent samples t-Test comparing mean values between groups.
[d]Independent samples t-Test comparing mean change scores from baseline between groups.
[e]PHQ-9: Patient Health Questionnaire-9.
[f]IDAS: Inventory of Depression and Anxiety Symptoms.
[g]GAD-7: Generalized Anxiety Disorder questionnaire-7.

TABLE XI. PRENATAL BREASTFEEDING OUTCOMES

	Sunnyside					Sunnyside Plus						
Outcomes over time		Outcome measure		Change from baseline			Outcome measure		Change from baseline		Significance of difference in mean between groups	Significance of difference in mean change between groups
	N	Mean (SD)	Median (IQR)	Mean (SD)[a]	*P* value[b]	N	Mean (SD)	Median (IQR)	Mean (SD)[a]	*P* value[b]	*P* value[c]	*P* value[d]
Intended BF duration (months)												
Baseline	9	12.7 (6.2)	12 (6)			13	14.3 (5.5)	13 (6)			0.5225	
3rd trimester	7	10.0 (2.6)	12 (4)	0.1 (0.9)	0.6891	11	13.4 (7.3)	12 (4)	-0.3 (9.6)	0.9149	0.1877	0.8777
Knowledge												
Baseline	9	2.3 (0.7)	2 (1)			13	2.4 (0.7)	2 (1)			0.8649	
3rd trimester	7	2.4 (0.5)	2 (1)	0.1 (0.9)	0.6891	11	2.1 (0.9)	2 (2)	-0.3 (1.0)	0.3911	0.3478	0.3778
Positive attitudes toward embarrassment												
Baseline	9	3.0 (1.0)	3 (1)			13	3.5 (0.9)	4 (1)			0.2801	
3rd trimester	7	2.9 (0.7)	3 (0.5)	0.1 (1.5)	0.8049	11	3.2 (0.8)	3 (1)	-0.3 (0.9)	0.3409	0.3634	0.5175
Positive attitudes toward time and social constraint												
Baseline	9	3.6 (0.5)	4 (1)			13	3.0 (1.2)	4 (2)			0.1641	
3rd trimester	7	3.7 (0.5)	4 (0.5)	0.1 (0.7)	0.6036	11	3.5 (0.7)	4 (1)	0.5 (0.8)	0.0519	0.5516	0.2808
Positive attitudes toward social support												
Baseline	9	2.6 (0.5)	3 (1)			13	2.8 (0.6)	3 (0)			0.3881	
3rd trimester	7	2.4 (0.5)	2 (1)	-0.1 (0.7)	0.6036	11	2.8 (0.4)	3 (0)	0.1 (0.7)	0.6761	0.1287	0.4983
Self-efficacy (PBSES)[e]												
Baseline	9	77.3 (14.3)	80 (16)			13	83.5 (14.0)	89 (27)			0.3266	
3rd trimester	7	86.1 (16.7)	93 (13)	5.9 (14.2)	0.3179	11	86.7 (10.5)	88 (17)	4.9 (6.1)	0.0242*	0.9358	0.8721

[a]Estimated mean change in the difference between the baseline and follow-up means.
[b]Paired t-Test comparing mean change score to zero within groups.
[c]Independent samples t-Test comparing mean values between groups.
[d]Independent samples t-Test comparing mean change scores from baseline between groups.
[e]PBSES: Prenatal Breastfeeding Self-efficacy Scale.
*<0.05

TABLE XII. POSTPARTUM BREASTFEEDING OUTCOMES

	Sunnyside		Sunnyside Plus		
	N	N (%) or Mean (SD)	N	N (%) or Mean (SD)	*P* value[a]
Initiation	5	5/5 (100%)	10	10/10 (100%)	1
Time to introduction of formula (weeks)	4	3.3 (5.9)	8	0.5 (0.5)	0.417
Exclusive breastfeeding					
6 weeks postpartum	5	3/5 (60%)	10	9/10 (90%)	0.2418
12 weeks postpartum	4	3/4 (75%)	8	6/8 (75%)	1
Any breastfeeding					
6 weeks postpartum	5	5/5 (100%)	10	10/10 (100%)	1
12 weeks postpartum	4	4/4 (100%)	8	8/8 (100%)	1
Self-efficacy (BSES-SF[b])					
6 weeks postpartum	5	50.2 (18.8)	10	50.1 (14.2)	0.992
12 weeks postpartum	4	40.8 (20.8)	8	54.3 (10.1)	0.2906

[a]Independent samples t-Test (continuous variables) comparing mean scores between groups or Fisher's exact test (categorical variables) examining independence of variables between groups.
[b]BSES-SF: Breastfeeding Self-Efficacy Scale – short form.

