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The Postpartum Maternal and Newborn Microbiomes

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Abstract

Biological and environmental changes to maternal and newborn microbiomes in the postnatal period can affect health outcomes for the mother-baby dyad. Postpartum sleep deprivation and unmet dietary needs can alter commensal bacteria within the body and disrupt gut-brain communication. Perineal injury and breast infections also change microbial community composition, potentiating an environment favoring pathogen growth. The gut microbiome refers to the collection of microorganisms working in a harmony. Disruptions within the gut microbiome and gut-brain communication may lead to postpartum depression, a potentially devastating sequela. Postnatal newborn changes to the gut and skin microbiome materialize quickly after delivery and are profoundly influenced by delivery mode, feeding method, and bathing and skin care practices. During the newborn period, infant microbiomes are highly vulnerable and susceptible to multiple influences. Maternal-newborn nurses have a valuable role in helping mothers and newborns promote healthy microbiomes. This paper will review factors that influence the rapidly changing postnatal microbiome of the mother and her newborn and identify the role nurses have to positively influence immediate and long-term health outcomes.

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Keywords

1. Postpartum Period; 2. Maternal-Child Nursing; 3. Infant Health; 4. Microbiota

The human microbiome comprises the collective genome of all microorganisms living in and on the body. These organisms play an integral role in maintaining or disrupting homeostasis. As the tools to study the microbiome advance, the role of the microbiome in maternal and neonatal health has become a focus of biomedical research. Maternal and neonatal microbiomes in the postpartum period are dynamic and influenced by environmental and biological factors. Although research in the field of -omics science is revealing the influence microbial communities have on our health, few have focused on postpartum maternal microbiome changes occurring after birth. This paper reviews biological and environmental factors influencing postnatal microbiomes and includes important nursing considerations to promote health. Specific maternal areas of focus include considerations for after delivery including diet, sleep, depression, breast infection, and perineal injury. Specific newborn areas of focus include infant feeding and skincare.

Maternal Microbiome

Maternal Recommendations after Delivery

Little focus has been placed on examination of microbiome niches in the postpartum period, but evidence from pregnancy and general populations suggests the microbiome likely plays a role in maternal and infant health (Dunlop et al., 2015) and recovery following childbirth. In the postpartum period, the vaginal microbiome dramatically changes composition with an increase in alpha diversity characterized by a decrease in *Lactobacillus* species. Furthermore, women who develop gestational diabetes also experience a gut microbiome characterized by low microbial richness (Koren et al., 2012). When followed into postpartum, women who previously experienced gestational diabetes had a significantly different composition of postpartum microbial taxa compared those with normoglycemic pregnancies, although differences in diversity indices were not found (Fugmann et al., 2015). These findings suggest perturbations in microbiota that may precede or develop during pregnancy may have lasting postpartum effects. Future research is needed to characterize the microbiome from pregnancy through postpartum and how these changes are linked to maternal health and recovery.

To support women in the postpartum time period, recommending healthy dietary patterns that support maternal recovery and lactation and minimize weight retention are required. Although long-term dietary intake has the most established influence on the gut microbiome (Xu & Knight, 2015), no current microbiome-specific dietary recommendations exist. For lactating women, total energy intake should be at least 1800 kilocalories per day to support a sufficient milk supply and depends on the mother's activity level and whether the infant is exclusively breastfed or not (Jordan, Engstrom, Marfell, & Farley, 2014; Institute of Medicine [IOM], 2001). Nearly all maternal macro- and micronutrient needs are increased during lactation, most notably protein, carbohydrate, vitamin A, C, and E (IOM, 2001). Studies examining dietary intake, the gut microbiome, and health outcomes have established

associations linking dietary habits to microbiome patterns and disease states, but mechanistic pathways are not yet understood (Meyer & Bennett, 2016).

