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Development of the Infant Gut Microbiome: An Empirical Survey of Prenatal Practitioners

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Abstract

The critical window of infant gut microbiome development (IGMD) is preconception through three years of age. The improper development of the infant gut microbiome contributes to the rise of chronic illness. The literature provides no evidence that prenatal care practitioners educate patients about the critical window of IGMD. The purpose of this empirical study is to investigate knowledge of prenatal care practitioners (obstetrical and gynecological physicians, nurse practitioners, midwives, and doulas) about IGMD and how they use this knowledge in their practices. Seventy-eight registered prenatal care practitioners from Minnesota participated in an online survey consisting of 18 qualitative and quantitative questions. The researchers used descriptive statistics and summative content analysis to answer two aims: to describe prenatal care practitioners' breadth of knowledge about IGMD and to describe how prenatal care practitioners apply information about IGMD with their patients. Some participants (32%) report having knowledge about the critical window of IGMD. Forty-one percent of participants do not educate their patients about the critical window of IGMD. These findings suggest most prenatal care practitioners are not knowledgeable about the critical window; therefore, they do not educate their patients. Replicating and improving upon this pilot study will increase understanding of how practitioners' knowledge and how patient education can influence optimal development of the infant gut microbiome to reduce the rise of chronic illness.

Keywords: chronic illness, gut health, infant development, gut microbiome, prenatal care, pregnancy

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Dedication

For Poppy.

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Introduction

The human body is made up of four major microbiomes: genital, skin, oral, and gut (Christian et al., 2015; Huse, Ye, Zhou, & Fodor, 2012). Each biome consists of a mini ecosystem of microorganisms that include a diverse array of bacteria and pathogen intelligence (Eckburg et al., 2005; Huse, et al., 2012; Huttenhower et al., 2012; Knight, 2014; Palmer, Bik, DiGiulio, Relman, & Brown, 2007; Peterson et al., 2009). In fact, The National Institutes of Health's Human Microbiome Project (2012) determines that the human body hosts 10,000 more microorganisms than human cells (Azad et al., 2013; Huttenhower et al., 2012; Palmer et al., 2007; Peterson et al., 2009). The discovery that we are more bacteria than cells demonstrates the need to understand the importance of microbiome development. Specifically, the gut microbiome is the most influential of the microbiomes and is foundational to human health and wellness (Dethlefsen, Huse, Sogin, & Relman, 2008; Dominguez-Bello et al., 2010; Golubeva et al., 2015; Palmer et al., 2007; Zijlmans, Korpela, Riksen-Walraven, de Vos, & de Weerth, 2015). The gut microbiome is housed in the stomach, small intestine, and colon, and is responsible for many bodily functions such as immune regulation, hormone responses, and metabolizing nutrients (Huse et al., 2012; Huttenhower et al., 2012; Knight, 2014). Gut microbiota is the microbial flora within the gut, and the gut microbiome is the collection of all qualities of the specific microbiota, including their genetic material and surrounding environment (D'Argenio & Salvatore, 2015; Huttenhower et al., 2012; Peterson et al., 2009). Many developmental factors, including maternal and infant diet, pharmaceutical use, environment, stress, and genetics determine the unique gut microbiome composition of every human (Eckburg et al., 2005; Koenig et al., 2011; Palmer et al., 2007; Zijlmans et al., 2015). Therefore, no two gut microbiomes are alike (Huttenhower et al., 2012; Palmer et al., 2007; Peterson et al., 2009).

Current researchers are emphasizing the role of the gut microbiota in maintaining human health because the gut symbiotically participates in many important functions of the body, including metabolizing and digesting nutrients and drugs, hormone regulation, and immune system development and function (Dethlefsen et al., 2008; Dominguez-Bello et al., 2010; Golubeva et al., 2015; Palmer et al., 2007; Zijlmans et al., 2015). Because the gut microbiome participates in many important bodily functions, a compromised gut microbiome affects human health and well-being (Ghaisas, Kanthasamy, & Maher, 2016; Kamada, Chen, Inohara, & Nunez, 2013).

Improper development of the gut microbiota during infancy leads to gut dysbiosis, which is implicated in the development of chronic illness (Cassidy-Bushrow et al., 2016; Ghaisas et al., 2016; Koenig et al., 2011; Oriach, Robertson, Stanton, Cryan, & Dinan, 2016; Rinne et al., 2005; Scher et al., 2015; Ubeda et al., 2012; Walker & Lawley, 2013). Furthermore, an epidemic of chronic illness, such as depression, irritable bowel syndrome (IBS), autoimmune disease, asthma, and allergies is affecting many Americans (Christian et al., 2015; Kavuri, Nagarathna, Malamud, & Selvan, 2015). Autoimmune diseases are among the most prevalent diseases in the United States, affecting more than 23.5 million Americans (National Institutes of Health, 2012). Globally, the most common functional gastrointestinal disorder is IBS (International Foundation for Functional Gastrointestinal Disorders, 2016). In the United States, Americans spend approximately 21 billion dollars annually on functional gastrointestinal drugs (Hulisz, 2004). Protection and healthy development of the IGM could be crucial to averting these chronic ailments.

Preconception to about three years of age is the critical window for IGMD in the early stages of life (Allen-Blevins, Sela, & Hinde, 2015; Cassidy-Bushrow et al., 2016; Heijtz et al.,

2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). This critical window of opportunity is foundational to develop a fully functional, healthy IGM. At about age three, the infant gut becomes adult-like, and although the gut microbiome composition will shift throughout life, if it is improperly developed, it cannot be fully restored (Arrieta, Stiemsma, Amenyogbe, Brown, & Finlay, 2014; Azad et al., 2013; Koenig et al., 2007; Palmer et al., 2007; Rinne et al., 2005). Prenatal factors that affect infant gut microbiota development include mother's nutrition, environmental exposure, mode of delivery, nutrition, and pharmaceutical exposure (Cabrera-Rubio et al., 2012; De Filippo et al., 2010; Dethlefsen et al., 2008; Dominguez-Bello et al., 2010; Schnorr et al., 2014; Sellitto et al., 2012; Vitali et al., 2012; Wu et al., 2011; Zaura et al., 2015; Zijlmans et al., 2015).

Prenatal care practitioners are the primary care providers who work with pregnant women (Hamilton, Martin, Osterman, Curtin, & Mathews, 2015). Prenatal care practitioners have an important role influencing the development of the IGM during the critical window. However, our search of the literature finds no information about the focus prenatal care providers have on IGMD in their practices.

The purpose of this research project is to describe what prenatal care practitioners (obstetrical and gynecological physicians, nurse practitioners, midwives, and doulas) know about IGMD and how they are using the knowledge in their practice. We begin our research process by examining the current literature relevant to the development of the IGM. Next, we articulate our research lenses. Then, we discuss our research method, research results, and then discuss the interpretation and implications of our findings.

Literature Review

The purpose of this chapter is to review the current research regarding the development of the IGM. First, we explain the current research about the human microbiome. Then, we explore the importance of the gut microbiome. Next, we examine gut dysbiosis and the factors that influence the gut microbiome. Lastly, we investigate the critical window of IGMD. We conclude with a summary and our research purpose.

The Human Microbiome

The human genome is the complete set of all 23 human chromosomes (National Genome Research Institute, 2007); scientists have primarily focused on studying these 20,000 to 25,000 genes to learn how the body is structured and functions. However, further study of the human genome led to the discovery that bacteria is a significant factor in learning how the body operates (Azad et al., 2013; Huttenhower et al., 2012; Konkel, 2013; Palmer et al., 2007; Peterson et al., 2009). Bacteria in the body contain around 150 times more distinct genes than the human genome (National Genome Research Institute, 2007). The discovery of the symbiotic relationship between the genome and bacteria changed the way we understand human health (Azad et al., 2013; Huttenhower et al., 2012; Konkel, 2013; Palmer et al., 2007; Peterson et al., 2009; Qin et al., 2010)).

These trillions of microbes make up the human microbiome (Azad et al., 2013; Huttenhower et al., 2012; Konkel, 2013; Palmer et al., 2007; Peterson et al., 2009; Qin et al., 2010). Lederberg and McCray (2001), established the term the human microbiome which, “Signifies the ecological community of commensal, symbiotic, and pathogenic microorganisms that share our body and space" (p. 8). Simply stated, a microbiome is a community of microorganism species that create a habitat and intelligence (D’Argenio & Salvatore, 2015;

Huttenhower et al., 2012; Knight, 2014; Peterson et al., 2009).

The human body is made up of four major microbiomes: oral, skin, genital, and gut (Christian et al., 2015; Huse et al., 2012). Microbial ecologist Knight (2014) points out that the gut is the most fundamental biome to health and well-being because most of the bacteria in the body reside in the digestive tract. The gut microbiome symbiotically participates in many important functions of the body, including metabolizing and digesting nutrients and drugs, hormone regulation, and immune system development and function (Azad et al., 2013; Cassidy-Bushrow et al., 2016; Oriach et al., 2016; Peterson et al., 2009).

The Importance of the Gut Microbiome

Palmer et al. (2007) find that what constitutes a healthy gut microbiome is complex. Guarner & Malagelada (2003) and Palmer et al. (2007) estimate there are up to 500 bacterial species (beneficial and pathogenic) existing in the adult gut. Previously, microbiology has focused on studying disease-causing pathogens in the gut, with less focus on the beneficial microbes (Peterson et al., 2009). However, Guarner & Malagelada (2003), Palmer et al. (2007), and Peterson et al. (2009) suspect further research will identify an even larger number of species. In this section, we explain the importance of the gut microbiome by discussing how the gut microbiome participates in many important functions of the body. First, we discuss how the gut microbiome metabolizes and digests nutrients. Next, we discuss the gut microbiome and the immune system relationship. Lastly, we discuss the gut-brain axis theory.

Metabolizing and digesting nutrients. The intestinal microbiota composition affects the function of metabolizing and digesting nutrients (Walker & Lawley, 2013). There is a clear symbiotic relationship between the gut microbiota, diet, and immune and inflammatory responses that affect overall host health (Ferraris, 2001; Hooper et al., 2001; Maslowski et al.,

2009; Walker & Lawley, 2013). The gut bacteria are an essential component of metabolizing nutrients (Bergman, 1990; Hooper et al., 2001).

Carbohydrates are the most critical form of nutrients for gut microbiota diversity (Ferraris, 2001). Humans receive energy through nutrients in carbohydrates including monosaccharides, disaccharides, and polysaccharides (Bergman, 1990; Hooper, 2002). The intestinal wall quickly absorbs monosaccharide and disaccharide carbohydrates. However, there need to be gut bacteria to break down the complex polysaccharide carbohydrates (Hooper, 2002).