V. FUTURE DIRECTIONS

The bidirectional relationship between maternal mental health and BF is well-established. A number of physiological, social, environmental, and situational factors likely provide an explanation for the intersecting association between the two. In some ways, it seems illogical to examine one without the other, given that those in the perinatal period will naturally find themselves at the mercy of physiological changes, of which they are not in control, and with the responsibility of feeding their child, no matter the method. In this light, future research efforts that consider their concurrence might lead to a better understanding of the etiology of maternal mental health and BF outcomes.

Based on findings from the systematic review, future interventions aimed at improving maternal mental health and BF should span across pregnancy and the postpartum period, including at or around the time of birth. Interventions should provide individualized and timely support by a combination of hospital / medical staff, mental health and lactation professionals, and peer support, all working collaboratively across their respective disciplines.

Emerging evidence suggests that online and digital-technology interventions offer potential in extending preventative and supportive services, especially for those navigating the complex and vulnerable early postpartum period. In very practical ways, online interventions may lessen the logistical barriers associated with seeking care (e.g., physical recovery after birth, worry of disrupting baby's sleep, transportation challenges) and improve translation of recommendations in a meaningful way (i.e., individuals are using their own physical space to BF, rather than a well-staged lactation room that they cannot replicate when they return home).

In fact, results of the present pilot study suggest that Black women at-risk for perinatal depression were receptive to and satisfied with an online CBT-based internet intervention, with and without BF education and support, and that the online interventions had a positive impact on symptoms of depression and anxiety and on BF outcomes. To better understand if mental health support alone or in

combination with BF support is most beneficial, a larger-scale and longer-term randomized controlled trial is needed.

In addition, results of the pilot trial picked up on week-by-week changes (via text interactions) in BF exclusivity that weren't always conveyed by participants when retrospectively reporting infant feeding method over a period of time (i.e., six or 12 weeks). To better understand when and why changes in mental health and BF status are occurring, more frequent assessment is recommended, especially in the first few weeks when BF is being established and the transition into newborn parenthood is taking place.

Future research must also take an intersectional approach to understand how varying identities and compounding experiences of discrimination and oppression impact outcomes of mental health and BF. Practically speaking, this means the data we collect must come from those who represent the entire population, and not just those of majority identities.

VI. CONCLUSION

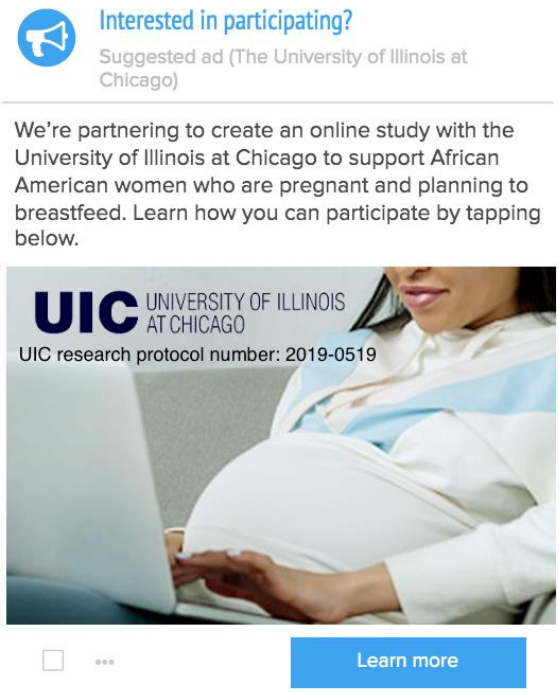
In summary, findings from the systematic review and pilot trial highlight the intersection of maternal mental health and BF. Results from the systematic review on the efficacy of behavioral interventions (n=35) to improve maternal mental health *and* breastfeeding outcomes suggests interventions that extend across pregnancy and postpartum and offer individualized support from both professionals and peers who collaborate through a continuum of settings are most successful. By acknowledging and addressing that mental health and breastfeeding both occur in complex settings affected by many factors, we move into a whole-person approach to preventative and supportive services.

To further acknowledge and address racial disparities in maternal mental health and breastfeeding, the pilot study was developed using components shown to improve mental health and BF outcomes among Black women. Additionally, many of the suggestions gleaned from the systematic review were also incorporated into the study design.

Results from the pilot study suggest that Black women at-risk for perinatal depression were receptive to and satisfied with an online CBT-based internet intervention, with and without BF education and support, spanning from mid-pregnancy through six weeks postpartum. Preliminary findings indicate that both Sunnyside and Sunnyside Plus interventions have a positive impact on symptoms of depression and anxiety and on BF outcomes across pregnancy and the first 12 weeks postpartum. Larger-scale, longer-term randomized controlled trials are needed to better understand the intersection between maternal mental health and BF.

VII. APPENDICES

APPENDIX A – OVIA RECRUITMENT MATERIAL



APPENDIX B – INTERNET POSTING RECRUITMENT MATERIAL

Online Intervention to Prevent Perinatal Depression and Promote Breastfeeding

Seeking volunteers for a University of Illinois at Chicago (UIC) research study.