Maternal Sleep Disturbance in the Postpartum Period

A primary concern for women in the postpartum period is the sleep disturbance and deprivation that accompanies newborn care (Kennedy, Gardiner, Gay, & Lee, 2007). Sleep effectiveness is critical for healthy functioning of immune and nervous systems, and healing (National Institute of Neurological Disorders and Stroke, 2014) required in the puerperium. Sleep disturbance is associated with fatigue and depression (Park, Meltzer-Brody, & Stickgold, 2013), and chronic sleep disturbance is associated with altered hormone secretion, altered metabolism, and linked to cardiometabolic disorders like obesity and diabetes (Voigt et al., 2014). Although no studies directly address the relationship between sleep disturbance and postpartum recovery, recently uncovered associations between sleep, circadian rhythm, chronic fatigue syndrome, and the microbiome may provide some insight. Giloteaux et al. (2016) found chronic fatigue syndrome patients to have a less diverse gut microbiome. This dysbiosis augments gut permeability, facilitating the leakage of microorganisms through the gut membrane and dysregulating the immune system (Giloteaux et al., 2016) resulting in a chronic pro-inflammatory state.

It is important to note the aforementioned are only potential implications of postpartum sleep disturbance on the maternal gut microbiome. More research is needed. However, these potential microbiome implications do provide another reason for nurses to promote sleep effectiveness, alleviate fatigue, and promote overall postpartum recovery. Well known strategies nurses can implement include napping when the baby naps, eliciting assistance for nighttime newborn care, encourage efficient sleep positions for breastfeeding mothers, alleviate pain, and advise sleep hygiene measures.

Postpartum Depression and the Microbiome

Depression is a debilitating and life threatening postpartum complication affecting approximately 13% of women (Gaillard, Le Strat, Mandelbrot, Keita, & Dubertret, 2014). Inflammation, hormonal, and neuroendocrine processes have all found a place in the physiologic picture of postpartum depression (PPD). Limited data examines potential associations between the gut microbiome and PPD specifically. However, a growing body of literature considers how gut microbiota may influence other depressive disorders (Dash, Clarke, Berk, & Jacka, 2015). In animal models, manipulation of the gut microbiome has been associated with depressive-like behaviors (Foster & McVey Neufeld, 2013). Human studies have found individuals with major depressive disorder had significantly lower counts of *Bifidobacterium* and *Lactobacillus* and variations in bacterial diversity (Aizawa et al., 2016; Jiang et al., 2015). Further studies are needed to characterize the specific nature of the gut-brain axis in PPD and determine if the gut microbiome can be used to improve or prevent depressive symptoms in the future.

Psychosocial variables such as partner conflict, lack of social support, and stressful life events may contribute to development or worsening of PPD (Dennis & Dowswell, 2013). Bedside nurses can play an integral part in PPD prevention and early detection. By using

validated screening tools such as the Postpartum Depression Screening Scale (PDSS) nurses can screen at risk populations for early intervention (Beck & Gable, 2002). They can also educate patients on depressive signs and symptoms and encourage prompt follow-up with their providers.

Breast Infection and the Microbiome

Mastitis is generally defined as an inflammation of the breast that can result from a myriad of etiologies and is most common in the postpartum period (Contreras & Rodriguez, 2011). Mastitis occurs in 3–33% of breastfeeding women, primarily during early stages of lactation (Arroyo et al., 2010). Bacterial mastitis is thought to result from an overgrowth of pathogenic strains of *Staphylococcus* spp., group B *Streptococci*, and other bacteria in the mammary gland (Maldonado-Lobon et al., 2015). As the pathogenic microbiota overwhelm normal, healthy bacteria or commensals, a sequence of immunologic and biochemical distortions take place that subsequently result in clinical symptoms of mastitis (Contreras & Rodriguez, 2011).

Mastitis is a common deterrence from breastfeeding due to pain, fever, and general malaise. Additionally, mothers are often apprehensive to continue breastfeeding during treatment due to a misconception that infection may be transmitted to the infant (Betzold, 2007). Thus, this condition is responsible for countless cases of undesired weaning that deprives infants of the benefits of breastfeeding (Latuga, Stuebe, & Seed, 2014).

