

# Creating Healthier Microbiomes, from Conception to Childhood

A Clinical Conversation with Geeta Maker-Clark, MD, and Robert Rountree, MD

*Geeta Maker-Clark, MD, attended medical school at Rush Medical College, in Chicago, Illinois, and graduated in 1999. She completed her family medicine residency in 2002 at the West Suburban Medical Center on Chicago's west side and went on to complete a maternal child health fellowship there as well. She also completed a fellowship in integrative medicine at the University of Arizona, in Tucson, Arizona. Dr. Maker-Clark is a board-certified family physician specializing in integrative medicine. She currently practices at the North Shore Medical Group in the Chicago area, and is a clinical assistant professor and coordinator of integrative medical education for the University of Chicago Pritzker School of Medicine. She is also on the faculty at the University of Chicago's NorthShore Family Medicine Residency program. Dr. Maker-Clark is the founder of the Food as Medicine workshops and codirector of a culinary medicine program.*

**Robert Rountree: Please tell us about your background and professional journey? What led you toward specializing in integrative medicine?**

**Geeta Maker-Clark:** I started training in a conventional family medicine residency. However, throughout my residency, the one area that always really spoke to me was maternal and child health. This interest started for me prior to going to medical school. I had worked in India in rural villages, helping midwives and healers. I was not necessarily looking for that experience, but that is the way that medicine is practiced in the rural communities of so many countries. That shaped my early ways of thinking about how to take care of people: What do you do with what you have? What is the power of ancient and traditional medicine in time-honored practices such as birth?

I knew that I truly wanted to have excellent training in maternal child health and birth. I personally saw the impact of taking good care of mothers and what that means for families. In public health, we know that one of the most important ways of effecting positive change in communities is to take care of women.

To reach these goals, I chose a residency that was strong in obstetrics and pediatrics. I enjoyed this work so much that I stayed on and did a fellowship in maternal child health. In this fellowship, I worked with obstetricians and midwives. I learned how to perform C-sections and operative deliveries, and how to attend water births and natural births. I had the opportunity to see how these practices varied over the disciplines, and I found my own unique way. I wanted to be the physician that a woman could come and see while pregnant and stay with throughout her course and beyond with her family. I wanted to be relied on for all of her care. I truly feel honored to be involved with women in the birth process and also honored to hold the knowledge I gained from my teachers of how to deliver babies safely. I think that we do much better in all cases when we are able to respect both traditional and modern approaches to childbirth and child care, rather than one exclusively, because there is so much wisdom in both.

After this early training, I moved to southern California and was working as an attending physician at a county medical center in a high-risk obstetrics clinic. I would see many of these high-risk patients. Along with performing ultrasounds and C-sections, I was working with midwives. I was also teaching residents and prenatal yoga. During this period, I also had 3 children of my own. All were birthed by midwives, and 2 were born in the water. I was choosing to make different decisions for myself as to how I wanted to bring my babies into the world. So, both my training and my personal experiences inform the way that I currently practice.

In my clinic at that time, I was seeing 25–30 patients a day and only getting a couple of minutes with each patient. None of the time I spent was the kind of quality time that allowed me to have conversations about nutrition, stress, lifestyle, or how to get people off of medications instead of adding more medications to take. At this point, I did not feel like I had the integrity with which I started medical school. My intention of being a healer was not reflected in my work, as I was just managing problems and not getting to root causes. So I started looking into a different level of training. I decided on an integrative medicine fellowship at the University of Arizona, led by many of my mentors. I gained so much in that fellowship, but mostly grew from associating with the people and

community that I was now a part of. I met many teachers, guides, and other physicians from all over the country and world, who felt the same way I did. We could share information across boundaries. It was a really powerful time for me.

It was after this point that I shifted my practice entirely to being one that focuses on using food as medicine. I also use botanicals and herbs, and conventional medicine as needed. I now feel like all of my past experience, internationally and nationally, with midwives and traditional healers, has really come into play in the way that I practice. It is all integrated into a meaningful whole, and I feel like I am honoring the wisdom that exists in so many different modalities. I love being a doctor again.

