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The association between breastfeeding, the stress response, inflammation, and postpartum depression during the postpartum period: Prospective cohort study Authors

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Abstract

Background—Research suggests that exclusive breastfeeding may have a stress-protective role in postpartum depression, however, less is known about the underlying mechanisms by which this protection may occur or whether the protective relationship holds for women who mix breast and bottle feeding.

Objectives—To examine patterns of the stress response, inflammation, and depressive symptoms among women predominantly breastfeeding or bottle feeding their infants at 6 months postpartum.

Design—A part of a larger longitudinal study across 6 months postpartum investigating the psychoneuroimmunology (PNI) of postpartum depression.

Setting—Prenatal clinics and community.

Participants—One hundred nineteen postpartum women who met inclusion/exclusion criteria and followed up from the prenatal period to postpartum 6 months.

Methods—Data were collected during seven home visits occurring during the 3rd trimester (weeks 32–36) and on postpartum days 7 and 14, months 1, 2, 3, and 6. Women completed stress and depression surveys and provided blood for pro- (IL-1 β , IL-6, IL-8, TNF- α , IFN- γ) and anti-inflammatory (IL-10) cytokines, and collected saliva for diurnal cortisol.

Results—Self-report of predominant breastfeeding during 6 months postpartum ranged from 91.9% at day 7 to 70.6% at month 6 postpartum. There were no associations between the pattern

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Conflict of interest: None

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of feeding and depressive symptoms. Biological differences, however, existed between the groups, with levels of salivary cortisol at 8 AM and 8:30 AM at month 6 higher and levels of IL-6 at month 6 lower in women who primarily breastfed compared to those who primarily bottle fed their infants after controlling for confounding variables.

Conclusions—Breastfeeding was not related to postpartum depression however differences in stress and inflammatory markers are apparent at month 6 postpartum.

Keywords

breastfeeding; depression; inflammation; postpartum; psychoneuroimmunology; stress

1. Introduction

Symptoms of depression are prevalent during the perinatal period (Beck, 2008; Lee et al., 2007) and may have a significant impact on maternal and neonatal outcomes (Barker et al., 2011; Field et al., 2010). Elevated depressive symptoms are estimated to occur in up to 37.1% of women during pregnancy (Lee et al., 2007), while in the postpartum period, as reviewed by Beck (2008), estimates of prevalence vary widely from 11% in US population (Rychnovsky and Beck, 2006) to 42.6% in Taiwanese mothers (Chen et al., 2007) depending on data collection time points, the population, and the instruments used. Regardless of prevalence, postpartum depression (PPD) has adverse consequences for both mother and child that may last a lifetime. Untreated PPD poses a serious threat to the emotional well-being of the mother and her confidence and capacity to care for her infant (Lovejoy et al., 2000; Goodman, 2007) including her success in maternal role attainment (Cooke et al., 2007). In addition, children of depressed mothers are at risk for delays in growth and development and reduced cognitive, neuropsychological, social and emotional skills across childhood and into adolescence (Feldman and Eidelman, 2009; Murray et al., 2011; Verbeek et al., 2012). Given the profound disruptive influences of depression for both mother and child, the detection and early treatment of vulnerable women at risk for PPD is essential.

While psychosocial risks for depression have been recognized for some time (Beck, 2003; Beck, 2008), accumulating evidence also suggests biological risk factors. For example, research suggests that the volatility in reproductive and hypothalamic-pituitary-adrenal (HPA) axis hormones (Glynn et al., 2013; Yim et al., 2009) that occur toward the end of pregnancy and in the early postpartum period may contribute to the development of PPD as well, at least in some women (Bloch et al., 2000). More recently, researchers interested in psychoneuroimmunology (PNI) have linked physical and psychological stressors that both stimulate the HPA axis response (Mastorakos and Ilias, 2003; Lommatzch et al., 2006) and increase the production of pro-inflammatory cytokines (Raison et al., 2006) with an increased risk of depression in non-pregnant, non-postpartum populations (Schiepers et al., 2005; Wilson and Warise, 2008). Given that both stress and inflammation accompany labor and delivery and the important role of inflammation in postpartum healing (Dunn et al., In Press), researchers have also hypothesized that PPD may likewise have a PNI etiology (Corwin et al., 2008; Corwin and Pajer, 2008; Glynn et al., 2013; Groer and Morgan, 2007). The literature remains mixed, however, as to whether higher or lower levels of cortisol or pro-inflammatory markers (Osbourne and Monk, 2013) do indeed associate with depressive