Antibiotics are the typical first line treatment for bacterial mastitis; however, due to concerns over multi-drug resistant bacteria and frequent recurrent cases, alternative therapies are being researched (Urbaniak, Burton, & Reid, 2012). Probiotics have been a recent area of interest as both an adjunct and primary therapy for bacterial mastitis treatment (Amir, Griffin, Cullinane, & Garland, 2016; Arroyo et al., 2010). If antibiotic therapy simultaneously eliminates both pathogenic and commensal bacteria, probiotic treatment can potentially restore the balance of commensal bacteria normally found in breast milk ((Jeurink et al., 2013; Maldonado-Lobon et al., 2015; Soto et al., 2014). When used as a preventative measure, probiotics can help prevent overgrowth of virulent microbial species that contribute to mastitis (Klaenhammer, Kleerebezem, Kopp, & Rescigno, 2012). While present research shows promising results, recommendations for probiotic therapy as an evidence-based guideline are in development (Amir et al., 2016).

Postpartum nurses should concentrate efforts on the prevention of mastitis. A primary strategy to optimize breastfeeding is through instruction of proper infant latch techniques to avoid nipple trauma. Feedings should largely be on demand. Education on infant feeding cues and promoting skin-to-skin contact will help the mother feel confident that feeding is adequate. To avoid clogged mammary ducts, warm compresses and gentle massage of the breasts can be suggested to encourage let down. Nurses should also evaluate newborns for oral anomalies such as tongue-tie that would cause ineffective feeding and subsequent engorgement. Utilizing strategies to reduce the risk of infection will ultimately reduce the risk of bacterial mastitis in lactating women (Cusack & Brennan, 2011).

Perineal Injury and the Microbiome

Injury to the perineum, common after vaginal delivery, varies by degree and is caused by spontaneous laceration and/or episiotomy. The perineal region is populated by commensal skin and vaginal bacteria primarily belonging to four phyla: *Actinobacteria*, *Firmicutes*, *Proteobacteria* and *Bacteroidetes* (Zeeuwen et al., 2012). These play an essential role in protecting the area from colonization of pathogenic organisms (Zeeuwen et al., 2012). Perineal trauma, however, breaches the integrity of the cutaneous tissue, and disturbs homeostasis of commensals (Zeeuwen et al., 2012) by the inflammatory process (Steen, 2007). A pro-inflammatory environment is hostile to commensal microbes and provides an opportunity for nearby pathogens to colonize, create infection, and delay healing.

Stabilization of the perineal microbiome, therefore, is essential and can be facilitated by: promoting wound healing to speed the end of the inflammatory process; keeping potential pathogens away; and minimizing irritation to prevent additional pro-inflammatory responses. Promoting wound healing involves overall immunity boosting strategies like good nutrition, stress and anxiety management, and minimal exposure to tobacco smoke (Steen, 2007). Pain control mitigates the stress response and facilitates the immune response. Oral analgesia is useful, and there is some limited evidence for the analgesic effect of cooling treatments (East, Begg, Henshall, Marchant, & Wallace, 2012). To ward off potential pathogens postpartum, women should cleanse their perineal and perianal area daily with soap and water.

Newborn Microbiome

Supporting Newborn Microbiome After Delivery

Upon vaginal birth, the fetus is exposed to a copious amount of maternal bacteria in the vagina and perianal area (Rutayisire, Huang, Liu, & Tao, 2016). Infants born by cesarean section, regardless of exposure to prophylactic antibiotics, harbor a less diverse microbiome resembling their mother's skin, mouth, and bacteria from surrounding surfaces (Rutayisire et al., 2016). Infants delivered by cesarean tend to harbor a greater portion of antibiotic resistant genes compared to those delivered vaginally (Forslund, Sunagawa, Coelho, & Bork, 2014) which increases the likelihood of resistance to later antibiotic therapy and treatment for infection. Delivery mode implications further underscore the need to support the developing infant microbiome during the postpartum period. Postpartum nurses can positively impact the integrity of newborn microbiota by supporting breastfeeding and safe skin care practices during patient education.