**Dr. Rountree: What has driven your interest in the role of the microbiome in health?**

**Dr. Maker-Clark:** I am not a researcher, and I have not done any original research concerning the microbiome. However, more recently, much of the focus in functional and integrative medicine has gone toward healing the gut as a primary means of healing other organ systems and chronic disease processes. It was through my experiences in integrative medicine—and spending a lot of time on intestinal epithelial integrity—that I realized the power of the gut microbiome. As I work with pregnant women and have such an extensive background in maternal health, I truly began to think that taking care of the maternal gut microbiome was likely very important—women are in the process of helping create other human beings! This made me think about the relationship with the vaginal microbiome as well. What are we doing to understand the importance of the vaginal microbiome ecology and its influence on infants?

**Dr. Rountree: Rob Knight [PhD]—a professor at the University of Colorado, in Boulder—one of the world’s top microbiome researchers, has written that “vaginal microbes determine our destiny.”<sup>1</sup> Would you elaborate on this statement?**

**Dr. Maker-Clark:** Yes. I absolutely believe this too. I think we are at the precipice of understanding what that statement really means. In modern obstetrics, we have treated this ecology only as a source of disease. We do a swab, and see what is imbalanced. We give antibiotics if needed to treat one or more microbes that are abundant. However, I think the vaginal microbiome needs to be looked at with the same respect as we do the gut microbiome, if not more.

**Dr. Rountree: What is our current knowledge about how and when the fetal microbiome begins to develop? What other sources are there besides the vagina for the microbes that colonize the infant?**

**Dr. Maker-Clark:** In most hospital-based obstetric settings it is still believed that the mother’s womb is sterile (of microbes). However, research over the last several years has shown that this is not true. We are finding bacteria in the amniotic fluid

and the placenta, as well as in the cord blood and the baby’s first meconium.<sup>2–7</sup> That “sterile” womb paradigm has been a very enduring premise in human biology; however, I think it is going to be completely overturned by these recent studies that show that infants are actually developing their microbiomes before birth. Certainly, the birth process and breastfeeding result in copious amounts of maternal microbiome supplementation. However, this is not the first exposure for the infant.

Researchers are finding that amniotic fluid bacteria have a similarity to the mother’s oral bacteria and are likely transmitted to the uterus through the bloodstream. We do know that there have been studies in the area of gingival inflammation and increased risk of preterm labor.<sup>8</sup> This has resulted in a huge push forward in dental care for pregnant women. However, again, this focuses on the negative effects of these oral bacterial and does not focus on the possibility that normal oral bacteria—even when there is not a disease process—are being transmitted as well. So, the mouth is one source. Other sources of bacteria influencing the infant microbiome include the breasts, both internally and externally. Within the breast tissue, there is an enteromammary pathway that brings the gut bacteria to the mammary gland via lymph and blood circulation.<sup>9</sup> Outside of the breasts, there is an exchange between the maternal skin and the infant’s oral cavity.<sup>9</sup> Oral bacteria tends to be *Streptococcus*, fusobacteria, and some other lesser-known strains.<sup>10,11</sup> From the breast, we find a diversity of bacteria. Recent research suggests that these microbial communities are like fingerprints, vary significantly among women of different ethnicities, and are affected by our genetics.<sup>12</sup>

**Dr. Rountree: What maternal factors or lifestyle practices influence the maternal and fetal microbiome?**

**Dr. Maker-Clark:** One of my areas of interest is the dietary relationship to the vaginal microbiome. Standard practice focusing on a more plant-based, reduced-processed, -sugar, and -high-fat diet makes sense in a pregnant patient. However, is there anything more specific that we could offer for someone? The diet is one of the ways in which we can change the microbiome very quickly. Some evidence suggests that the microbiome—including the vaginal microbiome and gut microbiome—respond to dietary changes within 24 hours, sometimes changing with a high degree of significance.<sup>13,14</sup> In monkeys, low-fat, plant-rich diets have resulted in more varied microbiomes than high-fat and more-typical Western diets.<sup>15</sup> The change in diets actually altered the microbiome gene expression. In humans, maternal nutritional habits have appeared to influence the specific type of bacteria present in the gut.<sup>16</sup>