Polysaccharides are essential for the diet, as they become 60-75% of the energy for the body through short-chain fatty acids (SCFAs) (Bergman, 1990). The concentration of the SCFAs' range depends on diet. The predominant SCFAs are acetate, propionate, and butyrate, all of which are found in the fiber of starchy vegetables (Walker & Lawley, 2013; Hooper et al., 2001). Segain et al. (2002) find that butyrate inhibits inflammatory responses specific to Crohn's disease. Hooper et al. (2001) further demonstrate that the efficacy of gut bacteria fermentation of SCFAs can determine the effectiveness of the host's immune response regulation. Intake of fermentable dietary fiber SCFAs, particularly acetate and propionate, in mice played a critical role in controlling inflammation and overall immunity (Maslowski et al., 2009). The gut bacteria are an essential component of metabolizing nutrients (Bergman, 1990; Hooper et al., 2001). There is a clear symbiotic relationship of the gut microbiota, diet, and immune and inflammatory responses that affect overall host health (Ferraris, 2001; Hooper et al., 2001; Malowski et al., 2009; Walker & Lawley, 2013).

Immune system. Guarner & Malagelada (2003) and Konkel (2013) point out that approximately two-thirds of immune cells in the body reside in the gut microbiome. The balance of beneficial and pathogenic microbes in the microbiome influences the immune system

(Huttenhower et al., 2012; Kamada et al., 2013; Peterson et al., 2009). Homeostasis happens when the beneficial microbes and pathogenic microbes are balanced, allowing the body's immune cells in the gut to effectively combat non-self-pathogens (Konkel, 2013; Kramer et al., 2013). The immune system functions to fight infection, disease, and allergens (Kramer et al., 2013); therefore, it is important to understand how bacterial populations build a properly functioning immune system (Guarner & Malagelada, 2003; Rinne et al., 2005; Sellitto et al., 2012). Strachan (1989) founded the hygiene hypothesis theory, stating that very hygienic measures in early childhood and a lack of bacterial exposure might have consequences on immune system development and function. Another theory that helps to understand the human gut microbiome is the gut-brain axis theory (Barouei, Moussavi, & Hodgson, 2012; Dinan & Cryan, 2012).

Gut-brain axis. The gut-brain axis theory explains the critical role the gut microbiome can have on overall human health and well-being (Dinan & Cryan, 2012; Oriach et al., 2016). The gut-brain axis is a bi-directional communication pathway between the gastrointestinal system and the central nervous system (CNS) (Aziz & Thompson, 1998; Barouei et al., 2012; Dinan & Cryan, 2012; Oriach et al., 2016). Communication between the gut and the brain happens within the autonomic nervous system (ANS), specifically via the vagus nerve (de Lartigue, de La Serre, Barbier, & Raybould, 2011; Dinan & Cryan, 2012; Oriach et al., 2016).

The vagus nerve, the largest nerve of the ANS, plays a significant role in facilitating neurotransmitter and hormone signals between the gastrointestinal tract and the central nervous system (CNS) (Bravo et al., 2011; Hosoi, Okuma, & Nomura, 2000; Wang et al., 2002). This bi-directional pathway affects the immune and stress response systems (O'Mahony, Clarke, Borre, Dinan, & Cryan, 2015a). Imbalance or inflammation of this pathway between the gut

microbiome and the CNS can lead to a wide variety of physical effects. Physical effects include, but are not limited to, visceral pain, addiction, depression, anxiety, body temperature regulation, motor or cerebral control, circadian rhythm regulation, metabolizing of nutrients and drugs, inflammation, and IBS (Cryan & O'Mahony, 2011; Neufeld, Kang, Bienenstock, & Foster, 2011; O'Mahony et al., 2015a; Oriach et al., 2016;). This interdependent relationship helps to regulate behavior, digestion, and mood (Barouei et al., 2012; Heijtz et al., 2011; Konkel, 2013; Silk, Davis, Vulevic, Tzortzis, & Gibson, 2009). If the composition of the gut microbiome changes, this directly affects the brain, and if the brain changes, this directly affects the composition of the gut microbiome (Hosoi et al., 2000; O'Mahony, Clarke, Dinan, & Cryan, 2015b).

Allen-Blevins et al. (2015) and Cabrera-Rubio et al. (2012) demonstrate this bi-directional function of the gut-brain axis by observing mood changes in infants as a result of manipulating microbes in the mother's milk. Christian et al. (2015) also demonstrate the importance of early gut-brain axis development by observing mood changes in toddlers in relation to their gut microbiota composition. Understanding the gut-brain axis theory establishes a connection between chronic illness and gut dysbiosis (Aziz & Thompson, 1998; Dinan & Cryan, 2012; Oriach et al., 2016). The gut-brain axis theory is an explanation as to why gut dysbiosis affects a significant amount of functions in the body (Aziz & Thompson, 1998; Dinan & Cryan, 2012; Oriach et al., 2016).

Gut Dysbiosis

Gut dysbiosis occurs from antibiotic use, poor nutrition, stress, or environmental toxins that directly affect proper gut functioning (Ghaisas et al., 2016; Oriach et al., 2016; Scher et al., 2015; Ubeda et al., 2012; Walker & Lawley, 2013). Kamada et al. (2013) explain that gut dysbiosis as an imbalance of microbiota population in the gut, which can lead to an overgrowth

of disease-causing pathogens (p. 689). Walker & Lawley (2013) expand on Kamada et al.'s (2013) work and describe gut dysbiosis in more depth: "Dysbiosis of the gut microbiome has been implicated in numerous disorders, ranging from intestinal maladies, such as colorectal cancer and inflammatory bowel disease, to systemic diseases such as diabetes, metabolic syndrome, and atopy" (p. 75). Several factors influence the composition of the gut microbiome and a compromised gut can affect the functions of the stress response, brain development, and neurotransmitter growth (Barouei et al., 2012; Clarke, O'Mahony, Dinan, & Cryan, 2014; Dinan & Cryan, 2012; Sudo et al., 2004).

Factors that Influence the Gut Microbiome

Factors such as nutrition, pharmaceuticals, microbial exposure, stress, environmental toxins, and genetics can alter the gut microbiome (Cabrera-Rubio, 2012; De Filippo et al., 2010; Dethlefsen et al., 2008; Dominguez-Bello et al., 2010; Konkel, 2013; Schnorr et al., 2014; Sellitto et al., 2012; Vitali et al., 2012; Wu et al., 2011; Zaura et al., 2015; Zijlmans et al., 2015;).These factors are constantly shifting the balance of commensal*s* and pathobiont*s* species in the gut (Chow, Tang, & Mazmanian, 2011; Kamada et al., 2013). Commensals, the dominant beneficial bacterial species, and pathobionts, the pathogenic species, help to maintain a healthy gut balance (Chow et al., 2011; Kamada et al., 2013). Understanding in more detail how some of these factors change the balance of commensals and pathobionts is essential. In this section, we explore the factors that influence the gut microbiome such as nutrition and diet, antibiotics, stress, probiotics and prebiotics.

Nutrition and diet. Diet is a major determinant of bacterial colonization in the gut microbiome (De Filippo et al., 2010; Schnorr et al., 2014; Wu et al., 2011). Turnbaugh et al. (2009) demonstrate consuming higher amounts of sugar and fat altered the bacterial structure and

gene expression of the microbiome. Wu et al. (2011) expand on this research by examining how diet specifically affects the gut microbiome composition. In this cross-sectional study, researchers collected 98 fecal samples and dietary questionnaires from healthy volunteers. Researchers placed ten of these volunteers on a controlled diet to compare high-fat/low-fiber diets to low-fat/high-fiber to determine the influence on gut microbiome composition. Wu et al. (2011) find that specific bacterial strains associate with different nutrients in the diet, and the microbiome composition can shift within 24 hours after eating a controlled diet. However, only long-term diets correlate with distinct clusters of bacterial strains. Long-term diets versus short-term diets are the only therapeutic intervention to restore a compromised gut microbiome.

De Fillipo et al. (2010) and Schnorr et al. (2014) show how dietary patterns correlate with specific clusters of bacterial strains by demonstrating that microbial structure varies across cultures depending on diet. De Fillipo et al. (2010) compare the diets of African children consuming low-fat and high-fiber with little animal protein, to European children eating a high-fat diet high in animal protein. The findings from this study show a different bacterial strain dominate African children's gut microbiome compared to the European children. Furthermore, African children have greater beneficial bacteria diversity and less pathogenic microbes in the gut microbiome than the European children (De Fillipo et al., 2010).

De Filippo et al. (2010) and Maslowski and Mackay (2011) further state that the standard American diet, mainly consisting of industrialized red meat, high trans fats, processed carbohydrates, and sugar may result in compromised gut microbiota diversity. Lack of gut microbiome diversity may be related to an increase in illness, including cardiovascular disease, obesity, diabetes, chronic stress, allergies, and autoimmune diseases (Cassidy-Bushrow et al., 2016; Koenig et al., 2011; Oriach et al., 2016; Rinne et al., 2005; Walker & Lawley, 2013).

Sellitto et al. (2012) explore the link between gut microbiome diversity and dietary sensitivities by researching how the age of gluten introduction affects the child's gut. Sellitto et al. (2012) find that infants are more likely to develop antibodies against gluten if introduced to gluten at six months rather than at twelve months; therefore, gut microbiome diversity may contribute to food sensitivities. Nutrition influences the gut microbiome as well as antibiotics (De Filippo et al., 2010; Dethlefsen et al., 2008; Dethlefsen, Relman, & Gordon, 2011; Rashid et al., 2015; Schnorr et al., 2014; Walker & Lawley, 2013; Wu et al., 2011; Zaura et al., 2015).

Antibiotics. Antibiotic use can cause an array of side effects including chronic diarrhea, Clostridium difficile, colitis, asthma, and allergies (Dethlefsen et al., 2008; Mueller, Bakacs, Combellick, Grigoryan, Dominguez-Bello et al., 2015; Rashid et al., 2015). A less diverse and imbalanced gut microbiome, a shift in bacterial species, as well as potential for a buildup of antibiotic resistance can be a result of antibiotic use (Dethlefsen et al., 2008; Dethlefsen et al., 2011; Rashid et al., 2015; Walker & Lawley, 2013; Zaura et al., 2015). To better understand how antibiotics disturb the gut, Dethlefsen et al. (2008) examine fecal samples from three healthy adults before, during, and after a standard antibiotic prescription of *ciprofloxacin*. The results confirm that antibiotics have an intense effect on the microbiome composition, decreasing up to one-third of the bacterial diversity. Some bacteria strains regained normal levels within a few weeks, while some bacterial strains did not recover until six months later (Dethlefsen et al., 2008).

