MODE OF DELIVERY: EFFECTS ON INFANTS' MICROBIOME COMMUNITIES

Autumn M. Harrison

ABSTRACT

There are two delivery modes used for a newborn to enter the world: vaginal delivery or Cesarean section (C-section). Depending on how the baby is born, they will obtain certain microbes that will play a fundamental role in the colonization and composition of their gastrointestinal tract (GI tract). These two modes of delivery are shown to affect the transmission of initial bacteria differently from mother to newborn. During a vaginal delivery, newborns are directly exposed to their mother's vaginal microbial communities (such as). Add a result/future result. During a C-sectional delivery they are exposed to microbes in the environment (such as). Studies showed newborns delivered vaginally resembled their mother's microbial communities, while newborns delivered by C-section resembled environmental microbes. This exposure can alter the colonization and composition of newborns' gut leading to a higher risk of developing diseases (e.g. asthma, diabetes, allergies). To restore the vaginal microbes lost by C-section, breastfeeding and vaginal seeding can be completed. These methods of restoration have shown to be effective.

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Commented [LH2]: Such as- name at least two types of environmental microbes that the newborn will be effected by.

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INTRODUCTION

Human Microbiomes

There are many different types of microorganisms (e.g. bacteria and yeast) living within and on the human body. Bacteria, archaea, viruses, and fungi found in and on the human body are collectively termed the microbiota. The totality of the genomes comprising the microbiota are defined as the metagenome, and together the microbiota and metagenome comprise the microbiome (Schulfer and Martin, 2015). The microbiome interacts with its infants hosts and environment to build a strong functional immune system. Scientists are trying to understand how and when the microbiome assembles and the factors in early-life that can affect the natural ecological succession of the microbiome (Mueller et al., 2015).

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The human microbiome plays an important role in the body. Its job is to protect humans from pathogens, assist in the development and maintenance of the immune system, break down food for energy, produce natural vitamins, and overall maintain a functional human body (Schulfer and Martin, 2015). The human gastrointestinal tract (GI tract) refers to the stomach, intestines, and colon which is where most of our colonizing microbes live. While those three organs contain most colonizing microbes, other organs such as skin, mouth, vagina, and bladder do as well. The GI tract is a host to a large, active, and complex microbe community (Pandey, Prashant Kumar, et al). These gut microbes make their way to the digestive tract during a human's growing years to become the primary colonies. Their composition and colonization of the microbiome is important

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The human gastrointestinal tract refers to the stomach, intestines, and colon which is a host to a large, active, and complex microbe community called gastrointestinal microbes (GI microbiota).

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in infants lives because they influence the status of the gut mucosal immune system, which will help achieve and maintain good health in the future.

Infants Obtain Microbiomes from Vaginal and Caesarean Deliveries

Humans obtain and/or produce their microbiomes at a very young age, which will help them shape and maintain a healthy state during their lifetime. Babies are first exposed to small amounts of microbes in the womb of their mother from the amniotic fluid, placenta, umbilical cord, and membrane surrounding the fetus (Mueller, Noel T., et al, 2015). These primary microbes mark the beginning of the colonization of a baby's microbiome community. Babies are then introduced to a whole new variety of microbes when delivered into the world; but what types of microbes acquired depends on the mode of delivery. A baby can enter the world either through the vaginal canal of their mother (vaginal delivery) or surgically through the abdomen and uterus of their mother (cesarean delivery or C-section). During a vaginal delivery, the baby is exposed to and bathed in his or her mother's natural vaginal microbiomes. This type of delivery has been shown to prime the newborn with bacterial communities that are directly related to those of the mother's vaginal microbiota. Maternal derived microbes become established in infant mucosal tissues and play an important role in the development of the innate immune system and the achievement of an effective immune homeostasis (Dietert, 2013). Exposure to vaginal microbiomes can help build the baby's gut and intestinal microbiomes that comprise their neonatal immune system. The neonatal immune system is what protects the baby from harmful microbes (MacIntyre et al., 2015). Vaginal microbes serve as a shield or coating that the baby gets before being exposed to microbes in its new environment. If the baby is not born vaginally, they will not be able to receive this first coating of microbes; but instead be directly exposed to environmental microbes.