Pregnant African American women who are 18 years of age and older, between 20-28 weeks pregnant, and who plan to breastfeed their child are invited to participate in a research study investigating an online intervention to promote and support breastfeeding and help pregnant women learn how to better manage their mood during and after pregnancy.

What will you do?

- Participants will be randomly assigned to participate in an online intervention to better manage their mood during and after pregnancy OR an online intervention to better manage mood and promote and support breastfeeding during and after pregnancy.
- Participation in the study includes a 6 week online intervention during pregnancy and a 6 week online intervention following the birth of their baby.
- Some women will have additional contacts (by text and video calls) with a Lactation Educator to support them through their breastfeeding experience.
- Participants will be compensated $80 for completing all study assessments.
- All study-related tasks will take place online; no in-person study visits are required.

To determine if you are eligible for the research study, you may complete the eligibility screen below.

This study is being conducted by Dr. Jennifer Duffecy, PhD in the Department of Psychiatry at UIC (912 S. Wood St., Chicago, IL 60612).

UIC research protocol number: 2019-0519

APPENDIX C – INFORMED CONSENT DOCUMENT

University of Illinois at Chicago
Research Information and Consent for Participation in Biomedical Research
Online Intervention to Prevent Perinatal Depression and Promote Breastfeeding

Principal Investigator/Researcher Name and Title: Jennifer Duffecy, PhD
Department and Institution: Department of Psychiatry, University of Illinois at Chicago
Address and Contact Information: 912 S. Wood St., Chicago, IL 60612; 312-413-1225

About this research study
You are being asked to participate in a research study. Research studies answer important questions that might help change or improve the way we do things in the future.

Taking part in this study is voluntary
Your participation in this research study is voluntary. You may choose to not take part in this study or may choose to leave the study at any time. Deciding not to participate, or deciding to leave the study later, will not result in any penalty or loss of benefits to which you are entitled and will not affect your relationship with the University of Illinois Hospital and Health Sciences System (UI Health) and/or University of Illinois at Chicago (UIC).

This consent form will give you information about the research study to help you decide whether you want to participate. Please read this form and ask any questions you have before agreeing to be in the study.

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

Important Information
This information gives you an overview of the research. More information about these topics may be found in the pages that follow.

WHY IS THIS STUDY BEING DONE?	We want to evaluate two online interventions that have been created to promote and support breastfeeding, manage mood, and prevent depression.
WHAT WILL HAPPEN TO ME DURING THE STUDY?	If you take part in this study, you will progress through 2 online lessons per week for 6 weeks during your pregnancy; each lesson takes approximately 10 minutes to complete. You are also provided with tools that will help you practice the techniques you are learning. It is suggested that you utilize these tools once every day or two; they each take approximately 5 minutes to complete. You will progress through additional online lessons during the first 6 weeks after your baby is born. These will help you apply the things you had previously learned now that your baby is here. Some women will have additional contacts (either by text or video calls) with a Lactation Educator to support them through their breastfeeding experience. For more information, please see the "What Procedures Are Involved?" section below.
HOW MUCH TIME WILL I SPEND ON THE STUDY?	All study participation takes place over the internet. You will be enrolled in the study starting between 20-28 weeks gestation through 12 weeks postpartum. For 6 weeks during your pregnancy, you will complete 2 online lessons per week and utilize tools. This will require approximately 40-60 minutes per week. For 6 weeks during your early postpartum, you will progress through additional lessons each week. This will require approximately 10-20 minutes per week. Some women will have contact with a Lactation Educator. These interactions will occur on an as-needed basis and may take approximately 20-60 minutes, depending on your needs. All participants will complete online questionnaires at 4 time points across the entire study. These will each take approximately 1 hour to complete.

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

ARE THERE ANY BENEFITS TO TAKING PART IN THE STUDY?	There may or may not be any benefit to participation in this study. We hope that your participation in the study may benefit other people in the future by helping us learn more about ways to manage mood and improve breastfeeding outcomes.
WHAT ARE THE MAIN RISKS OF THE STUDY?	For this study, the main risks to know about are: A risk of feeling emotionally uncomfortable when completing questionnaires about mood, breastfeeding, or health. A risk of feeling emotionally or physically uncomfortable when interacting with the Lactation Educator over video calls. A risk of loss of privacy (revealing to others that you are taking part in this study). A risk of loss of confidentiality (revealing information about you to others to whom you have not given permission to see this information). For details and a list of risks you should know about, please see the "What Are the Potential Risks and Discomforts of the Study" section below.
DO I HAVE OTHER OPTIONS BESIDES TAKING PART IN THE STUDY?	You have the option to not participate in this study.
QUESTIONS ABOUT THE STUDY?	For questions, concerns, or complaints about the study, please contact Jennifer Duffecy, PhD at 312-413-1225 or email at jduffecy@uic.edu If you have questions about your rights as a study subject; including questions, concerns, complaints, or if you feel you have not been treated according to the description in this form; or to offer input you may call the UIC Office for the Protection of Research Subjects (OPRS) at 312-996-1711 or 1-866-789-6215 (toll-free) or e-mail OPRS at uicirb@uic.edu. If you have questions or concerns regarding your privacy rights under HIPAA, you should contact the University of Illinois HIPAA Privacy Office at (844) 341-2201 or hipaa@uillinois.edu.