The antibiotic resistance theory demonstrates that the excessive use of antibiotics in our food, environment, and pharmaceuticals result in drug-resistant bacterial strains (Cantas et al., 2013; Dethlefsen et al., 2008). Which in turn limits the function of the gut microbiota, resulting in chronic illness and permanently altering intestinal microbiota (Cantas et al., 2013; Dethlefsen

et al., 2008). Zaura et al. (2015) demonstrate that a dramatic shift took place in the gut after antibiotic treatment of *clindamycin, ciprofloxacin, amoxicillin, and minocycline* in 66 healthy human adults, resulting in an increased number of microbes associated with antibiotic resistant genes. Specifically, clindamycin reduced microbiome diversity up to four months, and ciprofloxacin reduced diversity for up to twelve months (Zaura et al., 2015). Dethlefsen et al. (2008) further demonstrate treatment of ciprofloxacin reduced a third of the microbiome diversity, and in some individuals, certain bacterial strains never recovered at six months post-treatment. Evidence from these studies highlight the consequences of antibiotic use, even after just one round of treatment (Dethlefsen et al., 2008; Zaura et al., 2015). Antibiotic use influences the gut microbiome as does stress (Bailey, Lubach, & Coe, 2004; Bailey et al., 2010; Bailey et al., 2011; Knowles, Nelson, & Palombo, 2008)

Stress. Stress can cause a decrease in bacterial diversity and beneficial microbes and an increase in microbes associated with pathogens (Bailey et al., 2004; Bailey et al., 2010; Knowles et al., 2008). Bailey et al. (2011) find that exposure to social stressors can affect bacterial populations in the gut. Bailey et al. (2010) conducted further research with mice to demonstrate the effects of stress on the gut microbiome. Researchers injected mice with pathogens and exposed them to varying levels of stress to study gut microbiome composition (Bailey et al., 2010). Mice exposed to stressors for one week appeared to have an overgrowth of anaerobic bacteria and overall reduced microbial diversity (Bailey et al., 2010).

Knowles et al. (2008) examine how stress affects the gut in an undergraduate student population. Researchers collected salivary samples, stool samples, and perceived stress questionnaires from 23 students during two separate periods of their semester to determine how stress affects bacterial activity. Consistent with the findings of the Bailey et al. (2010) mice

study, Knowles et al. (2008) also find that students who experience high stress during a week of intense testing had less bacterial diversity than during a week of less perceived stress. Stress factors can compromise the gut and lead to dysbiosis (Ghaisas et al., 2016; Oriach et al., 2016). Probiotics and prebiotics are a treatment option to help restore microbial balance in the gut (Gibson & Roberfroid, 1995; Rinne et al., 2005; Scher et al., 2015; Walker & Lawley, 2013).

Probiotics and prebiotics. Gibson & Roberfroid (1995) define probiotics as "Microbial food supplements that beneficially affect the host by improving its intestinal microbial balance" (p. 1401). Probiotics are mixtures of beneficial bacterial strains including, but not limited to, *Lactobacilli* and *Bifidobacteria* (Ghaisas et al., 2016). Probiotics stimulate the immune response and interactions between the gut bacteria (Ghaisas et al., 2016). Evidence suggests that specific probiotic treatments can be helpful in addressing disorders related to gut dysbiosis such as colitis and antibiotic associated diarrhea (De Vrese & Marteau, 2007; Johnston, Goldenberg, Vandvik, Sun, & Guyatt, 2011; Deshpande, Rao, Patole, & Bulsara, 2010). Targeted probiotic strains such as psychobiotics are a therapy that benefit mental health by enhancing brain function (Oriach et al., 2016).

Prebiotics are, "Indigestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacterial species already resident in the colon, and thus attempt to improve host health" (Gibson & Roberfroid, 1995, p. 1401). Prebiotics typically include inulins (polysaccharides in plant-based food) and *fructose-*, *galactose-*, and *xylooligosaccharides,* which all help to promote the growth of beneficial bacteria (Langlands, Hopkins, Coleman, & Cummings, 2004). Prebiotics also increase production of SCFAs and stimulate the growth of beneficial bacteria that can protect against pathogens like E. Coli and Clostridium difficile (De Vrese & Marteau, 2007; Fukuda et al.,

2011). Nutrition, diet, antibiotics, stress, probiotics and prebiotics can influence the gut over a lifetime. However, the critical window is the most fundamental period to prepare, form, and protect the gut microbiome for optimal functioning throughout life (Azad et al., 2013; Dethlefsen et al., 2008; Palmer et al., 2007; Zijlmans et al., 2015; Zaura et al., 2015).

Critical Window of IGMD

The initial colonizers of the IGM are imperative to later health outcomes because they determine the future habitat of the adult gut (Allen-Blevins et al., 2015; Cassidy-Bushrow et al., 2016; Heijtz et al., 2011; Hooper et al., 2001; Koenig et al., 2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). There are many factors that influence the early stages of IGMD. (De Filippo et al., 2010; Dethlefsen et al., 2011; Palmer et al., 2007; Zijlmans et al., 2015). In this section, we explore the factors that influence the gut microbiome such as prenatal care practitioners, prenatal nutrition, prenatal stress, prenatal antibiotics, prenatal probiotics and prebiotics, labor and birth, and infant feeding. Before looking at these factors, we describe researchers' understanding of the modes and timing of IGMD during the almost-four-year critical window.

Previous to the discovery of the critical window of IGMD, research dating back 30 years states that microbial colonization begins at birth, meaning the infant's gut was sterile in utero (Bailey et al., 2004; D'Argenio & Salvatore, 2015; Palmer et al., 2007; Prince, Antony, Chu, and Aagaard, 2014). Zijlmans et al. (2015) challenged the belief that the infant's gut was sterile in utero by conducting the first study linking human maternal stress to microbial alterations in the human infant gut, bringing new evidence that the infant begins microbial colonization in utero. Prince et al. (2014) conduct a systematic review demonstrating that bacteria in utero influences the infant development. Prince et al. (2014) also find that bacteria is present in placental tissue,

amniotic fluid, and umbilical cord blood. Aagaard et al. (2014), Fardini, Chung, Dumm, Joshi, and Han (2010), and Stout et al. (2013) demonstrate that the placenta has a microbiome, which influences infant microbiota development.

Today, researchers identify a critical window of development for the IGM beginning at preconception and lasting until about three years of age (Allen-Blevins et al., 2015; Cassidy-Bushrow et al., 2016; Heijtz et al., 2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). The infant gut microbiome is adult-like at age three, and if it is improperly developed it cannot be fully restored (Arrieta et al., 2014; Azad et al., 2013; Koenig et al., 2007; Palmer et al., 2007; Rinne et al., 2005).

Prenatal care practitioners. Medical professionals have a role in educating mothers about the factors of the critical window of IGMD (Center for Disease Control [CDC], 2014a). Specifically, prenatal care professionals are the first potential practitioner to influence infant development (CDC, 2014a). A woman's first prenatal visit is around eight weeks after her last menstrual period (American Pregnancy Association, 2017). There is currently no evidence in the literature that prenatal care practitioners are focusing on educating their patients about the gut microbiome (Knight, 2014). It is important to investigate if and how prenatal care practitioners are applying education in their practice because they are the first practitioner to influence infant development (CDC, 2014a).

Prenatal nutrition. Nutrition for the mother is important for proper gut development for the infant (Thum et al., 2012). The Western diet compromises the development and compromises the proper functioning of the gut microbiome (De Filippo et al., 2010; Maslowski & Mackay, 2011; Oriach et al., 2016). The World Health Organization (WHO) (2007) provides specific advice for prenatal care practitioners to guide healthy eating for pregnant women. However,

researchers show there is a lack of nutrition education in prenatal care (Lucas, Charlton, & Yeatman, 2014). In a systematic review about nutrition advice given during pregnancy, prenatal care practitioners perceive nutrition as important but are lacking time, resources, and training to include nutrition in their practices (Lucas et al., 2014). There is no research demonstrating that prenatal care practitioners are educating their patients about nutrition for the proper development of the IGM. Additionally, there is evidence that factors such as stress affect the development of the IGM (Bailey et al., 2011; Golubeva et al., 2015; O'Mahony et al., 2014; Zijlmans et al., 2015).

Prenatal stress. Acute stress in pregnancy occurs in all pregnant females because pregnancy is a major life change (Bailey et al., 2004; Golubeva et al., 2015). Physiological changes associated with chronic prenatal stress occur when the mother endures ongoing exposure to an adverse environment (Bailey et al., 2004; Golubeva et al., 2015). Bailey et al. (2004) define prenatal stress as chronically elevated cortisol levels during pregnancy. Golubeva et al. (2015) further point out that prenatal stress can result in psychosocial responses, such as depression and anxiety. Bennett, Einarson, Taddio, Koren, and Einarson (2004) explore chronic prenatal stress and find that of 432 pregnant women, 59% reported anxiety and 19% reported depression. The hypothalamic-pituitary-adrenal (HPA) axis, a neuroendocrine system that regulates cortisol levels, provides physiological context to the regulation of stress (Bailey et al., 2004; Golubeva et al., 2015). Elevated stress provokes a dysregulation of the HPA axis and an increase in cortisol (Barouei et al., 2012; Golubeva et al., 2015). Dysregulation of the HPA axis influences the gut-brain axis. Consequently, chronic stress and elevated cortisol can cause gut dysbiosis (Barouei et al., 2012; Ziljmans et al., 2015).

Evidence of maternal gut dysbiosis and dysregulation of the HPA-axis and the gut-brain axis alter the maternal gut microbiome, which can affect the bacterial colonization of the IGM and potentially lead to chronic illness (Bailey et al., 2011; Beijers, Jansen, Riksen-Walraven, & de Weerth, 2010; Golubeva et al., 2015; Lupien, McEwen, Gunnar, & Heim, 2009; O'Mahony et al., 2014; Zijlmans et al., 2015). Ziljmans et al. (2015) find altered gut bacterial colonization occurs in infants when mothers report chronic stress and demonstrate high levels of cortisol during pregnancy. Golubeva et al. (2015) further find that chronic prenatal stress raises blood pressure and damages cognitive function in rat offspring, compromising bacterial balance. Beijers et al. (2010) show that chronic maternal prenatal stress (anxiety) relates to infant respiratory and skin illness in the first year of life. Bailey et al. (2004), Lupien et al. (2009), and O'Mahony et al. (2014) and indicate that stressors early in life such as mother-infant separation are associated with increased anxiety, depression, and gastrointestinal disorders in animal offspring. Zijlmans et al. (2015) demonstrate that chronic prenatal stress can disrupt the infant's gut composition up to 110 days after birth. Prenatal stress influences IGMD as do antibiotics (Bailey et al., 2011; Beijers et al., 2010; Chang-Hung et al., 2013; Foliaka et al., 2009; Golubeva et al., 2015; Lupien et al., 2009; O'Mahony et al., 2014; Thomas et al., 2006; Zijlmans et al., 2015).

Prenatal antibiotics. Early-life exposure to antibiotics is correlated with an increase of chronic conditions such as allergies, eczema, and asthma (Chang-Hung et al., 2013; Foliaka et al., 2009; Strachan, 1989; Thomas et al., 2006). Limited findings exist in the literature of the implications of antibiotic use during pregnancy. One common reason for antibiotic use in pregnancy is group B Streptococcus (GBS), which occurs in approximately 35% of pregnant women (Cassidy-Bushrow et al., 2016). Although usually harmless in adults, GBS is a common

bacterial infection in the lower gastrointestinal tract of the mother and may cause serious illness, such as pneumonia, meningitis, and sepsis in infants if passed on during delivery (American Congress of Obstetricians and Gynecologists, 2011; Mayo Clinic, 2016; Cassidy-Bushrow et al., 2016). Infants born from mothers who are GBS positive show a shift in bacterial composition up to six months compared to infants born to mothers who are GBS negative (Cassidy-Bushrow et al., 2016).