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Commented [LH11]: Because you explain how a Csection work in the next paragraph, explain how a vaginal birth works. Guide your reader through the process at the same time explaining how the microbes fit in. Also explain other nutrients etcs the baby receives. If vaginal delivery is considered better, explain why in details.

Commented [LH12]: You should include an age range

Commented [LH13]: This first sentence can be placed in the introduction. Still need an age range. Stick with only Babies, but for future results or affects talk about when they are adults.

Commented [LH14]: You have two conflicting sentences. The First sentence says humans and at a very young age. Then you say Babies. Which one is it? You should try and stick with one age group or range. Especially, in same paragraphs.

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The names of the microbe communities the baby is exposed to by vaginal birth and their purposes.
What does each do for the immune system or organs?
How does the vaginal microbes serve as a shield or coating?
What does it look like or feel like? What bounds the microbes together to create this shield or coating?
Try adding detailed descriptions and explanation rather than stating facts.

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During a caesarean delivery (C-section) an incision is made in the mother's abdomen and the baby is taken out of her uterus and out of the stomach. and into its new environment (most likely the Operating Room). There are two types of C-sections that can be performed: elective and emergency C-section. An elective C-section, which is more common, is scheduled beforehand upon the patient's request whereas an emergency C-section results from unexpected complications during labor (Stokholm et al., 2016). Some possible unexpected complications could include: the baby is breeched or transverse, the baby is in distress, the umbilical cord is dangerously wrapped around the baby, or the baby is either premature or very large (macrosomia). C-sections are proven to be a more useful type of delivery in cases of medical necessity where the imminent health of the mother and/or child is in jeopardy and a vaginal delivery would not be an option (Dietert, 2013).

C-section deliveries date back to ancient times and have increased in modern times. Dietert et al., reported a threefold increase in elective C-section deliveries between the years of 1997 and 2006 in Canada and Azad et al., found that more than 1 in 4 newborns are born by C-section (Azad et al., Dietert et al.). In the United States, the rate of C-section deliveries rose 48% since 1996, reaching 31.8% of all deliveries in 2007 (Neu et al., 2011). Mothers are undergoing elective C-sections for various reasons, but they are unaware of how this mode of delivery will impact their baby's microbiome. C-section deliveries will cause the baby to lack certain microbes that help build their immune system and protect them from harmful microbes. Instead of getting the mom's maternal microbes, which are healthier, they will obtain microbes from the delivery room, the hands of the different physicians, instruments used during the procedure, and etc. Because these microbes are different compared to vaginal microbes, they can affect the development of the

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Commented [LH22]: This is good, but where is your data for the vaginal birth? You should have equal subtopics being discussed for both topics.

Also give an appropriate name or title for the website/etc you are getting your information from. Use According to… or use as cite.

Commented [LH23]: I think you should name the harmful microbes at the beginning or at this point. Explain what these harmful microbes do.

Commented [LH24]: Spell out etc or use such as at the beginning and exclude etc. For research papers, its best to list all of the information instead of using etc because then the reader will feel as if you've deprived them of some important information. Do this throughout essay.

baby's immune system differently and cause defect in the colonization of the baby's microbiome community (Stokholm et al., 2016).

The mode of delivery is important for a newborn because it will affect the direct transmission of initial bacteria from mother to newborn (Dominguez-Bello et al., 2010). Infant microbes play an essential role in human health and its assembly is determined by the maternal offspring exchanges of microbiota (Mueller et al., 2015). Many scientists have studied and analyzed the difference in the microbiome community of vaginally delivered babies in comparison to C-section delivered babies. The literature reviewed in this paper focuses on how delivery method affects infant microbiomes, how the lack of different microbes during a C-section delivery can affect a baby's developing health, and how C-section delivered babies can be treated to supplement their microbiome.