Please review the rest of this document for details about these topics and additional things you should know before making a decision about whether to participate in this research. Please also feel free to ask the study team questions at any time.

Who may participate in the study?

You are being asked to participate in the research study because you are an African American woman who is 18 years of age or older, between 20-28 weeks pregnant, and plan to breastfeed your child.

Approximately 50 subjects may be involved in this study at UIC.

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

What procedures are involved?
This research will take place over the internet. No in-person study visits are required. All procedures are being done for research purposes only.

Participants will be randomly assigned (chosen by chance, like flipping a coin) to an online intervention.

- An online intervention to better manage mood during and after pregnancy; OR
- An online intervention to better manage mood and promote and support breastfeeding during and after pregnancy.

If you agree to be in the study, you will be asked to do the following procedures:

Complete Online Lessons:

- You will progress through 2 online lessons per week for 6 weeks during your pregnancy; each lesson takes approximately 10 minutes to complete. You are also provided with tools that will help you practice the techniques you are learning. It is suggested that you utilize these tools once every day or two; they each take approximately 5 minutes to complete. In total, this will require approximately 40-60 minutes per week for 6 weeks.
- There will be additional online lessons during the first 6 weeks after your baby is born. These will help you apply the things you had previously learned now that your baby is here. Depending on which online intervention you are randomly assigned to, you will progress through either:
    - Additional lessons at 2 weeks, 4 weeks, and 6 weeks after your baby is born; OR
    - Additional lessons each week during the first 6 weeks after your baby is born.

  In total, this will require approximately 10-20 minutes per week for 6 weeks.

Complete Assessments (Questionnaires):

- You will be asked to complete online questionnaires at 4 time points across the entire study. These questionnaires will take place at enrollment (the beginning of the study), 6 weeks after your initial enrollment, 6 weeks after your baby is born, and 12 weeks after your baby is born. The questionnaires will each take approximately 1 hour to complete.
- The information, collected as part of this study, includes demographic variables (such as race/ethnicity, age, marital status, education, household size, number of children, household income, employment, and insurance coverage), maternal anthropometric measures (such as height, pre-pregnancy weight, current weights, and blood pressure), health history, medication and supplementation use, mood-related (depression and anxiety), breastfeeding-related, childbirth experience, health services utilization, sleep, physical activity, dietary behavior, neonatal and birth variables (such as baby's sex and birth weight, mode of birth, birth interventions, and labor and birth complications), and evaluation of the intervention. Maternal anthropometric measures, health history, medication and supplementation use, and neonatal and birth variables will be confirmed with medical record release processes. A request will be made by Dr. Jennifer Duffecy or Dr. Joanna Buscemi to obtain these records.

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

Allow Us Access to Your Medical Record

- We are asking you to let us collect some information from your medical records for this study. We will not need to look at all of your records. We will collect information about your clinic visits, medications, and hospitalizations (including the birth of your baby). We will collect this information from a period starting up to 1 year before your pregnancy and ending up to 12 weeks after your delivery.
- You will be asked to fill out a form to have your medical records released to a research team member (Dr. Jennifer Duffecy or Dr. Joanna Buscemi).

Receive Text Support Messages:

- You may (depending on which online intervention you are randomly assigned to) receive text support messages to your phone during the first 6 weeks after you baby is born. There will be 3 messages sent during weeks 1 and 2, 2 messages sent during weeks 3 and 4, and 1 message sent during weeks 5 and 6. You will have the ability to opt out of receiving these messages.
- On a weekly basis, you will be asked to reply to 2 breastfeeding continuation questions with a "YES" or "NO" (regardless of which online intervention you are randomly assigned to).

Complete Video Support Calls with a Lactation Educator:

- You may (depending on which online intervention you are randomly assign to) complete video support calls during the first 6 weeks after you baby is born. At least 1 video call is required during both week 1 and week 2 after your baby is born. Additional video calls will occur on an as-needed basis for breastfeeding support. The video support calls will be recorded.
- These interactions may take approximately 20-60 minutes, depending on your needs.

What will happen with my information used in this study?

Your identifiable private information collected for this research study will not be used for future research studies or shared with other researchers for future research.

What are the potential risks and discomforts of the study?

Side effects, risks, and/or discomforts from participation in this study include:

Assessments (Questionnaires):

- You may feel emotionally uncomfortable when completing questionnaires about mood, breastfeeding, or health. Some questions asked may be upsetting, or you may feel uncomfortable answering them. If you do not wish to answer a question, you may skip it and go to the next question.