To reduce GBS complications, health care providers often prescribe mothers antibiotics late in their pregnancy and in labor, which can influence the development of the IGM (Cassidy-Bushrow et al., 2016). GBS presence in pregnant females alters the vaginal microbiome, potentially influencing fetal gut development and posing a risk for chronic illness (Cassidy-Bushrow et al., 2016). Antibiotic use may be the only treatment option; therefore, probiotic and prebiotic supplements offer a potential solution for the implications of antibiotic use and of stress (Brantsaeter et al., 2011; Isolauri, Kirjavainen, & Salminen, 2002; Rinne et al., 2005; Vitali et al., 2012; Walker & Lawley, 2013).

Prenatal probiotics and prebiotics. Pregnancy changes hormone balance, influencing and potentially altering the maternal gut microbiota balance (Brantsaeter et al., 2011; Myhre et al., 2011; Vitali et al., 2012). Probiotics and prebiotics may be useful in restoring the balance of bacteria in the gut, benefiting both mother and infant (Brantsaeter et al., 2011; Myhre et al., 2011; Vitali et al., 2012). Prenatal practitioners can administer probiotics either to the mother during pregnancy and labor, or to the infant after birth (Dominguez-Bello et al., 2010; Mueller et al., 2015). Synbiotics (combined probiotics and prebiotics) administered to preterm babies result in an altered gut microbiota composition, reducing the babies' risk of developing a chronic condition and improving temperament (Dominguez-Bello et al., 2010; Mueller et al., 2015).

Barouei et al. (2012) demonstrate that probiotic intervention during pregnancy may potentially reduce the effects of stress on the infant after birth. Labor and birth also influence IGMD (Azad et al., 2013; Cabrera-Rubio et al., 2012; Dominguez-Bello et al., 2010; Fallani et al., 2010).

Labor and birth. The birthing process is one of the primary prenatal factors in determining the composition of the IGM (Azad et al., 2013; Cabrera-Rubio et al., 2012; Dominguez-Bello et al., 2010; Fallani et al., 2010). The two modes of delivery include a vaginal birth and cesarean section (American Pregnancy Association, 2016; Yang, Mello, Subramanian, & Studdert, 2009). Vaginal birth is the natural biological process of labor and is a foundational step for proper gut microbiome development (Dominguez-Bello et al., 2010; Kashtanova et al., 2015). The mother's beneficial vaginal microbes, primarily including *Bifidobacterium, Lactobacillus, Prevotella,* and *Sneathia,* are passed on to the infant when the infant is born vaginally (Aagaard et al., 2012, Dominguez-Bello et al., 2010; Mueller et al., 2015). Lactobacillus bacteria passes from the mother's vaginal canal during delivery and colonizes the infant's gut (Ghaisas et al., 2015; Prince et al., 2014; Rodriguez et al., 2015). Therefore, babies born by cesarean section have a different gut microbiome at birth (Azad et al., 2013; Dominguez-Bello et al., 2010).

Osterman & Martin (2014b) of The Centers for Disease Control (CDC) report about one-third of births every year are cesarean sections. Infants born via cesarean section have no exposure to vaginal and fecal microbes, acquiring bacteria primarily through the skin microbiome; therefore, infants born via cesarean section have a lower bacterial diversity (Dominguez-Bello et al., 2010; Jakobsson et al., 2014). Exposure to skin bacteria, primarily including *Staphylococcus, Corynebacterium,* and *Propionibacterium,* occurs when infants are born via cesarean section (Dominguez-Bello et al., 2010; Mueller et al., 2015). Thavagnanam,

Fleming, Bromley, Shields, and Cardwell (2008) find a 20% increased risk for asthma with infants born via cesarean section. Disruption of the infant's gut bacterial composition because of cesarean section increases the risk of numerous chronic health implications including asthma, celiac disease, diabetes, obesity, and allergies (Barros et al., 2012; Decker et al., 2010; Cho & Norman, 2010). Infant feeding is another influence of IGMD (Azad et al., 2013; Hernell, 2011; Hoppu, Isolauri, Laakso, Matomäki, & Laitinen, 2012; Le Huërou-Luron, Blat, and Boudry, 2010; Rinne et al., 2005).

Infant feeding. Breastmilk and formula feeding are factors in developing the IGM (Azad et al., 2013; Hernell, 2011; Hoppu et al., 2012; Le Huërou-Luron et al., 2010; Rinne et al., 2005). In the general population of hospital births, 49% of mothers are still breastfeeding at six weeks postnatal (CDC, 2014). Mode of delivery, hormones, weight gain, and lactation period significantly affect the microbiota diversity of the mother's breast milk (Cabrera-Rubio et al., 2012). Cabrera-Rubio et al. (2012) determine that human breast milk has a unique microbiome and demonstrate that mode of delivery alters breast milk composition, which is an important prenatal factor in IGMD.

In most cases, formula replaces human breast milk for mothers who do not breastfeed (Harmsen et al., 2000; Hoppu, et al., 2011; Rinne et al., 2005). However, Hernell (2011) and Le Huërou-Luron et al. (2010) point out that human breast milk is difficult to replicate. Human breast milk contains a complex combination of nutrients that influence the immune and digestive systems and provide protection from pathogenic gut microbes (Arrieta et al., 2014; Cabrera-Rubio et al., 2012; Harmsen et al., 2000; Hernell, 2011; Le Huërou-Luron et al., 2010; Rinne et al., 2005).

Arrieta, Stiemsma, Amenyogbe, Brown, & Finlay, (2014) demonstrate the microbial

complexity of human breast milk. *Oligosaccharides,* prebiotics found in breastmilk, are a critical component essential in stimulating the growth of beneficial gut microbes in infant and mother (Arrieta et al., 2014). Oligosaccharides help protect the infant from gastrointestinal illness such E. Coli (Allen-Blevins et al., 2015). Furthermore, Harmsen et al. (2000) find that breastfed babies have higher amounts of Bifidobacteria than formula-fed babies. Bifidobacteria correlates to beneficial health outcomes later in life, such as fewer allergies, gastrointestinal issues, and respiratory infections (Harmsen et al., 2000; Rinne et al., 2005). Azad et al. (2013) further support that formula-fed infants have a lower prevalence of Bifidobacteria, and have a higher abundance of pathogenic microbes, which are associated with Clostridium difficile. Rinne et al. (2005) demonstrate human infants who were exclusively breastfed or fed with a formula supplemented with prebiotics, had similar levels of beneficial bacteria that surpassed the concentrations in the group that was solely fed formula. Rinne et al. (2005) further point out that using formula with prebiotics is beneficial to stimulate the growth of specific gut bacteria.

Summary and Research Purpose

Investigation of human bacterium has led to the discovery that humans are made up of a collection of microbiomes (Azad et al., 2013; Christian et al., 2015; Huse et al., 2012; Huttenhower et al., 2012; Konkel, 2013; Palmer et al., 2007; Peterson et al., 2009). Of this collection of microbiomes, the gut microbiome is the most influential for human health and well-being (Dethlefsen et al., 2008; Dominguez-Bello et al., 2010; Golubeva et al., 2015; Palmer et al., 2007; Zijlmans et al., 2015). Compromised gut health affects human health and well-being; this compromise may lead to severe microbiome imbalance known as gut dysbiosis (Ghaisas et al., 2016; Kamada et al., 2013). Improper development of the infant gut microbiota leads to gut dysbiosis contributing to the rise of chronic illness (Cassidy-Bushrow et al., 2016; Ghaisas et al.,

2016; Koenig et al., 2011; Oriach et al., 2016; Rinne et al., 2005; Walker & Lawley, 2013; Scher et al., 2015; Ubeda et al., 2012). There is a critical window for IGMD during the stage of preconception to about age three (Allen-Blevins et al., 2015; Cassidy-Bushrow et al., 2016; Heijtz et al., 2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). Prenatal care practitioners are the primary providers for pregnant women. They have an important role influencing the critical window of IGMD (Hamilton et al., 2015). However, the literature provides no evidence about the focus prenatal care providers have on IGMD in their practices (Knight, 2014). Therefore, our research question is, what do prenatal care practitioners (obstetrical and gynecological physicians, nurse practitioners, midwives, and doulas) know about IGMD and how are they using the knowledge in their practice?

Research Lenses

The purpose of this chapter is to disclose our research, theoretical, personal and professional lenses. It is important to acknowledge our lenses, as it helps the reader better understand how they each affect our project selection, design, implementation and interpretation. First, we elaborate on how our research paradigm and culture of inquiry frames this research project. Next, we describe the theoretical lenses guiding our project. Lastly, we articulate our personal and professional lenses.

Research Paradigm and Culture of Inquiry

We are situating our research in the critical paradigm, with a realist ontology, subjective epistemology, and a radical change axiology because the literature demands an empirical approach. The empirical approach presumes our inquiry is based on direct experience and breaking down the observations into parts, to analyze common patterns or irregularities among our population (Bentz & Shapiro, 1998). Our paradigm and culture of inquiry also reflect how we have designed this study.

The critical paradigm is not fixed in reality or in time. External reality is objective and internal reality is subjective (Guba, 1990). We value the critical paradigm because it is rooted in objective reality. We challenge the status quo in prenatal care practices by asking deeper questions about IGMD. Gut dysbiosis is measurable and identifiable (positivist). However, we chose the critical paradigm to apply objective reality to the individual subjective reality of the prenatal practitioner community. Using the critical paradigm, we can bring a holistic approach to investigate gut health and prenatal care, and to understand how people's subjective reality and internal perceptions of gut health may affect this problem.

Theoretical Lenses

Several theoretical concepts are relevant to our study. Our study is grounded in holism, the gut-brain axis theory, the hygiene hypothesis theory, and antibiotic resistance theory. These theories influence our lenses and affect our research design, implementation, and interpretation.

Holism theory. The holism theory demonstrates that every living organism in the universe is interconnected; the whole is greater than the sum of the parts (Merriam-Webster, 2016). Holistic medicine aims to treat both mind and body. Additionally, holism views humans and the environment as a single system (Merriam-Webster, 2016). The holism theory exists within gut microbiome research because no biome is identical (Palmer et al., 2007) and the microbiome is an example of holism, a system of living organisms that are interconnected. The theory of holism demonstrates that humans and the environment are one living system. The principles of the holism theory influence IGMD.