REVIEW

Culture Independent and Dependent Approaches
using 16S rRNS Gene Sequencing

Culture Independent and Dependent approaches are studies on cultivating microbial populations used to survey microbial community composition and structure in women and newborns (Ma, Bing et al., 2012). These approaches consist of sampling of genetic materials from the environment and/or mom and infant. Following is the amplification of the 16S rRNA genes using primers that recombine to highly conserved regions of the gene. Many of the literature review articles mentioned studies using 16S rRNA sequencing along with other sequencing approaches such as DNA extraction, PCR amplification, or cloning and sequencing to characterize first bacterial assemblages associated with babies born vaginally or by C-section and compare it to their mothers' bacterial assemblages. 16S rRNA sequencing is a common sequencing method used to

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Commented [LH26]: This is a repeating paragraph. Delete. You can add the **Many scientist have studied and analyzed the difference in the microbiome community of vaginally delivered babies in comparison to c-section delivered in the introduction.** Also state how many studies they have done and where in the world. Give some facts and data to introduce to readers how this is so important that scientist all over are focused on it and wish others to take notice.

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identify and compare bacteria present in samples of microbiomes and/or environments. that are challenging to study. DNA is extracted from samples of the mothers' vaginal canal and PCR primers, complementary to conserved regions of the 16S rRNA, are used to amplify the variable sequence. It demonstrates several kinds of vaginal communities that exist in most normal and healthy women. Then, there is the sequencing and classification of related genes present (Ma, Bing et al., 2012). This process is an efficient way to characterize microbial diversity within humans. Many of the literature reviews mentioned in this paper uses culture-independent and dependent studies to identify maternal vaginal communities existing in pregnant and otherwise healthy women. These studies have shown that vaginal communities are composed of array of diverse microbiome species in women of different ethnic groups (Ma, Bing et al., 2012). Despite these differences, all women share at least two similar microbe species (e.g. *Lactobacillus* and *Prevotella*). which means they are not that different. The knowledge of microbial diversity has increased throughout the use of culture-independent and dependent approaches with the use of 16S ribosomal RNA (rRNA) gene sequencing.

Maternal Microbiomes

The human vagina hosts a variety of microbial communities that can impact the health of women and their neonates (babies) (Srinivasan et al., 2010). The composition of vaginal microbiota changes throughout the course of pregnancy to increase the number of bacteria that is beneficial for the baby (Mueller et al., 2015). Dominguez-Bello et al., did a study on Amerindian mothers to track the development of a babies' microbiome in different body habitats and after different modes of deliveries. Sampling of nine mothers and their 10 newborns was completed. Four of the mothers delivered their babies vaginally and five of them delivered their babies by C-section. The mothers' skin, oral mucosa, and vagina were sampled one hour before delivery. Their

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Commented [LH30]: Write out the words for DNA then put in parenthesis (DNA). You can write DNA afterwards.

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Combine:
Many of the literature reviews mentioned in this paper have shown that vaginal communities are composed of an array of diverse microbiome species in women of different ethnic groups.

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Commented [LH35]: This is quite interesting. However, add one or two examples of two different ethnicity of women and some number data from a recent study to show accuracy.

Also, some of these paragraphs can be cut into two or more. Unless you prof want you to do it this way, then that's cool.

Commented [LH36]: ? Can you put the writer's name instead or article name? et al does not sound right.

Commented [LH37]: I had to look this up. Just write American Indian or even better Native American mothers. They are actually the same thing babies' skin, oral mucosa, and nasopharyngeal aspirate were also sampled after delivery. DNA extraction and purification was completed on the cotton tips of the sampled swabs and then for each sample the bacterial 16S rRNA gene was PCR-amplified using a primer-set (Dominguez-Bello et al., 2010). Dominguez-Bello et al., found that most of the mothers' vaginal bacterial communities were dominated by *Lactobacillus spp*., and/or *Prevotella* spp taxa. ; but they varied mother to mother.