Video Support Calls with a Lactation Educator:

- You may feel emotionally or physically uncomfortable when interacting with the Lactation Educator over video calls. Video support calls will occur on a secure web application. The Lactation Educator will provide video support from a private location

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

and you will be encouraged to utilize the video support calls in a private location. You get to determine the level of support that you receive during these video calls.

There may be risks from the study that are not known at this time.

A risk of this research is a loss of privacy (revealing to others that you are taking part in this study) or confidentiality (revealing information about you to others to whom you have not given permission to see this information).

What about privacy and confidentiality?

Efforts will be made to keep your personal information confidential; however, we cannot guarantee absolute confidentiality. In general, information about you, or provided by you, during the research study, will not be disclosed to others without your written permission. However, laws and university rules might require us to tell certain people about you. For example, study information which identifies you and the consent form signed by you may be looked at and/or copied for quality assurance and data analysis include:

- Representatives of the university committee and office that reviews and approves research studies, the Institutional Review Board (IRB) and Office for the Protection of Research Subjects.
- Other representatives of the State and University responsible for ethical, regulatory, or financial oversight of research.
- Government Regulatory Agencies, such as the Office for Human Research Protections (OHRP).

A possible risk of the study is that your participation in the study or information about you and your health might become known to individuals outside the study. Your personal information and research data will be coded (you will be assigned a number that will be attached to your research data instead of your name or any other identifiable information) and kept in a password protected, secure database to prevent access by unauthorized personnel. Your individual data will be stripped of all direct and indirect identifiers after 10 years after the completion of the study.

When the results of the study are published or discussed in conferences, no one will know that you were in the study. During the study, video recordings will be collected. Your name may be used during the video call with the Lactation Educator. If you wish, you can review the video recordings at the end of the session and choose to withdraw your recording, if desired. Only Dr. Jennifer Duffecy and her research team will have access to these video recordings.

Will health information about you be created, used or shared with others during this study?

State and federal laws, including the Health Insurance Portability and Accountability Act (HIPAA), require researchers to protect your health information. This section of this form describes how researchers, with your authorization (permission), may use and release (disclose or share) your protected health information in this research study. By agreeing to this form you are authorizing Dr. Jennifer Duffecy and her research team to create, get, use, store, and share protected health information that identifies you for the purposes of this research.

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

The researchers may need to use health information from your doctors not at UIC. In this case, you will be asked to sign a separate authorization (medical release) form requesting your non-UIC doctor to give the information to Dr. Jennifer Duffecy.
During the conduct of the research, the researchers may use or share your health information:

- With each other and with other researchers involved with the study;
- With law enforcement or other agencies, when required by law;
- With non-UIC collaborators of the research study: Dr. Joanna Buscemi at DePaul University;
- With representatives of government agencies (i.e., Food and Drug Administration), review boards including the University of Illinois at Chicago Institutional Review Board, the University of Illinois Medical Center and its representatives, and other persons who watch over the safety, effectiveness, and conduct of research.

If all information that identifies you is removed from your health information, the remaining information is no longer subject to the limits of this Authorization or to the HIPAA privacy laws. Therefore, the de-identified information may be used and released by the researchers (as permitted by law) for other purposes, such as other research projects.

How will your health information be protected?
The researchers agree to protect your health information and will only share this information as described within this research consent/authorization form.

When your health information is given to people outside of the research study, those agencies that receive your health information may not be required by federal privacy laws (such as the Privacy Rule) to protect it. They may also share your information with others without your permission, if permitted by laws that they have to follow.

What are the costs for participating in this research study?
There are no costs to you for participating in this research study; however, you may be charged fees from your phone carrier for the use of your phone for calling and/or text messaging during this study.

Will I be reimbursed for any of my expenses or paid for my participation in this research study?
You will receive a $20 Amazon gift certificate for each completed study assessment point. If you do not finish the study, you will be compensated for the assessments points you have completed. If you complete all 4 assessments points, you will receive a total of $80. You will receive your payment within approximately 30 days after each assessment by email.

Your participation in this research study may contribute to the development of commercial products from which the Sponsor company or others may derive economic benefit. There are no plans to compensate you for any of these developments.

Will I be told about new information that may affect my decision to participate?
During the course of the study, you will be informed of any significant new research findings (either good or bad), such as changes in the risks or benefits resulting from participation in the research or new alternatives to participation, that might cause you to change your mind about

APPENDIX C – INFORMED CONSENT DOCUMENT (continued)

continuing in the study. If new information is provided to you, your consent to continue participating in this study may be re-obtained.

Can I withdraw or be removed from the study?
If you decide to participate, you have the right to withdraw your consent and leave the study at any time without penalty.