Gut-brain axis theory. The gut-brain axis theory is a bidirectional communication pathway between the gastrointestinal system and the central nervous system (Aziz & Thompson, 1998; Dinan & Cryan, 2012; Oriach et al., 2016). This interdependent relationship regulates behavior, mood, and emotion (Konkel, 2013). The gut-brain axis theory provides an explanation that if the gut or brain alters, the other is directly affected (O'Mahony et al., 2015a). The gut-brain axis theory demonstrates holism by highlighting the interdependent relationship between the gastrointestinal system and nervous system (Aziz & Thompson, 1998; Dinan & Cryan, 2012; Oriach et al., 2016). The gut-brain axis theory influenced the questions we asked on our survey and emphasized the importance of this topic for everyone and not solely the prenatal care community and pregnant women.

Hygiene hypothesis theory. The hygiene hypothesis theory establishes that very hygienic measures in early childhood and a lack of bacterial exposure may have consequences on immune system development and function (Strachan, 1989). The hygiene hypothesis theory also influences IGMD, because the lack of bacterial exposure in early childhood may alter the development of the immune system (Strachan, 1989). The hygiene hypothesis theory helps to understand the importance of bacterial exposure at a young age to ensure a balanced gut microbiome. The hygiene hypothesis theory may also be another explanation for the rise in chronic illness, because if children are not exposed to tolerable amounts of good and bad bacteria, the gut cannot achieve a state of homeostasis and build a strong immune system. To build a strong immune system, exposure to both good and bad bacteria during the critical window of IGMD is critical.

Antibiotic resistance theory. The antibiotic resistance theory demonstrates the excessive use of antibiotics in our food, environment, and medicine. This excessive use results in drug-resistant bacterial strains, and limits the function of the gut microbiota, which causes chronic illness and permanently alteres the intestinal microbiota (Dethlefsen et al., 2008; Cantas et al., 2013). The antibiotic resistance theory emphasizes that prenatal care practitioner should take caution when exposing the IGM to antibiotics during the critical window of IGMD to prevent permanent alterations of the intestinal microbiota and chronic illness (Dethlefsen et al., 2008; Cantas et al., 2013).

These theories inform our project design, implementation, and interpretation. Our holistic lenses naturally inform our choice of research topic and design. These theories help to explain the holistic nature of the gut microbiome. Our comprehensive literature review addresses the factors that affect the gut microbiome. We use a survey method to explore what prenatal care

practitioners know about the gut microbiome, and how they are applying the knowledge in their practices. Our interpretation has at least one bias, as we believe IGM education should be a priority for prenatal care practitioners. Next, we disclose our personal and professional lenses.

Personal and Professional Lenses

Our personal and professional lenses also affect the development, implementation, and interpretation of this research. The collaborative nature of research conducted in the Master of Arts in Holistic Health Studies program emphasizes our differing research lenses and contributes to a more cohesive project.

Sally St. John. My worldview greatly influences how I approach research. Acknowledging my research lens informs and influences this research project. I come to this research with an axiology of radical change grounded in the critical paradigm.

I have come to understand my critical paradigm by examining how I participate in the world. The Western culture I was born into influences how I think objectively through a fixed reality. However, in my childhood I was encouraged to view the world through other people's perceptions and experiences. I have come to learn that reality is subjective and that paradigm shifts can occur through various perceptions and experiences. Thus, as a researcher in the critical paradigm, I identify with a subjective epistemology and a relativist ontology. Additionally, my personal and professional life experiences greatly influence my choice to investigate the relational phenomena of gut health, prenatal care, chronic illness, and the human microbiome.

A series of life experiences related to gut health began when I was a child with an anxiety disorder. I remember now following through on life events in my childhood because of an anxious stomach. Because of my anxiety, I would frequently hear from my elders, “Don’t be so sensitive!” as I was often struggling to cope with the world physically, mentally, and

emotionally. As a coming-of-age woman, my list of symptoms continued to grow into deeper anxiety and other chronic symptoms, such as IBS and hormone imbalances. My elders and conventional practitioners advised, "You'll grow out of it," and/or offered a pill. This reductionist approach did not provide the sustainable life tools I needed to cope with my symptoms. I am driven to challenge the status quo of the positivist healthcare system and inquire for a deeper meaning of health. My passion to challenge the status quo in healthcare and to find a deeper meaning of health is reflected in this research project.

In 2008, I enrolled in an integrative nutrition training program, and I learned how to understand my health holistically. I did an in-depth exploration of my relationship to self-care, especially my relationship with food. I started to value the individual as unique and the body as a whole – mind, body, spirit. I began to connect the root cause of my chronic health symptoms to heavy antibiotic use, poor nutrition, and self-destructive lifestyle habits resulting in gut dysbiosis. By prioritizing the health of my gut through a holistic health lens, I began to resolve my list of chronic health symptoms. Learning to view my health holistically informs the design, implementation, and interpretation of this project by helping to develop a framework that incorporates both an evidence-based research design and holism theory.

With my new holistic paradigm, I founded a food-centered holistic health coaching practice focused on gut health to address chronic illness. The health coaching profession provided a platform for me to offer a service that the conventional medical model was not providing; a space for people to view their health journey as unique and address their chronic symptoms holistically. In my practice, I observed time and again that gut dysbiosis contributed to a wide range of chronic illnesses. My desire to make a radical change in healthcare, specifically

in preventing gut dysbiosis and chronic illness, influences the development of our research purpose and question.

Recently, I joined the Functional Medicine movement. Functional medicine is a field of medicine that "Addresses the underlying causes of disease, using a systems-oriented, holistic approach, engaging both patient and practitioner in a therapeutic partnership" (The Institute for Functional Medicine, 2017). This field of study came into my life after I suffered a major health crisis: a second-trimester miscarriage. I found great comfort in functional medicine because it helped me to identify the root cause of my pregnancy loss through the balance of using my intuition and evidence-based medicine. Functional medicine introduced me to the influential role of the symbiotic relationship between the gut-brain axis, the gut microbiome, and the immune system to support a healthy pregnancy and address chronic illness. My miscarriage and functional medicine experience further motivate me to make a radical change in healthcare and influences the design, implementation, and interpretation of this research project.

My experience with conventional prenatal care practitioners during my pregnancy influenced the implementation of this project, specifically the decision to focus on the critical window of IGMD. For example, when I was pregnant, I was astonished that insurance covered professional care did not include nutrition or stress regulation education. Furthermore, my provider instructed me to start seeing a prenatal care practitioner at the end of my first trimester, which is about six months into the critical window of IGMD. I view this as a missed opportunity in preventing chronic prenatal stress, gut dysbiosis, and most importantly chronic illness. My experience with prenatal care also contributes to how I design, implement and interpret the findings of this project.

I am inspired to investigate how gut health may be a leading root cause of the chronic illness epidemic. I am called to the Masters of Arts in Holistic Health to conduct research about gut health through a holistic health lens. Furthermore, I am taking on this research with the intention to better serve the prenatal community and the clients in my health coaching practice.

Kathleen Powers. My personal and professional lenses play an important role in my participation in this research project. It is important to disclose my lenses as it helps the reader to understand how this project evolved and the influence my experiences have on this research. I come to this research with an axiology of radical change grounded in the critical paradigm.

I obtain knowledge through a blend of personal experience and factual data; I seek facts to interpret and understand my experiences. I grew up in a household that valued objectivity, yet also encouraged critical thinking and understanding of different points of view. As a college student, my professors encouraged me to value this critical thinking in every aspect of my life. Post college, I explored a more subjective understanding of the world, and I am still shifting towards a more nuanced worldview. I do not believe in a single fixed reality and I think that reality is mediated by personal experience, yet I also believe that a large portion of any reality is objective. I identify with an objective epistemology and a relativist ontology. My worldview, as well as my personal and professional experiences, motivate me to research gut microbiome health and influence this project.

This project is very personal to me because I was born by cesarean section. I believe that this affects my health, causing gut dysbiosis; contributing to my development of IBS, autoimmune disease, and chronic pain. Prenatal care practitioners labeled my mother's pregnancy as high risk due to complications following her first delivery and because she was 43 years old at the time of my birth. Because of this high-risk label, she was never given a choice to

deliver naturally. She believes that had she been given access to greater prenatal support, she could have made a choice that better supported her labor experience, possibly preventing some of my health problems. Knowing that my mother had this experience motivates me to gather information about the choices that pregnant women and their practitioners make, so I can help the women in my life feel empowered to make choices that best serve themselves and their children. This research also provides me with concrete information that I can put into action to heal my gut.

Growing up I received primary care from conventional practitioners, most of whom were not able to provide the comprehensive care that I needed to be well. It wasn't until I learned to advocate for myself and seek out practitioners that could truly answer my questions and provide helpful therapies that I saw real progress in my healing. Because of this frustrating healthcare experience, I am skeptical of the care and education that conventional practitioners provide. My skepticism led to my desire to survey prenatal care practitioners, specifically to include both conventional and holistic practitioners in our research. My desire to evaluate and question conventional prenatal care situates me in the critical paradigm. Furthermore, I am driven to develop a deeper understanding of the gut microbiome, seek out information that conventional care has not provided me with, and encourage others to become empowered consumers of prenatal healthcare services. My desire to empower others motivated me to implement a survey that explores prenatal practitioners' knowledge and practice while also increasing practitioner awareness of the gut microbiome. Furthermore, my desire to share this information influences our interpretation of the survey results, ensuring that we analyze and report information that is useful to both conventional and holistic practitioners and the public.

I conducted research in the positivist paradigm in my undergraduate degree that taught me to value objectivity. My previous experience researching in a positivist lens helps us to remain objective in the review of the literature and the design of our project. Furthermore, this positivist lens helped ensure that we remained objective in the interpretation of results, reporting data with accurate context, and not skewing interpretation to meet our objectives.

Working in sustainable agriculture shifted my former positivist paradigm to a more subjective worldview. I believe health and wellness are rooted in our relationship to food, how we think about and consume food, and our connection to the land. While working in agriculture, I developed a holistic understanding of the interconnected relationship of how the health of microbes in our soil influences the health of microbes in our food, further influencing the microbes in the human body. This holistic paradigm motivates me to research the health of the gut microbiome and inspires me to implement a holistic approach within an empirical model of research. Lastly, my holistic worldview influences the interpretation of this project. Specifically, I value results that will inform the future of gut microbiome research and education, while also empowering us to share our research in an educational manner.

Alexandra Kerlin. My lenses affect my approach to this research topic, and it is important to disclose my paradigm so the reader can recognize how it influences the research process. I come to this research with an axiology of radical change grounded in the constructivist paradigm. This section discloses my personal and professional experiences that shape my research lenses.

I define myself as a subjective epistemologist and interpretivist/relativist ontologist. I grew up in a positivist environment that influenced my decision making regarding right or wrong. Through my traveling experiences, I learned that the world is subjective, and how I

interpret a situation may differ from others. I recognize that life is more cyclical than linear; this helps me to embrace my differences and become comfortable shifting away from the positivist paradigm.