Lactobacillus is an anaerobic genus of Gram-positive bacteria and a major part of the lactic acid bacteria that converts sugars to lactic. *Lactobacillus* has been concluded to be the dominant vaginal bacterial specie in most woman. It plays a major role in protecting the vaginal environment from non-indigenous and potentially harmful microorganisms and assisting in the baby in milk digestion. (Ma et al., 2012). *Prevotella* is an anaerobic genus of gram-negative bacteria that is found in the oral and vaginal flora and in the gut. It assists with breaking down protein and carbohydrate foods. Three out of the five pregnant mothers tested had uneven vaginal communities dominated by *Lactobacillus spp*. and a low assemblage of *Prevotella* spp. Other womens' vaginal bacterial communities were mostly dominated by *Prevotella* spp., *Coriobacterineae*, *Sneathia* spp. and/or other taxa. *Sneathia* is a genus of Gram-negative bacteria. There is not much known about this bacterium but it is closely related to *Sneathia sanguinegens* and other common species.

Studies of non-pregnant mothers also showed vaginal communities consisting dominantly of *Lactobacillus* (Dominguez-Bello et al., 2010). Srinivasan, Sujatha, et al, found that healthy women were colonized with several *Lactobacillu* species. 20% to 30% of healthy women lack *Lactobacillus* sp. and harbor a diverse array of facultative microorganisms such as members from *Atopobium, Streptococcus, Straphylococcus, Megasphaera, and Leptotrichia* species (Srinivasan et al., 2010) (Ma, Bing et al., 2012). *Bifidobacterium* species were found between the rectum and

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You should add the sentence about the other bactierial communites dominated by Prevotella in the paragraph before with the results. Then explain Coriobacterineae and Sneathia in this paragraph.

vagina of women at 35-37 weeks of pregnancy (Mueller, Noel T., et al, 2015). *Bifidobacteria* are primary colonizers of the neonatal gut in vaginally delivered newborns. It is an anaerobic bacterium that is found commonly in the GI tract and/or mouth of babies. It helps restore good bacteria in the gut of infants that was once killed off or lost. It is important for preventing harmful pathogens from growing and assisting in inflammatory responses (Mueller, Noel T., et al.). These studies showed that several distinct kinds of vaginal communities with markedly different species composition occur and the frequency of these types of microbiota varies in women (Ma et al., 2012).

<u>Maternal Microbiomes Exposed to Babies from Vaginal Delivery</u>

During delivery, the baby is exposed to for the first time a wide array of microbes from variety of sources, including maternal bacteria. Babies are born with immunological tolerance that is instructed by mother's induction of regulatory T-lymphocytes which allows the baby to become colonized by first inoculum (Dominguez-Bello et al., 2010)**.** Initial development and maturation of the neonatal microbiome is largely determined by maternal-offspring exchanges of microbiota (Mueller et al., 2015). Dominguez-Bello et al., sampled four mothers who delivered their babies' vaginally and compared their vaginal communities with their babies' samples. They found that, in three of the four vaginal deliveries, the mother's vaginal bacterial community was significantly similar to her own baby's microbiota which means the vaginal community is directly transmitted to the baby. The dominant vaginal microbes found on these newborns were *Lactobacillus, Prevotella, Atopobium* and/or *Sneathis* spp. Pandey et al., completed an experiment in India on 24 healthy full-term delivered infants. Majority of the infants were breeched which lead to C-section delivery. Fresh stool samples were collected in specialized collection tubes day seven of infants' lives. DNA extraction, PCR amplification, cloning and sequencing were then completed on the samples. The bacterial diversity was measured for each sample and composition compared among babies' samples (Pandey et al., 2012). Pandey et al., discovered that *Acinetobacter* spp., *Bifidobacterium* sp. and *Staphylococcus* sp. were found most abundantly in vaginally delivered newborns. Srinivasan, Sujatha, et al also found a variety of *Staphylococcus* and *Streptococcus* species in their library of clone sequences for vaginally delivered newborns. During vaginal deliveries, *Staphylococcus* and *Streptococcus* colonizes the gut of newborns the first few days of life (Mueller, Noel T., et al.) The microbiomes, mentioned in this section, demonstrate how a mother's vaginal microbiota can provide newborns with the chance of direct transmission of natural microbes when entering their new world. The direct transmission of these microbes will serve as a defense mechanism, help shape the baby's GI tract and build a strong immune system.