symptoms in new mothers. For example, while studies suggest that postpartum depressed women demonstrate a down regulated HPA axis, with lower levels of salivary cortisol compared to non-depressed mothers (55% breastfeeding) during postpartum 4–6 weeks (Groer and Morgan, 2007), other reports identify higher levels of serum cortisol in the group of depressed mothers (Lommatzch et al., 2006). Depressed mothers also have been reported to have lower serum levels of the pro-inflammatory marker interferon-gamma (IFN- γ) and the ratio of pro-/anti-inflammatory levels (IFN- γ /IL-10), suggesting possible depressed cellular immunity (Groer and Morgan, 2007). Added to this, a very recent publication from our group provides evidence that neither inflammation nor cortisol alone explains PPD risk, but instead dysregulation in the bidirectional feedback circuit between the HPA axis and the production of pro-inflammatory cytokines after delivery underlies PPD symptom development (Corwin et al., 2015).

At the same time, given the impact of breastfeeding on both stress and immunity (Kendall-Tackett, 2007), current literature also suggests that breastfeeding may have an important role to play in the mental health of new mothers, also within the PNI framework. Lactation has been identified as a variable affecting the pattern of cortisol output, and suckling has been reported to provide a neural stimulus that dampens the HPA axis circadian rhythm and reduces the stress response (Groer and Davis, 2006; Slattery and Neumann, 2008; Tu et al., 2006; Hahn-Holbrook et al., 2013), although other studies are conflicting (Dennis and McQueen, 2007; Taylor et al., 2009). These differences are perhaps related to different definitions of what encompasses breastfeeding: i.e., exclusive breastfeeding, mixed feeding, or breastfeeding only at night.

The recent 2014 “Breastfeeding Report Card” from the Centers for Disease Control concludes that most women combine breast and bottle feeding (Center for Disease Control, 2014). Specifically, in the United States, the rate of breastfeeding at 6 months was reported as 60.6%, while the rate of exclusive breastfeeding through 6 months was reported as only 25.5%. Little is known as to whether the protective effects of breastfeeding on mood hold for women who both breast and bottle feed, and no information is available on PNI function in this group. Moreover, few prospective studies exist that evaluate the association between breastfeeding and level of depression over time or consider how it changes, and again, none in light of the corresponding changes in the stress or inflammatory response.

Thus, the following prospective, naturalistic study was conducted to test the hypothesis that women who predominantly breastfeed for 6 months postpartum will have decreased level of depressive symptoms, a lower stress response, and a lower level of pro-inflammatory cytokines compared to women who primarily bottle feed their infants at month 6 postpartum. This study allows for further examination of the relationship between non-exclusive breastfeeding and symptoms of depression within a PNI framework.

2. Methods

2.1. Study design and study participants

This study was a part of a larger prospective cohort study, investigating the psychoneuroimmunology (PNI) of postpartum depression (Corwin et al., 2015). As

described previously (Corwin, 2013; Corwin, 2015), recruitment of 2nd and early 3rd trimester pregnant women was accomplished via outreach at prenatal clinics and via advertisements placed on community billboards. Prenatal inclusion criteria were that all women were between 18–40 years of age, less than 36-weeks pregnant, non-smokers, and anticipating the vaginal birth of a singleton infant. Additionally, women were required to be free of any medically-required pregnancy restrictions, any known chronic illness, and, with the exception of prenatal vitamins, not taking any over-the-counter or prescribed medications or herbs including anti-inflammatory or anti-depressant agents. Postnatal criteria for continued inclusion were that women had delivered a live singleton infant vaginally without experiencing hemorrhage or blood transfusion, and that both mother and infant left the hospital together within 72-hours of delivery.