Just as my paradigm has shifted from positivism to constructivism, my approach to this research remains flexible. I was initially drawn to this project to explore the connection between emotional health and the gut-brain axis. My desire to understand this connection stems from disordered eating in my teens. My disordered eating challenges have continued; depression, anxiety, and digestive issues have also surfaced in my life. I came to this project concerned about personal digestive issues and a desire to acquire a deeper understanding of the gut microbiome.

I came to this research with a limited understanding of the gut-brain axis connection. During this project, I learned that my mother's pregnancy may directly link to my digestive health issues, allergies, asthma, and eczema. I was born caesarean section and I remember suffering from numerous food allergies. I was unaware of how pregnancy can impact gut health, but my constructive nature kept me curious to do this research. Initially, I wanted to research disordered eating, and as the project evolved I realized that gut health affects disordered eating.

Leading up to this research project, I struggled to address my health concerns using the conventional model. My experience is that the conventional model is reductionist and does not address how the mind, body, and spirit affect digestive issues and emotional health. My co-researchers and I value the holism theory, and this project taught me the gut-brain relationship is holistic. Valuing holism informed the design of the survey and my interpretation of the results. I value subjectivity and constructivism. I wanted to gather an expanded view of knowledge about the gut microbiome, through asking both qualitative and quantitative questions on our survey.

My experience working at a University Health Promotion Office (HPO) affected my approach to this project. At the HPO, I recognized a gap in student health and healing. The resources we offered were not taking the whole person into account. My HPO experience inspired me to design a project that explored the use of holism in patient care. Furthermore, my desire to make this change influences the interpretation and implementation of this project. I recognize my bias in believing only a holistic approach is the best option for health and healing. The interpretation of this project helped me to better understand the connection to emotional health and chronic illness.

Method

The purpose of this chapter is to describe the cross-sectional online survey we used to answer the question: What do prenatal care practitioners know about IGMD and how are they using the knowledge in their practice? There is a critical window of IGMD (Cassidy-Bushrow et al., 2016). However, researchers have not investigated the breadth of knowledge prenatal care practitioners have about the IGMD. Our research aims are to:

- Describe prenatal care practitioners' knowledge of IGMD.
- Describe how prenatal care practitioners apply information about the IGMD with their patients.

In this chapter, we offer our rationale for our design, specifically for our culture of inquiry and method. Next, we discuss our sampling, instrument, data collection, process findings, and data analysis choices. Finally, we demonstrate rigor and highlight the strengths and limitations of our project.

Rationale for Survey Design

We are grounded in the empirical culture of inquiry, rooted in observation and experience (Bentz & Shapiro, 1998). Empirical inquiry brings mathematical facts to the observed relationships in a group (Bentz & Shapiro, 1998). Using the empirical culture of inquiry, we gathered information about a population's direct experiences, and break down the observations into parts, to analyze common patterns or irregularities (Bentz & Shapiro, 1998). A limitation of the empirical culture of inquiry is predominant objective nature, not providing the depth of interpretation that other cultures of inquiry may provide (Bentz & Shapiro, 1998).

We considered using an evaluation culture of inquiry, but we are not evaluating a service or program. However, we are describing the breadth of knowledge in prenatal care practitioners'

practices. We also considered using critical social theory, but we are not using an applied research model, and not applying action within this research design. Empirical is the most logical culture of inquiry for our study.

We sought specific information from a large population of prenatal care practitioners, so we used a researcher-developed online cross-sectional survey, which provided a quantitative and qualitative description of trends of the desired population (Creswell, 2014). We primarily collected quantitative data to gather direct and specific responses and identify the relationship among variables (Creswell, 2014). However, we also gathered a small amount of qualitative data because it provides a broader explanation of prenatal care practitioners' knowledge (Creswell, 2014).

The critical paradigm informs our use of subjective interpretations because we are describing the breadth of knowledge prenatal care practitioners have about the IGM. We use subjective data to identify themes in our sample population (Creswell, 2014; Guba, 1990). Researchers predominantly study the gut microbiome in the positivist paradigm. However, we use our subjective research design to investigate through a critical lens (Bentz & Shapiro, 1998; Guba, 1990; Rallis & Rossman, 2012). We used a researcher-developed survey as an instrument to ask specific questions tailored to our research purpose.

A survey instrument fits within the empirical culture of inquiry because it provides a linear model to ask objective questions and make subjective interpretations (Bentz & Shapiro, 1998; Guba, 1990; Rallis & Rossman, 2012). One limitation of using a survey as our instrument is that it only allows for limited communication between researchers and participants. Because researchers were not present at the time and location of survey completion, there was no option for participants to receive immediate clarification or assistance (Sue & Ritter, 2007). We had

only four weeks to collect data, so an online survey was an efficient platform to reach a large sample population in a short time frame (Fowler, 2009). Using a survey was an effective way to ensure widespread distribution to different groups of practitioners. Practitioners may also have been more likely to respond honestly to a survey because there was no risk of peer influence (Fowler, 2009). Lastly, a survey is a convenient and approachable instrument to ensure a high response rate of our sample population (Sue & Ritter, 2007). To carry out our survey, we used purposive sampling.

Sampling

Sampling is a way to systematically select subjects for a study from a defined population (Czaja & Blair, 2005). Our intended population was registered obstetrical and gynecological physicians, nurse practitioners, midwives, and doulas in the state of Minnesota. We used non-probability sampling to select subjects from within this population. Researchers use non-probability sampling to find available and willing participants when probability sampling is not feasible (Fowler, 2014). Probability sampling was not available to us because of the financial and time constraints of the research project. We used purposive sampling to develop our sampling frames.

Researchers use purposive sampling when it is not feasible to develop a single comprehensive sampling frame (Czaja & Blair, 2005). When using purposive sampling, researchers use their best judgment in choosing groups to sample (Czaja & Blair, 2005). Purposive sampling is a way to intentionally collect data, to accurately address our research question and aims, and better inform the direction of human gut microbiome research (Czaja & Blair, 2005). We used purposive sampling to target multiple prenatal care practitioner groups within a small timeframe (Czaja & Blair, 2005).

We also used purposive sampling to purposefully reach out to specific populations to gather a well-rounded sample that provided data to analyze overarching associations (Czaja & Blair, 2005; Sue & Ritter, 2007). However, researchers sometimes view non-probability sampling as not scientifically sound research (Sue & Ritter, 2007 p. 32). An additional limitation to using non-probability sampling is that it can be biased because participants self-select to complete the survey, and may not be a true representation of the sampling frame (Sue & Ritter, 2007).

We gathered contact emails of our sampling frames through the Minnesota State Mailing List Service for registered obstetrical and gynecological physicians, nurse practitioners, and midwives. We gathered contact emails of doulas from The Minnesota Department of Health Doula Registry.

Using the provided email addresses, we sent an email (Appendix A) inviting 5,000 registered prenatal care practitioners to participate in the study. Of the 5,000, there were 373 (7.5%) obstetrical and gynecological physicians, 23 (.5%) midwives, 4,590 (91.8%) nurse practitioners, and 14 (.28%) doulas that received the survey invitation. Any registered practitioners that did not have a current email address listed were not included in the sample population. In the email, there was a link inviting the participants to complete an online survey. Of the 5,000 practitioners, 258 participants began the survey. One participant did not meet the qualifying criteria for age; 171 participants did not meet the qualifying criteria of practicing in prenatal care.

Instrumentation

To collect qualitative and quantitative data from prenatal care practitioners, we used computer-assisted data collection (Fowler, 2009). Computer-assisted data collection is currently

the most streamlined form of data collection; therefore, we chose an online survey over a paper questionnaire (Fowler, 2009).

We chose to use Qualtrics Research Software (https://www.qualtrics.com) to develop and implement our survey because it is offered free of cost to students at St. Catherine University. Qualtrics is an online survey creation, collection, and analysis software tool that universities and companies use to conduct research. Qualtrics provided a streamlined platform to develop a sophisticated, user-friendly survey. At times, Qualtrics was easy to use and intuitive. However, we faced a significant learning curve to become familiar with the program. We encountered several formatting difficulties while developing the survey and issues in uploading contact spreadsheets for survey distribution. Another limitation to using Qualtrics was that no one was available to offer technical assistance through St. Catherine University. However, Qualtrics customer service was very responsive and helpful.

We used a researcher-developed survey (Appendix B) delivered via Qualtrics, to gather knowledge and opinions of the sample population in a quick and efficient way (Sue & Ritter, 2007). Consistent with our critical paradigm, we chose to write our own survey because 1) a survey meeting our objectives does not appear to exist, 2) it allows us to write questions intended to collect objective data to answer our aims, and 3) it allows us to evaluate practitioners' knowledge of the factors of IGMD that we identify in the literature while challenging the status quo of our practitioner population in the question-asking process (Guba, 1990). We pilot tested our survey with six prenatal care practitioners, whom co-investigator St. John recruited, to assess face validity and answerability of questions before implementing the survey with the sample population (Czaja & Blair, 2005). We also conferred with a statistics consultant from the Holistic Health Studies Department before administering it to our sample population. We implemented

feedback from the pilot to make the survey concise and ensure that each question sought responses to answer the aims and research question. We acknowledge reliability and validity come into question because we are not experts in creating surveys and no other researchers have used this survey (Czaja & Blair, 2005; Sue & Ritter, 2007).

Our survey asked participants to respond to eighteen questions, which consisted of multiple choice, yes or no, and open-ended questions.

The following items on the survey determined the eligibility of the participants:

1. Are you 19 years of age or older?
2. Are you currently practicing in prenatal care, or have you practiced in prenatal care within the last five years?

The survey consists of several groups of questions including:

- six qualitative descriptive questions about the participant and their practice;
- one quantitative multiple choice and four yes/no questions evaluating knowledge of the gut microbiome;
- two qualitative questions evaluating knowledge of the IGMD;
- three qualitative and quantitative questions about patient education;
- three qualitative questions are evaluating knowledge of theories including the hygiene hypothesis, gut-brain axis, and antibiotic resistance theory.

We used data from these questions for descriptive analysis to answer the question: What do prenatal care practitioners know about IGMD and how are they using the knowledge in their practice? Once we developed the survey instrument, data collection commenced.

Data Collection

The initial research invitation email (sent January 10, 2017) contained a passive consent statement that read, "By responding to items on this survey you are giving consent to participate." By clicking the provided link participants were automatically directed to the first page of the survey (Appendix B). Participants could step away or stop the survey at any point and we also gave them the option to skip any item that they did not feel comfortable answering. We permitted participants to return to any questions during the survey if they wished to change an answer. Researchers were not present when participants took the survey, and participants chose their pace and setting to complete the survey. Additionally, data collection was entirely online, eliminating researcher bias that may occur when conducting interviews or focus groups (Sue & Ritter, 2007). We sent two reminder emails (Appendix C) to all participants at one week (January 17, 2017) and two weeks (January 24, 2017) during the allotted data collection period to encourage completion of the survey. Participants received a thank you email once they completed the survey (Appendix D). All participants that finished the survey were eligible to win one $100 Amazon gift card. We selected one participant using a random number generator to receive the gift card after data collection was complete. The data collection period closed on January 31, 2017, at which point the Qualtrics survey link we provided to practitioners expired.