Infant Feeding and Microbiome

Vaginal birth facilitates immediate breastfeeding and limits the separation of the dyad inherent in cesarean deliveries. Initiation of breastfeeding within the first hour stimulates the rapid onset of lactogenesis II and increases milk supply 130% within three weeks (O'Sullivan, Farver, & Smilowitz, 2015). Over 85% of postpartum women intend to exclusively breastfeed yet only 32% meet their goal (Perrine, Scanlon, Li, Odom, & Grummer-Strawn, 2012). Hospital protocols supporting breastfeeding should be universally practiced.

Infant feeding patterns drive the maturation of the neonatal gut microbiome during the first year (Backhed et al., 2015). The gut microbial community of formula fed babies contains large amounts of *Clostridia* spp. mimicking typical adult patterns (Backhed et al., 2015). Conversely, exclusively breastfed babies, have gut microbiomes dominated by *Bifidobacterium* and *Lactobacillus* (Backhed et al., 2015). Mixed breast and formula feeding results in a microbiome that resembles exclusive formula feeders (O'Sullivan et al., 2015).

The mutual interaction of the developing infant gut with the changing microbiome plays a role in establishing long term metabolic and immune responses. Breastfeeding is the sole source of a range of biologically active elements, which promote development of the gut, systemic metabolism, and the immune system (O'Sullivan et al., 2015). Human milk oligosaccharides, natural prebiotics, are abundant in breast milk and selectively support the growth and function of protective bacterial strains while inhibiting the proliferation of undesirable strains (O'Sullivan et al., 2015). Further, given the bidirectional communication of the brain-gut axis, optimizing gut microbiome composition ensures proper metabolism and availability of vitamins and amino acids essential for neurologic development (Backhed et al., 2015). The crucial, rapid development of the brain-gut axis has the potential to affect infant cognition, mood, and social behavior, with lifelong implications (Yang et al., 2016).

Newborn Bathing, Skin Care, and the Microbiome

Newborn skin is ordinarily of good integrity. However, the newborn skin is vulnerable to environmental exposures that trigger irritation, immune reactions, and skin barrier breakdown. Adjustment to extrauterine life requires various physiologic changes including: transepidermal water loss, skin pH changes, and stratum corneum hydration and growth (Garcia Bartels et al., 2010). Early, diverse microbial skin colonization is important to strengthen the skin acid mantle barrier, develop the infant's immune system (Hartz, Bradshaw, & Brandon, 2015), and promote long term infant health.

Literature describing the association between skin integrity and the skin microbiome has led researchers and practitioners to question current newborn bathing and skin care practices (Coughlin & Taieb, 2014). Lavender et al. (2013), found no differences in skin barrier function tests for newborns that received baths with liquid baby soap versus water only. Daily bathing and the initial removal of vernix caseosa are not necessary. Vernix caseosa, composed of water, proteins, barrier lipids, and antimicrobial agents, contributes to skin hydration, lower pH, and protection against pathogens, suggesting that vernix removal in nonfolded locations immediately post birth can be unfavorable (Coughlin & Taieb, 2014).

Parent education can address common newborn concerns like diaper rash and skin breakdown. Skin emollients consisting of preservative-free 20% zinc oxide can help to protect and enhance the skin barrier by sealing in hydration while maintaining protective microbes (Coughlin, Frieden, & Eichenfield, 2014). Caregivers should be encouraged to frequently change soiled diapers (every 1–3 hours) to evade ammonia buildup and/or harmful fecal bacteria on skin. Clear and descriptive education regarding diaper wipes should include avoidance of those with harsh preservative chemicals such as methylisothiazolinone, that may strip protective skin microbes, disrupt normal skin pH, and further induce irritation, skin breakdown, or chemical burns (Coughlin et al., 2014). Finally,

nurses should support caregivers to read the ingredients of products they use and make informed choices about practices that may affect their infants' skin integrity, microbiome, and ultimately, their health.