2.2. Data collection procedures

Details of the data collection procedures have been reported previously (Corwin et al, 2013; Corwin et al, 2015). Briefly, study participants meeting basic inclusion criteria were visited at home by a registered nurse a total of eight times. The first visit was conducted during 32–36th week of pregnancy with the goal of reviewing the protocol and gathering informed consent, after which demographic information including age, marital status, race/ethnicity, and history of depression was also collected. At the first visit, participants also were provided a saliva collection kit and trained on how to collect saliva samples using Salivette swabs (Sarstedt, Numbrecht, Germany). All participants practiced the technique with a sample swab under the observation of the research nurse. Each of the seven subsequent home visits were conducted for the purpose of sample collection and were held between 3:30 and 4:30 PM to control for diurnal variability in both cortisol and cytokines. The sample collection visits occurred: between 32–36 weeks of pregnancy and at 1 week, 2 weeks, 1-month, 2 months, 3 month, and 6 months postpartum; each lasted about 30 minutes. At each data collection visit, women first completed questionnaires on current health status, the presence of depressive symptoms via completion of the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987), and self-report of stress via completion of the Perceived Stress Scale (Cohen et al., 1983). Next, venous blood was drawn by the nurse into an EDTA-containing tube for later measurement of plasma pro-inflammatory cytokines interleukin-1 beta (IL-1 β), interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- α), interleukin-8 (IL-8) and interferon-alpha (IFN- γ) and the anti-inflammatory cytokine interleukin-10 (IL-10). Collectively, these cytokines allow for assessment of innate cellular immunity and acquired cellular immunity. Diurnal saliva samples also were collected. Prior to leaving, prenatal women were reminded that a member of the research team would call them 2-weeks prior to their scheduled delivery, and to call the researchers if they delivered before that date, while for postnatal women, the next visit was scheduled prior to departure. In addition, each postpartum woman was called the night before her diurnal saliva collection to remind her to collect her samples, and on the day of saliva collection, five minutes before each collection, again to remind her. Women were compensated for their time at the conclusion of each visit. All data collection visits were held plus-or-minus two weeks of the scheduled date, except the day 7 and day 14 visits which were held plus-or-minus two days of the scheduled date. If a woman reported she was unwell prior to the home visit, the visit was rescheduled. All study procedures described

above were approved by the institutional review boards at the Ohio State University (Columbus, OH) and the University of Colorado (Denver, CO).

2.3. Measures

1) Questionnaires

Demographic Data: At the first visit, participants completed a demographic questionnaire regarding age, marital status, height, pre-pregnancy weight, race/ethnicity, and whether or not they currently were receiving government financial assistance.

The Health Survey Questionnaire: At the start of each home visit, women first provided information on their and their infant's current health, including any symptoms of infection or visits to a health provider, and whether they were using any prescription or over the counter medications. They also were asked whether they had experienced any major life change since the last postpartum visit and if so, of what sort. Lastly, they were asked to identify their current pattern of feeding their infant by marking on the form provided whether they were breastfeeding or bottle feeding most of time.

Sleep: Women were asked to track their sleep for the 2-nights prior to the scheduled home visit, by recording in a provided diary how many hours of sleep they received each night, and, as indicated by a scale from 1–3, whether they felt rested each day. These data were averaged over the two days.