A limitation of our data collection procedure was that some participants might have sought outside sources of information to answer the survey questions, which may affect the validity of data (Creswell, 2014). Additionally, some individuals may have chosen not to participate or complete the survey because they may have felt resentful about the survey content, potentially resulting in lower response rates (Creswell, 2014). To plan for a low response rate,

we sought a large sample size (Creswell, 2014). Next, we report the process findings that happened during the data collection period.

Process findings. Here we report the process findings, which include the emails of participants about this research topic and how many practitioners opted out of our study because they did not identify themselves as prenatal care practitioners.

First, six of the recruited practitioners who expressed passion and great interest about this research topic contacted us by email after receiving the invitation to complete the survey. The recruited practitioners sent these emails to our designated contact and co-researcher, St. John, expressing gratitude and best wishes for a successful study.

Lastly, we discovered that neonatal nurses were interested in this research topic; however, they were not eligible to participate in the study because we only used the word prenatal in the language of our research topic. For example, St. John heard from six neonatal practitioners who asked if they were eligible to participate in the survey. We learned that neonatal nurses are often present in the delivery of the baby, but do not consider themselves part of the prenatal care team because they care for the infant immediately after the baby is born. These findings are important to note and we discuss them further in both the limitations in this section, as well as implications for future research in the discussion chapter. After the data collection was complete, we prepped for and performed data analysis.

Data Analysis

We exported the raw survey data from Qualtrics into an excel spreadsheet. Next, we de-identified the raw data by removing any contact information associated with the data (i.e. names, email addresses, and IP addresses). We kept one copy of the data with identifiable information in case of data corruption. A password protected USB drive kept the data secure and was in

possession of co-investigator Powers.

To prepare data for analysis the we assigned a participant identification number to the raw data of each participant, and then we removed all identifying information. Next, we cleaned the excel spreadsheet of any unnecessary data (location, distribution method, etc.). We then removed data of participants who were not qualified to take the survey from the spreadsheet. The survey was started by 258 participants. We did not use the data of one participant in the analysis because he/she did not meet the qualifying criteria for age. We did not use the data of one participant in the analysis because he/she did not specify a practitioner title. We did not use the data of 171 participants because they did not meet the qualifying criteria of practicing in prenatal care. We did not use eight participants' data in the analysis because they began the survey but did not complete it. Thirteen participants answered only questions 1-7 which redirected them to the final page of the survey because they answered "No" to question seven, "Do you know about the human gut microbiome?" We used data from these 13 participants in data analysis. Sixteen participants answered only questions 1-8 which redirected them to the final page of the survey because they answered "No" to question 8, "Do you know about the IGM?" We used data from these 16 participants in analysis.

Next, we created a codebook for the quantitative data of the remaining 78 participants by assigning a numeric code to each possible answer for each item on the survey and converted all data into the assigned codes. Then we uploaded the quantitative data (excel spreadsheet) to IBM SPSS Statistics. We used SPSS software because it is accessible to us as researchers at St. Catherine University and is the most reliable statistical software on the market (spss.com, 2016). SPSS is an efficient tool to perform statistical analysis and create a visual representation of data. Furthermore, using computer software creates an effective storing system for all qualitative and

quantitative data (Creswell, 2014). After preparation of quantitative data was complete, we began data analysis.

Statistical analysis of the data is a way to identify and describe themes in the sample population (Creswell, 2014). We analyzed quantitative data using descriptive statistics to describe our sample population and to fulfill our aims to describe what prenatal care practitioners know about IGMD and how they are applying that knowledge to their patients (Rowntree, 1981). Descriptive statistics allow us to summarize and describe prenatal care practitioners' knowledge. A limitation to descriptive statistics is that it does not allow us to go beyond what we observe to make predictions about the general population of prenatal care practitioners (Rowntree, 1981). We performed frequencies for data from each survey question and cross tabulation analysis for data from select survey questions (Rowntree, 1981). Next, we used SPSS to create graphs and charts to display the quantitative data.

We then performed summative content analysis of the qualitative data from two items on the survey (Hsieh & Shannon, 2005). We used summative content analysis, as it is a flexible process. Each researcher had a unique process in analyzing the data (Hsieh & Shannon, 2005). Each researcher independently analyzed the data from each qualitative question, identifying keywords and content that was common. We counted keywords and interpreted the words to make meaning. The first question was "Please describe infant gut microbiome development." We categorized and coded the responses as follows:

- breastfeeding;
- maternal microbiome and mother's nutrition;
- environment (mother & infant);
- infant nutrition;

- mode of delivery;
- antibiotic and prescription drug over-exposure;
- colonization of beneficial bacteria;
- unanswered;
- "I don't know;" and
- sterile until birth.

The second question was "Please describe the critical window of the IGM." We categorized and coded the responses as follows:

- listing the factors that contribute to the critical window;
- birth-three days;
- preconception-three years;
- birth-three years;
- birth and during breastfeeding;
- first six months after birth;
- unanswered; and
- "I don't know."

After the content analysis was complete, we created a codebook for the qualitative data. We assigned each keyword or content a numeric code, entered the quantitative data as numeric data into the codebook, and exported the data to SPSS. We then analyzed qualitative data using descriptive statistics reported as frequencies to answer our research question further. Lastly, we spoke with a Holistic Health Studies Department Statistics Consultant to improve the validity and rigor of our data analysis process. Next, we discuss rigor of the research design.

Design Rigor

Rigor demonstrates trustworthiness of a project and reliability and validity (Creswell, 2014). We increased the rigor of the study by reaching out to a large population of registered prenatal care practitioners to obtain a sample population that was representative of more than one prenatal specialty. To ensure effectiveness and validity of our survey, we piloted it with six prenatal care practitioners and worked with a statistics consultant with the Holistic Health Studies Department. We implemented this feedback to align our intended questions with data analysis techniques that would provide relevant data.

Our personal beliefs, values, and experiences also contribute to the rigor of this study. We came to this project with various valuable experiences in the healthcare community. We have no professional training in evidence-based medicine or other natural sciences. We may have created an instrument that did not precisely measure the question we sought to answer, or may not have allowed practitioners to express their knowledge and patient education process adequately. Due to time constraints and difficulty in obtaining pilot study participants we compromised reliability. Furthermore, we did not test the reliability of the survey instrument with a test-retest measure or equivalent form technique (Coolidge, 2013).

We acknowledged these limitations throughout the research process and took precautions to improve the reliability and validity of our research to the best of our ability. Feedback from our classmates, advisors, the statistics consultant and pilot participants significantly improved the rigor of our project. We documented each step of the research project for reference throughout the process. To further demonstrate rigor, we also considered ethics to protect the human subjects of our sample population.

Protection of human subjects. Ethical considerations are important to consider to minimize risk to participants and researchers (Fowler, 2009). The Institutional Review Board (IRB) requires that researchers design studies that protect participants. The St. Catherine University IRB approved our research design as an exempt study which has the least foreseeable risk (Fowler, 2009). The least foreseeable risk means that the risk to participants is minimal. We also completed The Collaborative Institutional Training Initiative (CITI) in behavioral and social science research training to mitigate possible risks associated with this study: confidentiality, coercion, and privacy (CITI Program, 2016). We informed participants of the foreseeable risks through passive consent before beginning the survey.

Confidentiality was one possible risk in this study because data with identifiable information was available to researchers and advisors. To protect confidentiality, we de-identified and stored data on a password protected USB drive kept in possession of co-investigator Powers. We worked collaboratively on this project, so we only accessed data when all researchers were present and we did not share data via email or any other online document sharing programs. Only the researchers and advisors of this project had access to the data.

Coercion, an offer of an excessive or inappropriate reward that may influence a participant's decision to take part in research is a common risk (CITI Program, 2016). Because we offered an incentive to complete the survey we considered coercion to be a possible risk. However, coercion is unlikely because participants are paid professionals and we entered them in a drawing and did not directly reward them for their participation. Researchers did not have any direct contact with participants that may have resulted in coercion.

We did not conduct the survey in a controlled environment (i.e. testing facility), so privacy was of concern (CITI Program, 2016). The risk to privacy was minimal because participants determined the testing conditions.

Lastly, prenatal care practitioners are more prone to malpractice suits than other medical professionals. Some individuals may have felt vulnerable about disclosing information about their practice (Klick & Stratmann, 2007). To mitigate any worry about disclosure of information we advised the participants to skip any questions or discontinue the survey if they felt uncomfortable completing it. The benefits outweighed the risks because our project created awareness and provided the opportunity for prenatal care practitioners to share their perspective about IGM research (Fowler, 2009). Awareness of strengths and limitations is important because it further demonstrates rigor.

Limitations

All research has both strengths and limitations that inform the design, implementation, and interpretation of the project. In this section, we will explore the limitations of our research design.

Several limitations of this research design are also evident throughout the project. Although the contents of this project are predominantly based in biomedical research, we are not trained in the biomedical model of practice or research. We worked with our advisors and pilot population to understand how this might affect our project and greatly simplified our research purpose, question, and data collection process of reflecting this limited perspective.

Sampling procedures contribute to the limitations of our research. Non-probability sampling can be biased because participants self-select to participate in the research and may not be a true representation of the sampling frame (Sue & Ritter, 2007). The Minnesota State

Mailing List databases may not be the most current representation of registered prenatal care practitioners and The Minnesota State Mailing List does not require practitioners to provide an email address at all (Fowler, 2009). Therefore, the sample population surveyed may not be an accurate representation of the current population (Fowler, 2009). Researchers sometimes view use of a non-probability sample as unscientific research, because data is often not generalizable (Sue & Ritter, 2007).

We also identified several limitations in the data collection process. If participants had questions about the survey, there was no option for immediate clarification or assistance, and no face to face interaction (Sue & Ritter, 2007). Consequently, co-investigator St. John received emails from practitioners who were unsure of their eligibility to complete the survey. An additional limitation of using a survey not present when conducting interviews or focus groups was the limited quality of in-depth data about practitioner knowledge and practice about the IGM (Fowler, 2003).

The online survey also presented several limitations in design and implementation. We developed a new instrument because we were unable to find an existing survey that measured prenatal care practitioners' knowledge about IGMD and how they are using the knowledge in their practice. We pilot tested the survey; however, we did not receive much useful feedback from pilot participants about the structure, content, or participant experience of taking the survey. Consequently, there were several limitations in the format of the survey and the validity and reliability of data.

Because we required participants to be practicing in prenatal care to complete the survey, we lost many potential participants that identify as neonatal practitioners and pediatricians who do not consider themselves part of the prenatal care field. Additionally, if participants reported

that they did not know about the human gut microbiome or the human IGM, Qualtrics rerouted them to the final page of the survey thanking them for their participation; this resulted in less data for all subsequent questions. We gave participants the ability to skip any questions that they did not want to answer, resulting in limited data for qualitative questions.