What is related to this is our interest in the mother’s weight in prenatal care. We focus on weight at each visit and give recommendations on weight gain, with the idea that preventing obesity in the mother will prevent obesity in the child. However, some studies have shown that we should focus on the diet itself rather than on the mother’s weight. Diet may play a role in dysbiosis and potential obesity.<sup>17</sup> This idea of an *obesogenic diet* related to the microbiome has been studied to a much

greater extent in animals than in humans. It is common sense to spend time checking in on the nutrition of the mother, and enabling her access to good-quality food may be more important than spending that time thinking about her weight.

**Dr. Rountree: Do you discuss the microbiome concept with your patients routinely?**

**Dr. Maker-Clark:** I do talk to my patients about this. Many of my patients are not even familiar with the concept of having bacteria in their bodies. However, I think it is important to explain the reasons behind a lifestyle change that might be significant for these patients. Pregnant women, especially, are so open to any ideas that one has that could improve the health of the children. It is a beautiful time to start new ways of eating and exercising, and to include practices such as meditation or yoga. There is a sense that one is doing something really helpful for the baby, and, then, these habits may continue after pregnancy.

**Dr. Rountree: What dietary, lifestyle, or other advice do you typically give to mothers and their infants to foster long-term microbial health? Do you routinely prescribe prebiotic foods, supplements, and/or probiotics to mothers and/or infants?**

**Dr. Maker-Clark:** Having a conversation with pregnant women about foods can be difficult. It is not the same conversation I have with nonpregnant people who may be adventurous and try new things. It can be the opposite during pregnancy as they are lucky if they want to eat the same things they ate before. I try to focus on two things in particular: omega-3 fatty acids and probiotics.

There is plenty of evidence to suggest safely that omega-3 fatty acids are healthy fats with strong anti-inflammatory properties and that these fatty acids are incorporated into the growing baby's brain and retina.<sup>18,19</sup> I focus on obtaining omega-3 fatty acids through the diet. I suggest foods, such as walnuts, avocados, seeds, and greens for obtaining omega-3 and other healthy fats. As a lot of my patients eat eggs, I suggest omega-3 enriched eggs. However, I try to make sure that my patients are getting at least 3000 mg a day and, often, that requires a supplement. Information on probiotic-containing foods is a bit trickier. I suggest probiotic-rich foods that are fermented. Foods such as miso or sauerkraut fit this suggestion and also are enjoyed by some pregnant women who sometimes have a desire for something salty or a little more vinegary or bitter tasting.

The population that I work with does not have access to purchasing a lot of supplements that are not covered by insurance. Therefore, I don't often use probiotics as a common practice with every prenatal patient. If a patient were being treated with antibiotics for an infection during pregnancy, then I would recommend supplemental probiotics. I believe, though, that it is so much better to try to use a source that will be sustainable for these patients. If a food is introduced that they might actually continue eating after pregnancy, then that food is better than a supplement that they probably will not be able to continue to take.

**Dr. Rountree: How has the development of the fetal–infant microbiome changed in the last 100 years? What are the differences between the fetal and infant microbiome in developed versus developing countries?**

**Dr. Maker-Clark:** I find this area fascinating. Without being too dramatic, I do think we have the power to extinguish the human race by having a vaginal microbiome change too radically over time. Like Dr. Knight said, vaginal microbes are determining our destiny. Overtreatment with antibiotics or a high use of C-section deliveries could change human health radically and powerfully for the worse to the point that this could extinguish us.

In humans, these microbiomes have evolved very specifically over time and they will continue to evolve. The pressures that we have put on human microbiomes will affect their evolution. There have been some interesting studies comparing, for instance, the Malawi infant microbiomes<sup>20,21</sup> and the Amerindians of the Amazon to American babies.<sup>22</sup> Initially, it appears that most babies have similar gut microbiomes that are heavily populated by *Bifidobacterium*. These are the organisms that have evolved to break down the oligosaccharides in human breast milk. We do not have the enzymes needed to do this; the bacteria do that for us. However, once solid food is introduced, there are some radical shifts, as expected.