Conclusion

Emerging research suggests interwoven relationships between diet and other maternal health factors, including circadian rhythms, mental health, and infections, synergistically influence the maternal microbiome, illuminating the importance of a comprehensive and informed approach to caring for postpartum mothers and newborns. Targeted instruction on infant feeding, bathing, and skin care practices facilitate neonatal eubiosis. Understanding the role that the microbiome has in many aspects of postpartum recovery and newborn well being profoundly increases nursing knowledge, and allows maternal child nurses to take advantage of the unique opportunity they have to positively shape maternal and newborn microbiomes. Much of the literature presented does not *directly* relate to the postpartum period however, connections can still be drawn. Specific microbiome research during the postpartum timeframe is needed to better understand the rapid physiological changes. In light of the research around the implications of the maternal and newborn microbiome, the considerations provided here reinforce existing nursing interventions and can contribute to enhanced postpartum recovery and newborn health.

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Callouts

1. Few studies have focused on postpartum maternal or newborn microbiome changes that occur after one of the most potentially stressful times; birth.
2. Prolonged sleep disruption affects circadian rhythms leading to an irregular pattern of food intake, a dysbiotic gut microbiome, and cardiometabolic disorders.
3. Bedside nurses can support a diverse microbiome through PPD prevention and early detection of PPD in the perinatal period.
4. During an infection, pathologic microbiota overwhelm normal, healthy bacteria and a sequence of immunologic events results in clinical symptoms and microbiome alterations.
5. Postpartum nurses have direct influence over the integrity of newborn microbiota through feeding and skin care practices as well as patient education.

Table 1

Practical microbiome considerations for maternal newborn nurses

<p><u>Maternal Diet</u></p> <ul style="list-style-type: none"> • Dietary recommended intake of 1800+ k/cal/day for lactating mothers • Special attention to micro and macronutrient postpartum requirements • Optimal diets for microbiomes need further investigation • Avoid unnecessary use of antibiotics <p><u>Maternal Sleep Disturbance</u></p> <ul style="list-style-type: none"> • Establish night-time sleep hygiene routine • Encourage maternal night-time infant care assistance • Encourage maternal sleep positions that optimize breastfeeding and rest • Maintain pain control <p><u>Postpartum Depression</u></p> <ul style="list-style-type: none"> • Monitor for signs of dysfunctional maternal-infant attachment • Assess for PPD risk factors • Utilize validated screening tools at repeated visits for symptom detection <p><u>Mastitis</u></p> <ul style="list-style-type: none"> • Encourage continued breastfeeding through treatment • Preventative measures to minimize engorgement: <ul style="list-style-type: none"> ◦ Warm compresses at feedings; Gentle massage to breast; Instruct on proper latch; Nipple care to avoid trauma; On demand feeding <p><u>Perineal Injury</u></p> <ul style="list-style-type: none"> • Pericare with mild soap and clean water • Pat area dry, never wipe or scrub • Encourage frequent peri-pad changes • Avoid prolonged exposure to stool • Encourage healthy diet and smoking cessation • Control pain through oral analgesia and cooling treatments to perineum <p><u>Feeding Method</u></p> <ul style="list-style-type: none"> • Initiate breastfeeding and skin-to-skin contact within first hour of life • Exclusive breastfeeding to optimize diversity of the infant's gut microbes • Avoid in-hospital formula supplementation if not medically necessary • Breastfeeding support and encouragement is crucial for success <p><u>Newborn Bathing and Skin Care</u></p> <ul style="list-style-type: none"> • Immediate skin-to-skin contact for optimal microbial colonization • Limit handling of baby by non-family members • Use mild baby soap or water only for microbial preservation • Not necessary to remove vernix in nonfolded regions • Diaper changes every 1-3 hours optimal • Skin emollients (preservative-free 20% zinc oxide) to protect skin barrier • Diaper wipes should avoid harsh chemicals such as methylisothiazolinone
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