The researchers and sponsor also have the right to stop your participation in this study without your consent if:
- They believe it is in your best interests;
- You were to object to any future changes that may be made in the study plan.

If you choose to no longer be in the study and you do not want any of your future health information to be used, you must inform Dr. Jennifer Duffecy in writing at the address on the first page. Dr. Jennifer Duffecy may still use your information that was collected prior to your written notice.

Your Authorization for release of health information for this research study does not have an expiration date, but can be canceled sooner if you decide to withdraw your permission. You may change your mind and cancel this Authorization at any time. To cancel this Authorization, you must write to: Dr. Jennifer Duffecy at 912 S. Wood St., Chicago, IL 60612.

If you cancel this Authorization, you may no longer be allowed to take part in the research study. Even if you cancel this Authorization, the researchers may still use and disclose health information they have already obtained as necessary to maintain the integrity and reliability of the research and to report any adverse (bad) effects that may have happened to you.

Right to Refuse to Agree to this Authorization:
You do not have to agree to this Consent/Authorization. However, because your health information is required for research participation, you cannot be in this research study if you do not agree to this form. If you decide not to agree to this Consent/Authorization form, it will only mean you cannot take part in this research. Not agreeing to this form will not affect your non-research related treatment, payment or enrollment in any health plans or your eligibility for other medical benefits.

Remember:
Your participation in this research study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

If you have not already received a copy of the Notice of Privacy Practices, you should ask for one.

APPENDIX D – TEXT SUPPORT MESSAGES

SUNNYSIDE PLUS TEXT SUPPORT MESSAGES

Content of Text Support Messages in the Sunnyside Plus Group During the First 6 Weeks Postpartum

Week 1	1. Congratulations on the birth of your baby and your transition into motherhood (or your return to *newborn* motherhood)! Contact the study Lactation Educator to schedule your first one-on-one video support call. 2. Breastfeeding takes time for you and baby to learn and you are doing a great job. Contact the study Lactation Educator for more support. 3. The first weeks are a time of learning. Be patient and kind with yourself while your breastfeeding relationship develops feeding by feeding. Contact the study Lactation Educator for more support. a. Are you still breastfeeding your baby? (Text YES or NO) b. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)
Week 2	1. As your breastfeeding journey has begun, you may have concerns about yourself or your baby. Common breastfeeding challenges and solutions are discussed on the Sunnyside website. We are here to help you. Contact the study Lactation Educator to schedule your next one-on-one video support call. 2. It is common to feel that you aren't making enough milk for your baby. Most likely, you actually are making enough milk! Contact the study Lactation Educator for support and reassurance. 3. Breastfeeding is hard work, especially in the beginning. You are not alone. Contact the study Lactation Educator for support. a. Are you still breastfeeding your baby? (Text YES or NO) b. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)
Week 3	1. If you feel like you're always feeding, remember this can be normal in the early weeks as your baby transitions to the world and your milk supply is building. When baby's suck slows down and/or your breasts feel soft, take a break and change activity. Contact the study Lactation Educator for support. 2. Make sure that YOU are comfortable when breastfeeding. Skin-to-skin, tummy-to-tummy is a great place to return and reset. Contact the study Lactation Educator for more support. a. Are you still breastfeeding your baby? (Text YES or NO) b. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)
Week 4	1. If you are dealing with people who don't support your breastfeeding journey, remind them that you are parenting the way that feels right to you. Contact the study Lactation Educator for more support. 2. This week you can learn more about expressing, storing, and feeding breastmilk on the Sunnyside website. Contact the study Lactation Educator for more support. a. Are you still breastfeeding your baby? (Text YES or NO) b. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)
Week 5	1. Breastfeeding can feel overwhelming or lonely. Talk with the study Lactation Educator about any concerns. If you're having trouble finding local resources, we're here to help! a. Are you still breastfeeding your baby? (Text YES or NO) b. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)
Week 6	1. The breastfeeding journey typically gets more relaxed as you find your stride, work through challenges, and celebrate victories. Contact the study Lactation Educator for more support. c. Are you still breastfeeding your baby? (Text YES or NO) d. Is your baby receiving any foods or liquids besides breastmilk? (Text YES or NO)

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IX. VITA

Lacey B. (Wisslead) Pezley, MS, RDN, LDN, CD(DONA), LE

Education

B.S.	**University of Illinois, Chicago - Department of Biological Sciences**
Biology	May 2012
M.S.	**University of Illinois, Chicago - Department of Kinesiology and Nutrition**
Nutrition	December 2017
Ph.D.	**University of Illinois, Chicago - Department of Kinesiology and Nutrition**
Kinesiology	Anticipated May 2021
and Nutrition Breastfeeding	Thesis: Online Intervention to Prevent Perinatal Depression and Promote Supervisor: Dr. Lisa Tussing-Humphreys, PhD, MS, RD