**Dr. Rountree: What is the impact of a C-section on the development of the infant's microbiome and the associated long-term effects? Has this influenced the trend toward the number of C-sections performed?**

**Dr. Maker-Clark:** One of the biggest threats to changing the microbiome of the infant is the mode of delivery. The microbes that are found on infants delivered by C-section are not the microbes that we find on babies delivered naturally.<sup>23</sup> Often, the bacteria that the infant gut is populated with is primarily from the skin flora and the hospital environment rather than the mother's vaginal flora. While we have saved babies and mothers from serious consequences as a result of this procedure, there is a price that is being paid. It is our job as physicians to understand what the consequences are with any intervention, including C-sections and the use of antibiotics. In my experience, there is more awareness by obstetricians of the importance of the vaginal microbiome and there is more of an emphasis to keep the C-section rate low. We have quality-control meetings, looking critically at each time we use this intervention to understand if it was indicated and important. However, even with that in place, the number of C-sections is still very high in the United States and has been increasing. The primary goal is to deliver a healthy baby.

**Dr. Rountree: Is there anything we can do to improve the microbiome of infants who have been delivered by C-section? Can transfer of vaginal swabs to the infant postpartum, or similar practices help mitigate this situation?**

**Dr. Maker-Clark:** I personally would like to see some more interventions focused on preserving the microbiomes of babies

who are born by C-section. I think we could be doing a better job of that in a lot of different ways. Hospital practices are outdated, based on the knowledge that we have about what is good for humans and human health. That is why I look to midwives for answers to problems such as this. The midwives have been practicing this traditional knowledge that they have passed from one to another for hundreds of years. They have very low C-section rates with high rates of skin-to-skin contact and breastfeeding.

With any of my patients who have a C-section, I suggest transfer of vaginal flora to the infant using various means. This can involve swabbing a washcloth from the vagina to the baby's face, or even the mother's fingers from her vagina to the baby's mouth. I have found that this is becoming something more women know about. It is not common practice in most hospitals, by any means.

Putting a new procedure in place requires research, and then the suggestion must go through several committees and reviews for it to become common practice. I do hope that these practices will be used commonly in the future. This is how many midwives have been practicing, and I cannot find any downside to doing this. A patient may find it odd, but, as soon as I explain that it is exactly what would have happened if she had a vaginal delivery, she understands. As we know, there is a connection in the literature between being born by C-section and developing inflammatory problems or allergies later in life.<sup>24</sup> It is going to take some champions of this practice to bring it to the attention of leadership and make it common practice. We are already seeing many obstetricians allowing skin-to-skin contact immediately after the C-section by removing the sterile drape—and that is a big step forward.

**Dr. Rountree: Would you comment on other aspects of the microbiome in young children? For example, what is the effect of hygiene on the immune system?**

**Dr. Maker-Clark:** Yes. This speaks to the hygiene hypothesis. Some epidemiologic studies have shown that the offspring of women who are in a farm environment when they are pregnant actually have some protection against allergic sensitization and asthmatic disease.<sup>25</sup> There appears to be an upregulation of the receptors of the innate immune system, and those exposures are passed down to the babies. This has resulted in the idea that we may be seeing more disease because we are being more sanitary and sterile in our lives and not allowing our immune systems and our gut microbiomes to adapt to pathogens to which we would have normally been exposed. In our house, we always had the 30-second rule!

**Dr. Rountree: Would you share your perspective on the value of the vernix caseosa? Is it still standard practice to wash it away soon after birth? What is the potential value for neonatal health of leaving the vernix on?**

**Dr. Maker-Clark:** Yes, it is still standard practice to wash it off. I make sure that it does not happen with my moms, but it is the standard practice. The vernix is a biofilm that acts as a

protective moisturizing layer. I am not aware that it is a source of bacteria, but it does appear to have antimicrobial properties. Interestingly, vernix seems to be unique to humans, containing a very specific lipid-rich combination.<sup>26</sup> Not only does it function as a barrier to losing water, it also helps the baby regulate temperature and protects the baby during the transition time between the intrauterine and extrauterine environments. It has the ability to protect against exposure to ultraviolet light, as the vernix contains the antioxidant vitamin E and melanin. The vernix is thought to have wound-healing properties. Traditional practice in countries I have worked in has always been to keep the vernix on. There are no specific recommendations as to how long to leave it on, but, based on its properties, I would keep it on at least a day. The blankets and cap can go on top of the vernix if they are needed.