Depressive Symptoms: The 10-item EPDS was used for self-report of symptoms of depression within the past week. It is an easy to administer and effective screening tool that has been validated for both antepartum and postpartum use worldwide. Answers to questions such as “I have looked forward with enjoyment to things” are scored from 0 (“As much as I ever did”) to 4 (“Hardly at all”). After completion, a woman's score is summed to provide information on the likelihood of clinical depression. Validation of the EPDS against a diagnostic clinical interview identified a specificity of 78%, a sensitivity of 86%, and a positive predictive value of 73% for women scoring >10 (Cox et al., 1987).

Perceived Stress: The 14-item Perceived Stress Scale (PSS) was used for measuring maternal stress. The PSS is well validated, including during pregnancy and the postpartum period (Ruiz et al., 2003). Responses are based on a Likert-scale from 0 (never) to 4 (very often). Each question asks the individual how she has been feeling during the past month. Reliability and validity was established (Cohen et al., 1983).

2) Biomarker measures

Cortisol: On the day preceding the home visit, each woman collected salivary samples upon awakening, 30-min later, and at 11:00 AM, 4:00 PM, and 8:00 PM and stored at the saliva collection kit. Salivary samples were centrifuged at 4°C for 3 min at 3000 rpm and aliquoted into 1.5 cc polypropylene micro tubes for storage at the study lab at –70°C until assayed. Salivary cortisol levels were determined using an expanded range high sensitivity EIA kit (No. 1-3002/1-3012, Salimetrics, State College, PA). The cortisol detection limit of the kit is .018 mg/dl and shows minimal cross reactivity (4% or less) with other steroids. Intra-

assay coefficient of variation was 4.3% and inter-assay coefficient of variation was 5.2%. All samples were measured in duplicate. The area under the curve (AUC), a measure of the total amount of cortisol secreted over a given period of time, also was calculated with respect to ground. The cortisol awakening response was determined based on the difference in salivary cortisol concentration between that measured at awakening to that measured 30-min post-awakening.

Pro- to anti-inflammatory cytokines: Venous blood was drawn from the ante-cubital vein into EDTA-containing tubes for measurement of plasma pro-inflammatory cytokines IL-6, IL-8, IL-1 β , TNF- α , and IFN- γ , and anti-inflammatory cytokine IL-10. Blood samples were centrifuged at 4°C for 8 minutes at 2000 rpm. Plasma aliquots were placed into 1.5 cc polypropylene micro tubes and stored separately in the study lab, at -70°C, until assayed using a Human Pro-inflammatory Ultra-Sensitive assay and quantitative multiplex array technology (Meso Scale Discovery, Gaithersburg, Maryland). Intra-assay coefficient of variation was <5% and inter-assay coefficient of variation was <10%. The level of each cytokine is reported.

2.4. Data analysis

Descriptive statistics (mean, standard deviation and percentages) were computed for demographic variables, pattern of feeding, depressive symptoms, stress response (perceived stress and Salivary cortisol), and inflammatory cytokines (IL-1 β , IL-6, IL-8, IL-10, TNF- α , and IFN- γ). To test for differences of pattern of feeding on demographic variables, continuous variables were compared by pattern of feeding using independent sample Student t-tests. To evaluate associations among the pattern of feeding, demographic variables, stress, and inflammatory cytokines, correlation analysis were used. A series of hierarchical multiple regression were applied to test if the pattern of feeding could explain the level of depressive symptoms, salivary cortisol levels, and/or inflammatory cytokine concentrations after controlling for confounding variables.

Because the cortisol and cytokine data were skewed, natural log transformations were performed prior to the analysis and results were reported based on back transformation of the log values to the original scale. Statistical analysis was performed using IBM SPSS Statistics 21. All statistical tests were two-sided and a p value of <0.05 was considered statistically significant.

3. Results

3.1. Demographic and clinical characteristics

A total sample of 201 women were enrolled prenatally, of whom 119 participated in final data collection through 6 months postpartum (Fig 1). Of this group, the majority were Caucasian (68–82%), married (62–96%), had other children (48–51%), and were generally healthy (77–85%), while a minority (21–22%) had a history of depression. The participant flow chart is shown in Figure 1.