Environmental Microbiomes

There are many different microbes present in different environments. The most common place of delivery for a baby is the hospital room or operating room. Regardless of how sterile a hospital room and/or operating room may seem, it still contains microbes (Shin, Hakdong et al., 2015). The most common sources of microbiomes in a hospital room are skin follicles, maternal microbes, or microbes found on objects in the room (Azad et al., 2013). Many people enter in and out of hospital rooms and when they do they leave behind many small particles of skin (skin microbiomes). About 37 million bacterial genomes are shed by humans unto the environment per hour (Shin, Hakdong et al., 2015). Shin, Hakdong et al. sampled 11 sites in four operating rooms from three hospitals to determine if the environments contained human skin bacteria that C-sectional babies could be exposed to. They swabbed the floors, walls, ventilation grids, chairs and lamps. They sequenced the 16S rRNA gene of the 44 samples using Illumina MiSeq platform and analyzed them. By completing swabs of different operating rooms in the hospital, Shin, Hakdong et al., found skin-like bacteria such as *Staphylococcus, Corynebacterium,* and *Propionibacterium* around the rooms. *Staphylococcus* is a genus of Gram-positive bacteria comprised of at least 40 different species. It is commonly found on the skin and mucous membrane of humans. These microbes are found in babies' gut microflora and will help them maintain a healthy gut environment. *Corynebacterium,* is an aerobic genus of Gram-positive bacteria that is found commonly in the microbiota of humans and animals. These bacteria are also commonly found living in soil, water, plants, food products, and mucosa and normal skin flora of humans and animals. *Propionibacterium* is an anaerobic genus of Gram-positive bacteria that are able to produce propionic acid and live in and around human sweat glands and other areas of the skin. Members of this genus are widely used in the production of vitamin B12 and cheese to create CO2 bubbles that become the round holes in the cheese. These skin-like bacteria were also found colonizing on newborn babies after delivered by C-section.

Environmental Microbiomes Exposed to Babies from Caesarean Delivery

When babies are delivered by C-section, they are directly exposed to microbiomes in the environment. The environment they are delivered in is most likely a hospital operating room that consists of environmental microbiomes mentioned above. These skin microbiomes contact the baby as soon as she or he is surgically taken out of their mother's abdomen and uterus. The microbes can contact the baby from the air of the hospital room, the hands of physicians, and/or their mother's skin. Dominguez-Bello et al., suggested that exposure to skin bacteria in the hospital room could contribute to a baby's microbiota and developing neonatal microbiome when delivered by C-section (Dominguez-Bello et al., 2010). When a baby is inside their mother's womb, they have a relatively uncolonized digestive tract. They usually are colonized through their mother's vaginal canal; but when delivered by C-section they are colonized with environmental microbes instead (Dominguez-Bello et al., 2010). Pandey et al., also found that the gut of C-sectional babies is vulnerable to colonizing microbes from the environment rather than mother's vaginal microbes because the microbes move to the digestive tract and become the primary colonizers of the baby's gut (Pandey et al., 2012).