Positions

Research Assistant	**University of Illinois, Chicago - Department of Psychiatry** Women's Mental Health Research Program September 2010 - May 2012
Research Coordinator	**University of Illinois, Chicago - Department of Psychiatry** Women's Mental Health Research Program June 2012 - December 2017
Graduate Research Assistant	**University of Illinois, Chicago - Department of Medicine** January 2018 - December 2018
Graduate Teaching Assistant	**University of Illinois, Chicago - Department of Kinesiology and Nutrition** August 2018 - Present

Teaching Experience

Co-Instructor	**University of Illinois, Chicago - Honors College** HON 201: Foundations for the Future (Undergraduate level) Fall 2015
Co-Instructor	**University of Illinois, Chicago - Honors College** HON 201: Foundations for the Future (Undergraduate level) Spring 2016
Teaching Assistant	**University of Illinois, Chicago - Department of Kinesiology and Nutrition** HN 355: Supervised Practice I HN 455: Supervised Practice II Fall 2018 - Spring 2020
Teaching Assistant	**University of Illinois, Chicago - Department of Kinesiology and Nutrition** HN 302: Nutritional Assessment HN 311: Nutrition During the Life Cycle HN 332: Food Service Management Fall 2020
Teaching Assistant	**University of Illinois, Chicago - Department of Kinesiology and Nutrition** HN 420: Clinical Nutrition II HN 423: Nutrition Counseling Spring 2021

Awards

2011	Endocrine Society Summer Research Fellowship Award - Endocrine Society
2011	Sarah Madonna Kabbes Award - University of Illinois, Chicago
2012	Poster Presentation Award - University of Illinois, Chicago
2012	Chancellor's Student Service Award - University of Illinois, Chicago

Licenses and Certifications

2015-Present	Certified Birth Doula, CD(DONA)
2017-Present	Licensed (IL) and Registered Dietitian Nutritionist
2019-Present	Lactation Educator

Professional Affiliations

Member of the Endocrine Society since 2011

Member of the Academy of Nutrition and Dietetics since 2014

Member of the Chicago Academy of Nutrition and Dietetics since 2014

Member of DONA International since 2015

Member of the American Society for Nutrition since 2016

Member of Evidence Based Birth since 2018

Member of Childbirth and Postpartum Professional Association since 2019

Publications

1. Koenig MD, Tussing-Humphreys L, DeMartelly V, LaBomascus B, OjiNjideka Hemphill N, Welke L, **Pezley L**, Ruchob R, Hirsch B, Furlette-Koski M, Kessee N, Estwing Ferrans C. Recruitment and Retention of Urban Pregnant Women to a Clinical Study Administering an Oral Isotope Dietary Tracer. *Maternal and Child Health Journal.* Submitted.
2. Wenzel ES, Peñalver Bernabé B, Dowty SM, Nagelli U, **Pezley L**, Gibbons R, Maki P. Using Computerized Adaptive Tests to Screen for Perinatal Depression in Underserved Women of Color. *American Journal of Obstetrics & Gynecology.* Submitted.
3. Koenig MD, Klikuszowian E, O'Brian K, Pauls H, Steffen A, DeMartelly V, Ruchob R, Welke L, Hemphill N, LaBomascus B, **Pezley L**, McLeod A, Hirsch B, Ferrans C, Tussing-Humphreys L. Prepregnancy Obesity Is Not Associated with Iron Utilization during the Third Trimester. *J Nutr*. 2020;150(6):1397-1404. doi:10.1093/jn/nxaa065

Abstracts

1. **Wisslead L**, Drogos L, Rubin LH, Savarese A, Mordecai KL, Maki PM. Effect of Oral Contraceptive Use on Heart Rate Variability during Laboratory-Induced Stress. Annual University of Illinois Student Research Forum. Chicago, IL. 2012. [Poster presentation]
2. **Wisslead L**, Drogos L, Rubin LH, Savarese A, Mordecai KL, Maki PM. Effect of Oral Contraceptive Use on Heart Rate Variability during Laboratory-Induced Stress. University of Illinois Department of Psychiatry 3rd Annual Research Forum. Chicago, IL. 2012. [Poster presentation]
3. **Wisslead L**, Drogos L, Rubin LH, Savarese A, Mordecai KL, Maki PM. Effect of Oral Contraceptive Use on Heart Rate Variability during Laboratory-Induced Stress. Endocrine Society's 94th Meeting and Expo. Houston, T.X. 2012. [Poster presentation]
4. Dawood B, Drogos L, D'Aunno, **Pezley L**, Rubin LH, Maki PM. The Association between Vasomotor Symptoms and Sleep Disturbance among Menopausal Women: a Comparison of Physiological and Self-Reported Measures. Annual University of Illinois Student Research Forum. Chicago, IL. 2014. [Poster presentation]
5. Patel PD, **Pezley L**, Oakley JA, Rubin LH, Maki PM. Prevalence of Perinatal Depression and Anxiety in Adolescents versus Adults. Annual University of Illinois Student Research Forum. Chicago, IL. 2015. [Poster presentation]
6. Malhotra K, Dowty S, **Pezley L**, Rubin LH, Maki PM. Childhood Emotional Neglect, but not Physical Neglect, is Associated with Alterations in the Stress Response System in Midlife Women. Annual University of Illinois Student Research Forum. Chicago, IL. 2015. [Poster presentation]