Of the entire sample, 91.9 % of women reported breastfeeding most of time at day 7 postpartum. By day 14, the report of breastfeeding most of the time had gradually decreased

to 90.4%, followed by 89.7%, 83.1%, 79.8%, and 70.6% for month 1, 2, 3, and 6 respectively. As shown in Table 1, mothers who reported that they were predominantly breastfeeding were significantly older, married, of higher income, taking more over the counter medications (mostly vitamins and Omega-3 fatty acids), experiencing fewer major changes in life, and slept less than those who reported they were predominantly bottle feeding ($p<.05$). All subsequent analyses controlled for those variables as appropriate.

3.2. Depressive symptoms, stress response, and inflammatory cytokines between women predominantly breastfeeding or bottle-feeding over 6 months postpartum

Symptoms of depression were evaluated both as a continuous variable with a summated score of EPDS responses and as a dichotomous variable with a depressive subtype identified for those who scored > 10 on the EPDS at any time, and a non-depressive subtype identified for those who scored <10 on the EPDS at any time. As shown in Table 2, the mean scores of depressive symptoms across 6 months postpartum was less than 4.0 for women who predominantly were breastfeeding and 4.2 for those predominantly bottle feeding, indicating participants were emotionally stable over time. There were no group differences in depressive symptoms at any of the time points over 6 months postpartum.

Self-report level of perceived stress ranged across 6 months from 17.17 to 18.78 for women primarily breastfeeding and from 18.63 to 20.42 for women predominantly bottle feeding, with the highest scores of PSS at month 6. Although mothers who primarily breastfed through 6 months showed a tendency toward a lower level of perceived stress than those primarily bottle feeding over that time, no group differences were found. Mean level of salivary cortisol at month 6 was 0.36 ug/dl at 8 AM and increased to 0.41 ug/dl at 8:30 AM in women predominantly breastfeeding, and 0.27 to 0.30 ug/dl respectively in women predominantly bottle feeding. Women who predominantly breastfed their infants had marginally higher levels of salivary cortisol at 8 AM ($p=.05$) and 8:30 AM ($p=.02$) compared to those who bottle fed through 6 months. These effects remained significant after controlling for individual differences related to feeding pattern ($p=.01$, $p=.015$, respectively).

Among inflammatory cytokine variables, mean IL-6 level at month 6 was 0.76 pg/mL for women predominantly breastfeeding and 0.95 pg/mL for women predominantly bottle feeding. Women predominantly breastfeeding had lower levels of IL-6 than those who bottle fed at month 6 ($p=.04$). This effect remained significant ($p=.007$) after controlling for confounding variables. However, there were no differences in other cytokines or in any pro- to anti-inflammatory cytokine ratio by pattern of feeding at month 6.

3.3. Relationship among pattern of feeding, maternal characteristics, depressive symptoms, stress and inflammatory cytokines

As shown in Table 3, older maternal age, higher income, experiencing no major changes in life, and less sleeping hours were significantly and positively related to continuing to primarily breastfeeding for 6 months postpartum ($p<.05$). Neither severity of depressive symptoms nor perceived stress were related to primarily breastfeeding. However, higher

level of salivary cortisol at 8 AM and 8:30 AM, and lower level of IL-6 at month 6 postpartum were significantly correlated with breastfeeding ($p < .05$).

Among PNI variables, depressive symptoms were positively related to perceived stress ($p < .001$) and salivary cortisol level at 4pm ($p < .05$). There were no relationships between IL-6 and depressive symptoms or stress variables. No relationships among these PNI variables were found when separate correlation analyses were run based on the variable of primarily breastfeeding versus bottle feeding.

4. Discussion

This study is the first to our knowledge to test the impact of predominantly breastfeeding on postpartum depression, stress, and inflammation using a longitudinal study design across 6 months postpartum. Overall, we did not find a benefit of predominantly breastfeeding on depressive symptom or perceived stress compared to predominantly bottle feeding, however, our data do identify PNI effects of breastfeeding versus bottle feeding, including decreased level of the pro-inflammatory marker IL-6 and increased levels of salivary cortisol at 8 AM and 8:30 AM in women predominantly breastfeeding that potentially could have implications for health.