Stokholm, Jkob et al., completed a study on 738 unselected pregnant women and their 700 children followed from the 24th week of pregnancy. Fecal samples were collected a week, a month and a year after birth to see difference in microbiome community of newborns based on mode of delivery. All samples were cultured within 24 hours. Further data from the subjects were collected during visits to the clinical research unit and stored in online databases (Stokholm, Jkob et al., 2016). 12% of newborns born by emergency C-section and 9% by elective C-section showed significant differences in the babies' intestinal microbiota compared to vaginally delivered newborns (Stokholm, Jkob et al., 2016). After a C-section, the newborns' colonizing microbial communities consisted of mainly the environment and maternal skin (Stokholm, Jkob et al., 2016). Newborns born emergency C-section showed lower ratings of *Staphylococcus* and higher ratings of *S aureus* in their fecal samples than elective. Dominguez-Bello et al., 2010 took skin samples from mothers before C-sectional deliveries and found *Staphylococcus, Corynebacterium,* and *Propionibacterium spp.* After deliveries, they sampled the skin of the newborns and found that their skin bacterial communities matched their moms' skin. Shin, Hakdong et al., 2015 also found skin-like bacteria such as *Staphylococcus*, *Corynebacterium,* and *Propionibacterium spp* on babies that matched the dust samples collected from the four operating rooms.

These results indicate that the environmental microbes are colonizing in newborns' microbial communities. Results from Pandey et al., 2012 experiment showed distinct differences

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A study was completed by------ on 738 pregnant women and their newborns.

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Suggestion:
Use one study for every topic rather than putting two or three in one paragraph. Stick with one and explain what's connected to the topic.

present in the fecal microflora of vaginally and C-section born babies. Vaginally delivered babies, at day 7 of their lives, showed low species richness than C-section delivered babies. However, the composition of their bacterial community was similar to the gut microflora of babies from earlier studies. They also found that C-section babies were more susceptible to colonization environmental microbes, while vaginal babies acquired microbes from their moms leading to more diverse microflora. Because C-sectional babies do not pass through their mother's vaginal canal, mother to infant transmission is compromised, and infants will lack majority of vaginal microbiomes and their microbial communities will have low bacterial richness and diversity (Azad et al., 2013). This means their microbial community will lack the most dominant microbe *Lactobacilli* and all the other natural vaginal microbiomes from the mother. Lack of vaginal exposure leads to first microbial communities resembling human skin microbes with abundance of *Staphylococcus spp* and cause babies to develop health issues (e.g. asthma, allergies, diabetes, ect.) later in life (Dominguez-Bello et al., 2010).

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Caesarean Delivery Long-term Effects on Baby

Direct transmission of vaginal microbiomes to baby may serve as defensive role against other harmful pathogens and colonizing bacteria (Dominguez-Bello et al., 2010). Without that interaction, the baby will lack microbiomes that will help create a robust immune system. Bacteria exposed to human immune cells trigger immune cells to start dividing and multiplying to fight off harmful pathogens. These immune cells produce antibodies to fight disease. Babies get these bacteria from their mother's vaginal canal. Kero, Jukka et al., 2002 completed a study called The Finnish Birth cohort to evaluate the occurrence of atopic diseases between modes of delivery. 164 mothers, who had given birth by C-section, were randomly selected along with a control group of 164 mothers who had given birth by vaginal delivery (total of 328 mothers). Questionnaires about symptoms of atopic diseases were given and only 219 subjects responded and brought in for clinical examinations. Results showed that the risk of asthma was significantly higher in children, at the age of seven, born by C-section than vaginal delivery (Kero, Jukka et al., 2002).

C-sections can lead to differences in microbial succession patterns in gut and other body habitats that persist over time. Dominguez-Bello et al., found that when intestinal colonization of *Lactobacillus* is delayed it can lead to complications in immune functioning and development which puts the baby at higher risk of allergies and asthma (Dominguez-Bello et al., 2010). C-sections can affect the composition of early-life colonization of bacteria in the gut which increases the risk of asthma, allergies and eczema (Stokholm et al., 2016). Disruption of the mother to newborn bacteria transmission increases the risk of celiac disease, asthma, type 1 diabetes and obesity because of the disruption of the neonatal microbiome how shown? (Mueller et al., 2015). A different mix of colonizing microbes were found in the digestive tract of babies birthed by C-section than vaginally. The colonizing microbes of babies born by C-section, lack microbes needed to develop the immune system which will make the babies more susceptible to diseases (e.g. allergies, asthma, diabetes). Roduit, Caroline et al., 2015 completed a study investigate if children born by C-section were more at risk of having asthma. They followed 2917 children for 8 years who participated in a birth cohort study. Results did show that C-sections were associated with increased risk of asthma.