7. Elmasri A, Dowty S, **Pezley L**, Rubin LH, Maki PM. Anxiety in Pregnant Women with Gestational Diabetes. Annual University of Illinois Student Research Forum. Chicago, IL. 2016. [Poster presentation]
8. Arrieta M, **Pezley L**, Dowty SM, Rubin LH, Maki PM. Comparison of Culture-Bound Depressive Symptoms in Pregnant Women of Racial/Ethnic Minorities. Annual University of Illinois Student Research Forum. Chicago, IL. 2016. [Poster presentation]
9. Weaver NM, **Pezley L**, Rubin LH, Dowty SM, Maki PM. Enhancing Perinatal Mental Health: SCID Validation of the Computerized Adaptive Diagnostic Tool for Mental Health Disorders. Annual University of Illinois Student Research Forum. Chicago, IL. 2016. [Poster presentation]
10. Chouhdry H, Fogel J, Dowty SM, **Pezley L**, Maki PM. The Effects of Pregnancy Intention on Perinatal Depression. Annual University of Illinois Student Research Forum. Chicago, IL. 2017. [Poster presentation]
11. Peñalver Bernabé B, Dowty SM, **Pezley L**, Fernandez A, Go J, Hassan M, Shah Z, Shaheen S, Labomascus B, Tussing-Humphreys L, Maki PM, Gilbert J. Human Microbiome and Perinatal Depression. Arnold and Mabel Beckman Foundation. August 2017. [Poster presentation]
12. Peñalver Bernabé B, Dowty SM, **Pezley L**, Fernandez A, Go J, Hassan M, Shah Z, Shaheen S, Labomascus B, Tussing-Humphreys L, Maki PM, Gilbert J. Human Microbiome and Perinatal Depression. University of Illinois Department of Psychiatry 8th Annual Research Forum. Chicago, IL. 2017. [Poster presentation]
13. Fernandez A, Bark J, Dowty SM, Peñalver Bernabé B, **Pezley L**, Maki PM. Determining the Prevalence of Perinatal Depression in a Diverse, Urban Population using PHQ-9 and CAD-MDD. Annual University of Illinois Student Research Forum. Chicago, IL. 2018. [Poster presentation]
14. Dowty SM, Peñalver Bernabé B, **Pezley L**, Labomascus B, Tussing-Humphreys L, Gilbert R, Maki PM. Development of a Diverse Urban Population Registry to Understand Perinatal Neurological, Immunological, Endocrinological, Nutritional and Microbial Ecological Changes. Annual Maternal and Infant Microbiome Symposium. Chicago, IL. June 2018. [Poster presentation]
15. Tussing-Humphreys L, Koenig MD, Peñalver Bernabé B, Cralle L, McLeod A, DeMartelly V, LaBomascus B, Hemphill N, Welke L, Furlette-Koski M, Ruchob R, **Pezley L**. Iron Absorption and Gut Microbiota Composition in Pregnancy. Annual Maternal and Infant Microbiome Symposium. Chicago, IL. June 2018. [Poster presentation]
16. Peñalver Bernabé B, **Pezley L**, Dowty SM, Gibbons R, Maki PM. Rates of Perinatal Major Depressive Disorder using a Computerized Adaptive Test in a Diverse, Urban Population. International Marcé Society Conference on Perinatal Mental Health. Bangalore, India. September 2018. [Poster presentation]
17. Peñalver Bernabé B, Dowty SM, **Pezley L**, Shah Z, Hill E, Gottel N, Gibbons R, Tussing-Humphreys T, Maki PM, Gilbert J. Antenatal Depression is Associated with Altered Maternal Gut Microbiome and Immune System. Women and Their Microbes Conference. Hamilton, Ontario, Canada. March 2019. [Rapid-fire talk]
18. Peñalver Bernabé B, Dowty SM, **Pezley L**, Shah Z, Hill E, Gottel N, Gibbons R, Tussing-Humphreys T, Maki PM, Gilbert J. Antenatal Depression is Associated with Altered Maternal Gut Microbiome and Immune System. Society for Reproductive Investigation Conference. Paris, France. March 2019. [Poster presentation]

19. Shah Z, **Pezley L**, Dowty SM, Peñalver Bernabé B, Maki PM. Influence of Maternal Adiposity and Gestational Weight Gain on Perinatal Mental Health in an Urban Population. UIC Impact and Research Day. Chicago, IL. April 2019. [Poster presentation]
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