Overall, the level of depressive symptoms gradually decreased over time and was very low at month 6 postpartum in both groups, indicating emotional stability. In this study, we found that the levels of depressive symptoms at month 1, 2, 3, and 6 postpartum were not different between women predominantly breastfeeding compared to women predominantly bottle feeding for 6 months. As such, these data do not support the hypothesis that any level of lactation reduces maternal depressive symptoms. Previous literature presents a mixed picture concerning the relationship between PPD and level of breastfeeding. Some studies suggest that exclusive breastfeeding for three or more months has a beneficial effect on reducing the level of depressive symptoms (Figueiredo et al., 2013), while other studies do not support the relationship of exclusive breastfeeding with lowering symptoms PPD at 4–6 weeks (Groer and Davis, 2006), or at month 4 (McCarter-Spaulding, & Horowitz, 2007). In one study, women who mixed breastfeeding and bottle feeding at month 6 were more at-risk for depression than those who predominantly breastfeed, with the greater percentage of bottle feeding, the greater the risk of depression (Ystrom, 2012).

Lactation is a potential variable affecting the pattern of cortisol output. Although recent a review suggests that suckling provides a neural stimulus that dampens the HPA axis circadian rhythm and reduces the stress responses (Fodor and Zelena, 2014), this finding was not supported in our study. Rather, in our study, levels of salivary cortisol in both groups showed a diurnal pattern of cortisol and a significant increase in cortisol from waking to +30 min at month 6 postpartum. Taylor et al (2009) reported postpartum mothers had diurnal pattern of cortisol at 7.5 weeks of postpartum; both this study and ours indicates that the HPA axis is well functioning at 6 months postpartum. In fact, although data were not shown, our study showed diurnal rhythm returned on average by postpartum day 7 although there was clear variation between women.

In the current study, women who were primarily breastfeeding had higher mean cortisol levels at 8 AM and 8:30 AM at month 6 than the women who were primarily bottle feeding. One potentially contributing factor to this finding may be a moderating effect of sleep hours on type of feeding. Fatigue and disturbed sleep from breastfeeding at night or early morning may act as a stressor and alter the stress response. In addition, women primarily breastfeeding may wake up more than once during night for infant feeding, altering the diurnal pattern of cortisol and cortisol awakening response. Likewise, if they wake up early in the morning and start their activities, their diurnal rhythm of cortisol secretion may have started to rise at that time, resulting in higher levels of cortisol at 8 AM and 8:30 AM compared to women predominantly bottle feeding. It would be of interest to obtain objective sleep data together with cortisol awakening response data with comparable samples in future research. Since any protective effect of breastfeeding on stress may be dependent on frequency, duration, and intensity of breastfeeding, a detailed measure is needed to confirm this result regarding pattern of breastfeeding such as percentage of breastfeeding for daily feeding, feeding frequency and time at night.

Limitations of this study included self-report of measures of breastfeeding status, sleep and mood. Although participants were called prior to each saliva collection and measures were used to validate accurate collection of saliva, we could not verify that all women collected their saliva samples on time. In addition, although previous studies have identified a relationship between maternal identify, breastfeeding, and stress/depression (Cooke et al, 2007; Sheehan et al, 2010), we did not include the variable of identify in this study, which if included could have provided additional insight into our findings.

Although postpartum mothers may experience considerable home demands and more sleep deprivation, predominantly breastfeeding mothers reported similar level of perceived stress to those predominantly bottle feeding, consistent with the study reporting no relationship of feeding pattern with perceived stress (Groer and Davis, 2006). The reason for no group difference may be that predominantly breastfeeding provides a benefit for women in reducing stress, in spite of fewer hours of sleep. This is supported by Field et al. (2010b) who found that women who breastfed reported feeling more relaxed compared to women who bottle fed their infants, suggesting that breastfeeding may even serve as a coping mechanism among low-income mothers (Dozier et al., 2012).

