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The Microbiology and Immunology of Normal Physiologic Birth: A Plea for the Nature of Mother

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Without a significant change in practice, approximately 2 of 3 pregnant American women will have a normal, spontaneous vaginal birth in 2013. Countless scientific and healthcare leaders have delineated numerous maternal, neonatal, and socioeconomic consequences of the rising cesarean delivery rate.¹ In our integrative review of the literature on prenatal probiotics and prebiotics included in this issue of the *Journal of Perinatal and Neonatal Nursing*, we briefly describe the microbiome of healthy pregnant women. *Lactobacillus* predominates in the vagina and *Bifidobacterium* in the gut.^{2,3} These probiotic bacteria serve to maintain homeostasis on the mucosal surfaces and prevent the adherence of pathogens. Our review included outcomes from 37 studies of prenatal probiotics (most containing species of *Lactobacillus* and/or *Bifidobacterium*) to

produce health benefits. In this article, we make the connection between normal vaginal birth, breast-feeding, and the physiologic development of the healthy neonatal microbiome. We contrast this to the short- and long-term health concerns of children born by cesarean delivery.

It is long been understood that pathogenic bacteria can enter the pregnant uterus through a variety of pathways, leading to risks such as premature labor.⁴ However, in normal pregnancy, the uterine environment and the fetus are often considered to be sterile. Recently, it has been posited that the fetus receives preparatory exposure to healthy microbes from the mother and her environment that prime the neonatal immune system to adapt more quickly following birth.^{5,6}

The unique bacterial community of the mother is transferred to the neonate vertically during the process of physiologic birth through exposure to vaginal-perianal microbes.⁷ Although findings of some studies vary, the intestinal microbiota of infants born by vaginal delivery appear to rapidly resemble that of their mothers, where *Lactobacillus* dominate,^{7,8} later developing a higher proportion of *Bifidobacterium*.⁹ Both help stimulate the healthy development of the neonate's immune system.⁸ Since the immune system is largely mediated by gut microflora, there are long-term health implications, depending on which microbes colonize the neonate.⁸

Breast-feeding and close contact with the mother further promote healthy bacterial colonization of the baby. The maternal gut and breast milk are connected by what is called the enteromammary link.¹⁰ Pathogens ingested by the mother initiate an immune response in her gut; subsequently, immune-protective factors (eg, secretory IgA) specific to those pathogens are transferred to her infant through breast milk.¹¹ Another remarkable advantage of breast milk is that it is synbiotic, meaning that it contains both probiotic bacteria and prebiotics (food for the bacteria).¹²

The hygiene hypothesis suggests that limited exposure to bacteria in early life can increase the risk of immune-based diseases later in life.^{13,14} For example, formula-fed infants' have fewer *Bifidobacterium* in their stools than breast-fed babies.^{12,15} In addition, the flora of infants born by cesarean delivery more closely resembles that of skin surfaces (maternal and nonmaternal) and the hospital environment (eg, *Staphylococcus*).⁷ These neonates experience a delay of several months in the establishment of a stable and functional intestinal microbiota.^{16,17} This leaves babies born by cesarean delivery potentially more vulnerable because of a lack of exposure to protective maternal microbes.^{15,16} Even healthy infants born by cesarean delivery are more at risk of serious infections, such as methicillin-resistant *Staphylococcus aureus*.^{18,19} In summary, both cesarean birth and formula-feeding limit neonatal exposure to healthy probiotic bacteria.

Immune diseases	Odds ratio	Confidence interval	P	Reference
Allergic rhinitis	1.37	1.14–1.63	.0006	Renz-Polster et al ²⁰
Any allergic disorder	1.23	1.06–1.43	.007	Renz-Polster et al ²⁰
Asthma	1.24	1.10–1.53	.04	Renz-Polster et al ²⁰
Celiac disease	1.80	1.13–2.88	.014	Decker et al ²¹
Type 1 diabetes mellitus	1.19	1.04–1.36	.01	Cardwell et al ²²

Adapted from Neu and Rushing.¹⁴

Table 1. Increased risk of immune diseases in children born by cesarean delivery

Immune diseases	Odds ratio	Confidence interval	P	Reference
Allergic rhinitis	1.37	1.14–1.63	.0006	Renz-Polster et al ²⁰
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Adapted from Neu and Rushing.¹⁴

Table 1 contains a synthesis of the findings of 3 studies (1 meta-analysis and 2 retrospective studies) that demonstrated a significant increase in the odds of developing specific diseases among children born by cesarean delivery.²⁰ From an epidemiologic perspective, other characteristics of infants born by cesarean delivery such as birth weight, duration of breast-feeding, and antibiotic exposure may contribute to vulnerabilities.^{13,14} However, controlling for these and other confounding variables, cesarean birth significantly increases the odds of developing immune-related diseases.²⁰⁻²² While associations have not been established for other common immunologic diseases,^{20,21} further research is needed.

In their retrospective cohort study of 8953 children, Renz-Polster and colleagues ²⁰ found that the odds of children born by caesarean delivery having allergic rhinitis and asthma increased even further if the cesarean birth was an elective repeat. A classic study of white blood cells in umbilical cord blood demonstrated that fetal production of immune-protective factors is stimulated during the labor process.²³ Therefore, labor enhances fetal immune system activity in preparation for extrauterine life, while the absence of labor appears to place the neonate more at risk.²⁴

One irony of hospital birth is that providers' attempts to prevent exposure to harmful pathogens may in fact interfere with exposure to health-promoting probiotic bacteria.²⁵ When the physiologic process of birth is disrupted by a surgical cesarean intervention, the offspring may experience lifelong immunologic impacts. Women are commonly informed about the risks inherent in vaginal birth, yet few are counseled about the short- and long-term neonatal risks of elective cesarean birth.²⁶ If perinatal providers have a strong desire to support normal birth, it is critical that the microbiologic and immunologic benefits of experiencing labor, vaginal birth, and breast-feeding be shared with women and their families.

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