**Dr. Rountree: Would you clarify the current official policy on screening and treatment for Group B strep [GBS] colonization during pregnancy? Are there pros and cons of aggressive use of antibiotic treatment for asymptomatic GBS in low-risk individuals? Do we know what impact this has on the infant microbiome?**

**Dr. Maker-Clark:** In the United States, the guidelines of the Centers for Disease Control and Prevention state that GBS is the leading cause of meningitis and sepsis in a newborn's first week of life and recommend that a pregnant woman should be tested between 35 and 37 weeks. If the woman tests positive for GBS and receives antibiotics during labor, the guidelines state that there is a 1:4000 chance of delivering a baby with GBS compared to a 1:200 chance if she did not take the antibiotics. There is a 5% infant mortality rate in babies who contract GBS during labor.

Other questions to ask are: "What are the ramifications of treating a pregnant woman with IV antibiotics during labor?" "How does that affect the baby?" We have looked at it from the perspective of prevention of GBS sepsis but not from the perspective of what lifelong change this might be creating in the gut microbiome of the baby and in the vaginal microbiome of the mother, and how those two are connected. Given that GBS is not a pathogenic bacterium—it is found in ~ 25% of pregnant women in the rectum and vagina—there is a lot that needs to be looked at. What else is going on that causes a healthy bacteria to result in a fatal disease in a baby? Are there other cofactors that we should be taking a closer look at that could be causing this?

In many other countries, GBS screening is based on maternal risk factors. I am not aware of research involving the use of probiotics in this field, but we need to figure out how we can promote a healthy vaginal microbiome that crowds out GBS during pregnancy. Remember, a lot of women who become pregnant are not in optimal health. If we can foster healthy gut microbiomes from infancy, then, during pregnancy, we might see a microbe population that has a normal balance and does not have an overgrowth of a specific bacterium that can potentially cause harm.

## To Contact Dr. Geeta Maker-Clark

### Geeta Maker-Clark, MD

North Shore Medical Group  
909 Davis St #200  
Evanston, IL 60202  
E-mail: geetamaker@gmail.com  
Website: drgeetamakerclark.com

### Dr. Rountree: Is there anything else you would like to share or conclude with?

**Dr. Maker-Clark:** The maternal microbiome is very important for the health of the infant, and therefore, the human population. Any clinician can be part of the change by advocating for good-quality food availability for pregnant women and having that conversation. Whether the pregnant woman is in the office for a prenatal check-up, or for an infection, or for a musculoskeletal condition, there is always room to have a discussion about nutrition. That will make an impact on the woman's gut microbiome and thus impact her baby.

An obstetrician or a midwife can have conversations early on about vaginal versus C-section birth, about what the differences are, and what the consequences can be. These practitioners can discuss the importance of breastfeeding and take the time to explain what impact these decisions can have. That way, whether a woman needs a C-section or do not, or breastfeeds or not, that woman would have some options for optimizing the baby's health. As physicians, we are going to see those babies in our offices, and these babies may have inflammatory bowel disease 20 years from now. How wonderful it would be if we could be a part of "paying it forward" for the human race by taking great care of pregnant women so that they are birthing babies who are not at risk for chronic disease. ■

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**Geeta Maker-Clark, MD**, practices at the North Shore Medical Group in the Chicago area of Illinois, and is a clinical assistant professor and coordinator of integrative medical education at the University of Chicago Pritzker School of Medicine. She is also on the faculty of the University of Chicago's NorthShore Family Medicine Residency program; the founder of the Food as Medicine workshops; and codirector of a culinary medicine program. **Robert Rountree, MD**, practices family medicine in Boulder, Colorado.

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