We found that women primarily breastfeeding had a lower level of IL-6 at month 6 compared to IL-6 levels in women primarily bottle feeding before and after controlling for sleep hours. This suggests that predominant breastfeeding may have PNI benefits to mothers. These results are similar to those reported previously, where lower IFN- γ and IFN- γ /IL10 ratios were reported in women who breastfed their infants at 4–6 weeks postpartum (Groer and Davis, 2006). While protective active immunity during the postpartum is very important because mothers are the first care-taker for their newborn, chronic maternal inflammation on the other hand is not beneficial for women's long-term health.

Findings from this study do not identify clear benefits of predominant breastfeeding in terms of stress and depression other than potentially decreasing maternal inflammatory response long-term. Although multiple studies identify positive benefits of breastfeeding, physiologic

changes during the postpartum period could make PNI interactions more complex. Future studies also should include more detailed information about feeding pattern. Breastfeeding pattern in this study was measured in two categories: primarily breastfeeding or bottle feeding. However, this dichotomous variable could not indicate continuum from almost exclusive breastfeeding with minimal bottles to primarily bottle feeding with occasional breastfeeding. Further research is necessary to considering potentially confounding variables such as percentage of breastfeeding, frequency and duration of night time feeding, sleep data, and time to wake up that may moderate or mediate relationships among variables.

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What is already known about the topic?

- Research suggests that exclusive breastfeeding may have a stress-protective role in postpartum depression.
- There is no research available to date that uses a PNI perspective to explore the effect of predominantly breastfeeding on postpartum depression, stress, and inflammatory response in women at 6 months postpartum.

What this paper adds

- Predominantly breastfeeding does not impact depressive symptoms or perceived stress compared to predominantly bottle feeding.
- Our data do identify psychoneuroimmune effects of predominantly breastfeeding versus bottle feeding, including decreased level of the pro-inflammatory marker IL-6 and increased levels of salivary cortisol at 8 AM and 8:30 AM that may have implications for health.

The Consort Flowchart

Figure 1.
The consort flowchart.

Table 1

Demographic and clinical characteristics between mothers predominantly breastfeeding (N=84) versus mothers predominantly bottle-feeding (N=35) over 6 months postpartum

Variables	Predominantly breastfeeding (n=84)	Predominantly bottle-feeding (n=35)	t/ χ^2	p
Age, mean (SD)	30.5(4.5)	26.8 (5.6)	3.50	.001
Caucasian, n (%)	69(82.1)	24(68.5)	2.66	.103
Married, n (%)	81(96.4)	22(62.8)	24.31	<.001
Other children at home, n (%)	29(34.5)	13(37.1)	0.09	.756
Participating in WIC, n (%)	8(9.5)	18(51.4)	25.02	<.001
History of depression, n (%)	18(21.4)	8(22.8)	0.03	.864
Perceived mom and baby being healthy, n (%)	72(85.7)	27(77.1)	1.29	.255
Taking OTC medication (Vitamin, Omega 3, etc.), n (%)	65(77.3)	13(37.1)	19.36	<.001
Major changes in your life, n (%)	8(9.5)	10(28.6)	6.98	.008
loss of job for self/partner	7(8.3)	6(17.1)		
family problems	1(1.2)	3(8.6)		
financial problems	0(0.0)	1(2.9)		
Sleeping hours, mean (SD)	6.94(1.11)	7.59(1.54)	-2.45	.016

* WIC: Woman, Infant and Children; OTC: over the counter

Table 2

Depressive symptoms, perceived stress, salivary cortisol and inflammatory cytokines between women breastfeeding compared to bottle-feeding most of the time over 6 months postpartum ^a