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Make-up for Lack of Vaginal Microbiomes

Scientists are working on ways of restoring the maternal vaginal communities to C-sectional delivered babies. For now, direct manipulation (e.g. breastfeeding and antibiotics) of the infant microbiome is an alternative and method of restoration (Mueller et al., 2015).

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Breastfeeding

The breast milk from mothers is rich in microbes. Scientists found that microbes, such as *Lactobacillus,* in moms' digestive tract will make their way to the mother's milk during pregnancy. Mueller et al., sampled mothers' breast milk in multiple clinical trials and found that breastfeeding introduces new microbial communities to a baby birthed by C-section. This means when the mother gets ready to breastfeed her baby. The baby will obtain the natural microbes that they lacked from having a C-section. It is the postnatal route of mother to baby bacterial transmission. Breastfeeding stimulates maturation of the neonatal gut microbiome community which will assist in the development of the immune system. Breastfeeding has become one of the most effective preventive measures against childhood and adult diseases (Dietert, Rodney R. 2013). Dietert stated that in the early 20th century, there was an increase in breastfeeding due to primary health concerns for acute illness such as pneumonia (Dietert, Rodney R. 2013). Recently, breastfeeding has been used as a prevention of chronic diseases such as asthma and allergies. Mueller et al., found that breastmilk contains sugar polymers and human milk oligosaccharides (HMOs) that promotes specific microbial communities (e.g. *Bifidobacteria*) to grow in infants' guts. These microbes are important for promoting inflammatory responses, preventing pathogen growth, and providing infants with a stable and uniformed gut microbiome. (Mueller et al., 2015). Mothers can make sure their milk is rich in microbes by eating a healthy diet that contains natural occurring probiotics, such as yogurt that contains active cultures. If the mother is not able to breastfeed, there are donor breast milk banks and/or prebiotic formulas available as alternatives (Mueller et al., 2015).

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Vaginal Seeding

Recent studies are being completed on vaginal seeding as a method of restoration of microbiomes to infants born by C-section. After delivery, the doctor will directly transfer vaginal fluid to the newborn by swabbing the vaginal canal of mom and rubbing it on the newborn's mouth, eyes, and skin. This will help the newborn to stimulate and develop microbiomes (e.g *Lactobacillus, Prevotella, and Bifidobacteria*) like babies born vaginally. Jennifer C. Frankel discussed (where) how Dr. Maria Gloria Dominquez-Bello studied microbiomes for years trying to determine if C-section babies can benefit a vaginal birth through the process of seeding with gauze incubated in mom's vaginal bacteria (Frankel, Jennifer C., 2016). Dr. Dominquez-Bello visited Puerto Rico with fellow colleagues where they completed clinical trials on mothers scheduled to have C-sections. They had doctors place a sterile gauze inside the vaginal canal of moms an hour before delivery. Then they placed it in a sterile container till the procedure was over. Three minutes after the newborn was delivered, the doctor would take the gauze with the mom's vaginal fluid and rub it all over the newborn's body. They sampled and analyzed the newborn's microbial community over the next 30 days and found that the vaginal seeding was effective. Samples of the baby's skin, anus, and mouth revealed a transition from environmental microbe communities to vaginal communities. Even though it showed an effect, there were still some issues with the restoration method. Because the gauze was rubbed on the baby's body and not ingested, the baby's gut showed less of an affect than their other body parts (Frankel, Jennifer C., 2016). So, further research and larger sample sizes must be constructed to fully understand the effect of vaginal seeding on C-sectional babies.

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CONSLUSIONS AND FUTURE DIRECTIONS

Microbiomes play a major role in the human body. They protect the human body from pathogens, reduce the risk of obtaining different diseases, assist in the development and maintenance of the immune system, break down food for energy and help the body access nutrients in digested food, produce natural vitamins, and overall maintain a functional human body. Without certain microbes, the body is left exposed and unprotected for harmful microbes. Microbes first start to colonize in humans in the womb of their mothers. Depending on the mode of delivery either by vaginal or C-sectional, both play a major role in the transmission of microbiomes from mother to newborn. The literatures and studies reviewed in this paper show that the mode of delivery can have an immediate and a future effect on the composition and the colonizing microbiomes. However, the lack of microbes from C-sectional deliveries can be restored through means of breastfeeding and vaginal seeding. This may not strengthen the baby's GI tract, but it would strengthen the baby's skin, anus, and mouth. To prevent the development of chronic diseases such as asthma, allergies, and diabetes in the baby's future, vaginal birth can provide the baby with all the microbiomes needed to live a strong healthy life.

Future work is still needed to prove that the mode of delivery affects the colonization of microbiomes. Other factors such as the use of antibiotics during pregnancy, the diet of the mother during pregnancy, and/or the mother having vaginal infection(s) may need to be considered when trying to compare the colonization of microbiomes to delivery mode. Majority of the experiments, mentioned in this literature review, consisted of small sample sizes of newborns and their mothers. It is possible that the small sample sizes could make the results bias and inaccurately representing all women delivering their newborns vaginally or by C-section. More focus is needed on the effects of C-sectional deliveries on babies' developing health. The literature reviewed throughout this paper does not state exactly how C-sectional deliveries cause diseases such as asthma, diabetes, and/or allergies, so further analysis and studies need to be completed. More research is needed to determine whether other factors (e.g. antibiotics and formula feeding), along with mode of delivery, can cause babies to develop diseases such as asthma, diabetes, and allergies. Further research can also go into methods used to restore vaginal microbes to C-sectional babies. Even

Commented [LH53]: I rewrote

Commented [LH54]: Add one or two sentences about future work and studies and experiments needed to support the information provided in your essay. But include it into the paragraph above.

This who paragraph starting with Future can be deleted. It's only repeating and contradicting your purpose and points made throughout your essay. Do not contradict in your own essay or you will make readers think you don't know what you're talking about. Or may not be able to trust what you're saying.

Commented [LH55]: This sounds like you are contradicting yourself. You should stick with your theory and support it. You can put more research needs to be done, but the whole purpose of this essay was to express how the lack of microbes can cause future diseases.

though breastfeeding and vaginal seeding can help, there must be other ways in which restoration can be completed. Vaginal seeding is currently being introduced to mothers delivering their babies by C-section, but more information is needed in order to fully understand the effect it has on newborns born by C-section. Also, it would be nice to see the connection of this restoration method with the developing health of babies. With the advancement of technology, scientist should be able to further their research on mode of delivery and its effects on infants' microbiome communities.

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Note to you my precious sister.

- Overall, great research and essay. I enjoyed learning about microbiomes. However, for word count purposes, I think you included a lot of repeating.
- Delete the repeating.
- Combine some sentences and points made in different paragraphs.
- The Abstract section sounds more like the Introduction. Short and sweet but identifying exactly what you will be discussing in the paper. I don't understand how the Introduction part is an introduction. It just sounds like the beginning of a good essay. The Abstract sounds more like a thesis and introduction. But if that's how your prof wants it then, it's okay.

- Use one study/experiment for every subtopic instead of three. It can be confusing. Name the studies. Study A, Study B, Study D and give scientist or researcher or group name for credit for the work they've done. Give the exact number or group of women you are talking about. Give the groups of women names. Ec. Group A- women who did vaginal birth and Group B who did c-sectional and so on. Use another letter for the different studies etc.
- For your examples in parenthesis. Try and include into the sentence or paragraph. You are trying to make a point and there's no reason to isolate your examples.
- Put definition or short explanation for all new terminology around the first time they are mentioned. So, the rest of the essay, you do not need to restate.
- Cut your paragraphs.
- Also for the conclusion- exclude contradictions. You want to stand your ground and support what you've found. You believe that vaginal deliveries are healthier than c-sectional. You can say more studies need to be done or still are occurring as technology or medical practices grows or something like that.

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