Time point	Predominantly breastfeeding (n=84) M(SE)	Predominantly bottle feeding (n=35) M(SE)	p-value ^c
Depressive Symptoms			
Day7	3.89(0.41)	3.97(0.57)	.91
Day14	3.46(0.36)	3.24(0.51)	.73
Month1	3.44(0.33)	4.16(0.84)	.33
Month2	3.30(0.33)	3.00(0.55)	.63
Month3	3.32(0.34)	3.46(0.62)	.84
Month6	3.35(0.34)	3.39(0.60)	.94
Perceived Stress			
Day7	18.04(5.41)	19.94(6.72)	.12
Day14	17.17(6.21)	18.63(7.45)	.29
Month1	17.78(6.15)	20.13(9.18)	.20
Month2	18.41(7.27)	19.34(8.28)	.55
Month3	18.22(7.11)	19.88(8.47)	.28
Month 6	18.78(6.96)	20.42(8.72)	.30
Salivary Cortisol at Month 6 (ug/dL) ^b			
8 AM	0.36(0.02)	0.27(0.03)	.05 (.010)
8:30 AM	0.41(0.04)	0.30(0.17)	.02 (.015)
Awakening response	0.30(0.08)	0.73(0.45)	.36
11 AM	0.13(0.01)	0.17(0.03)	.61
4 PM	0.09(0.01)	0.09(0.01)	.97
8 PM	0.08(0.03)	0.07(0.01)	.84
Area Under the Curve (AUC)	1.66(0.12)	1.70(0.22)	.88
Cytokine at Month 6 (pg/ml) ^b			
IL-6	0.76(0.04)	0.95(0.09)	.04 (.007)
IL-1 β	0.38(0.03)	0.51(0.11)	.28
IL-8	1.71(0.05)	1.70(0.05)	.95
IFN- γ	0.94(0.04)	1.07(0.05)	.34
TNF- α	1.87(0.06)	1.99(0.11)	.34
IL-10	11.30(5.13)	9.04(2.94)	.40

^a Data are presented as mean and the standard error.

^b T-statistics were done with transformed data with natural log of original values to make normal distribution.

^c P values were from t-test, and corrected p-values were presented in parenthesis after controlling for confounding variables.

M(SE): Mean (Standard Error)

Table 3

Correlational relationships among breastfeeding, depressive symptoms, stress, and inflammatory cytokines at month 6 postpartum (N=119)

Variables	Primarily Breast feeding	EPDS score	Perceived stress score	Salivary cortisol at 8AM	Salivary cortisol at 830AM	IL-6
Demographic						
Age	.33**	.02	.09	.15	.19*	-.25**
Low income (1=yes)	-.46***	-.009	.01	-.14	-.12	.30***
Other child at home (1=yes)	.03	.04	.06	.06	.04	.04
Not married (1=yes)	.03	-.01	-.05	.09	.007	.01
History of depression (1=yes)	-.01	.13	.24	-.07	-.05	.01
Major life changes (1=yes)	-.24**	.24**	.16	-.10	.02	.12
Sleeping hours	-.22*	-.33***	-.21	-.06	-.17	-.12
Depression						
EPDS score	-.006	1	.72***	.04	.11	.04
Stress						
Perceived stress	-.09	.72***	1	.005	.05	.11
Salivary cortisol	-.14	.02	.05	-.71***	.03	.02
Awakening response						
Area under the Curve	-.01	.009	.14	.32**	.40**	-.11
Cortisol at 8 AM	.27**	.04	.005	1	.57***	.01
Cortisol at 8:30 AM	.22*	.11	.05	.57***	1	.06
Cortisol at 11 AM	-.06	.08	.14	.10	.10	-.08
Cortisol at 4 PM	-.003	.25*	.27**	.10	.19	-.01
Cortisol at 8 PM	-.02	.12	.16	.07	.22*	-.09
Inflammatory markers						
IL-6	-.19*	.04	.11	.01	.06	1

* p<.05,

** p<.01,

100>d

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