Lastly, we identified several limitations in the data analysis process. Because of the limited amount of data received from the survey, we were only able to report descriptive statistics as frequencies and cross tabulations. We were unable to perform any inferential statistics due to the small sample size.

Results

The purpose of this chapter is to describe in detail what happened in the study to answer our research question: What do prenatal care practitioners know about IGMD and how are they using the knowledge in their practice? This chapter begins with a description of the participants. Next, we report observational data. Then, we report descriptive statistics. Lastly, we report the qualitative results of the study.

Description of Participants

The sample population consisted of 78 prenatal care practitioners. Eleven (14.1%) obstetrical and gynecological physicians, seven (8.9%) midwives, fifty-five (70.5%) nurse practitioners, three (3.85 %) doulas, and one (1.2%) maternal fetal medical physician. Twenty-six percent of participants have practiced for 1-5 years, 18% have practiced for 5-10 years, 9% have practiced for 10-15 years, 19% have practiced for 15-20 years, and 28% have practiced for 20 plus years. Twenty-six percent of practitioners practice in a hospital, 61% practice in a clinic, 1% practice in their home, 7% practice in the patient's home, 3% practice in a wellness center, 2% did not specify where they practice, and 1% practice in a birthing center. Figure 1 displays the practice setting of participants.

Figure 1. Practice Setting of Participants

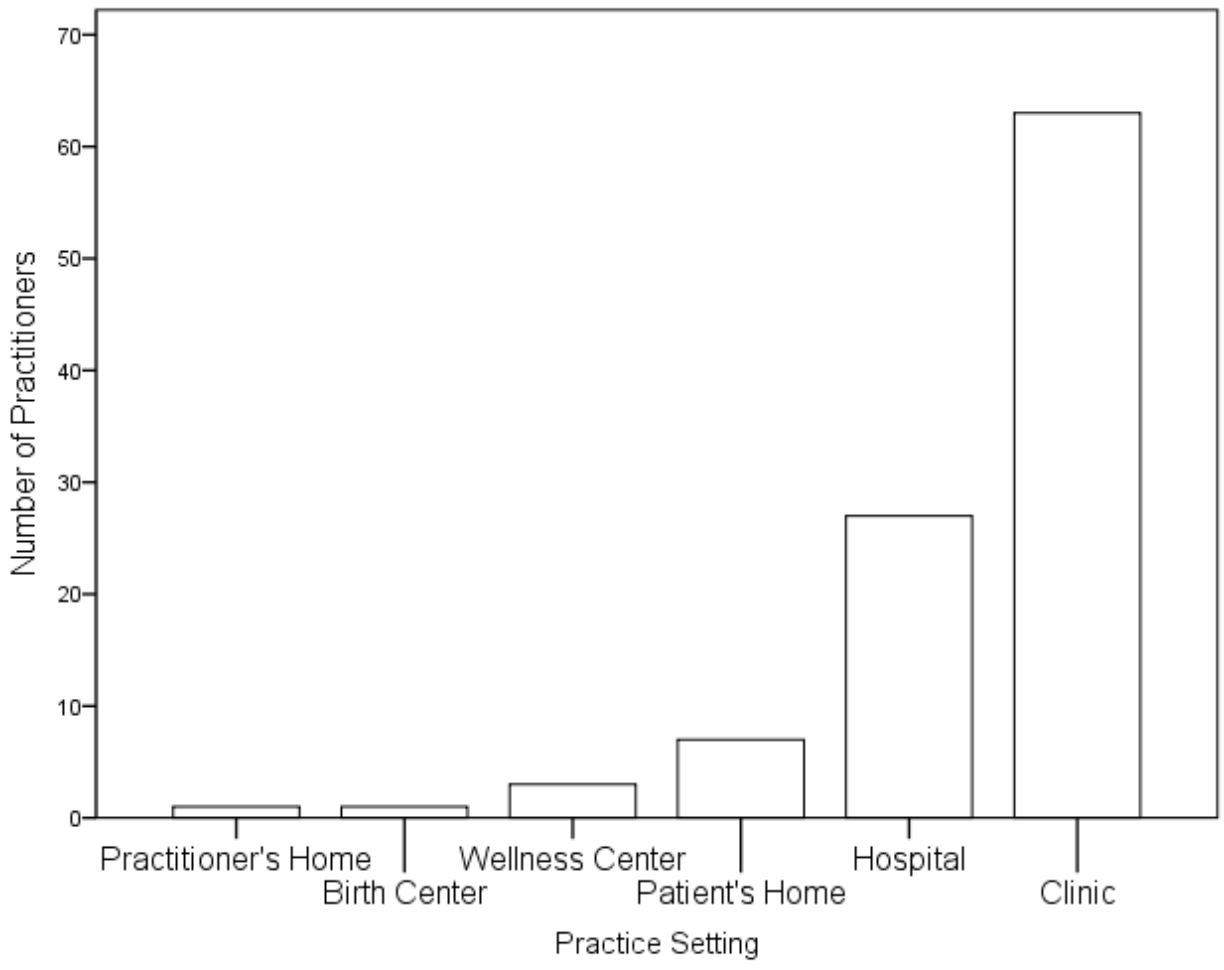

Figure 1. Practice Setting of Participants

When asked to choose their primary practice philosophy from six philosophy choices, 68% of the participants report primarily practicing evidence-based medicine, 18% report primarily practicing integrative medicine, 8% report primarily practicing holistic medicine, 4% report primarily practicing functional medicine, 1% report primarily practicing complementary and alternative and integrative medicine, and 1% report primarily practicing biomedicine. Figure 2 displays the dominant practice philosophy of the participants.

Figure 2. Dominant Practice Philosophy of Participants

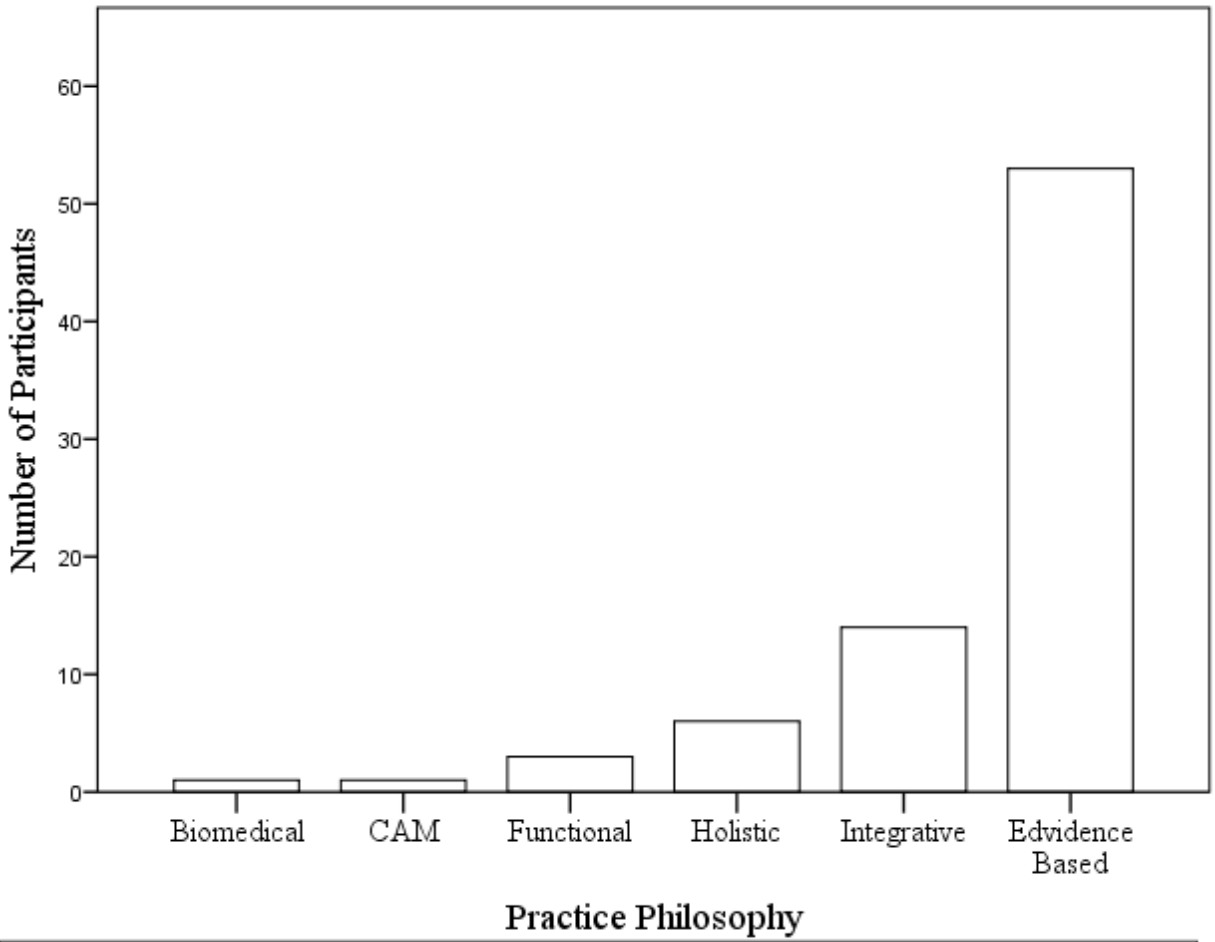

Figure 2. Histogram of Dominant Practice Philosophy as Identified by Participants

Observational Data

Next, we report observational data including descriptive information about survey completion and communication that took place with potential participants during the data collection period.

It took participants an average of 80 seconds to complete the survey, with a range of 33 seconds to 12,939 seconds (3.6 hours). Forty-four (56.4%) participants completed the survey during the first week of the data collection period, 23 (29%) participants completed the survey during the second week of data collection, and 11 (14%) completed the survey during the third and final week of data collection.

Co-investigator St. John, the designated contact for the study, received a total of 31 emails during the data collection period. The context of the correspondence was one of the following:

1. To verify validity of the study (1);

2. To express enthusiasm for the study (6);

3. To seek clarification about the requirements of the study (3); and

4. To be excluded from the study (21).

One participant who inquired about validity of the study asked,

> *I am responding to your survey request, just checking to make sure it is legit prior to opening up the survey link. Everything looks good except for the sending email address, which I don't trust. So, is this a legit survey request?*

Two participants who expressed enthusiasm for the study noted,

> *Best of luck to you in academic and research pursuits and much success at a very interesting university!*

> *Thank you for this research---it's so important! Three cheers to you and your team!*

An example of a participant seeking clarification about requirements for the study inquired,

> *I am a neonatal nurse practitioner so not sure I fit into you study group. If I am I will take the survey just let me know thanks.*

The last few participants asked that we remove them from the mailing list. Next, we report quantitative and qualitative results.

Knowledge of Gut Microbiome

Eighty-three percent of participants report having knowledge about the gut microbiome, while 17% report having no knowledge of the gut microbiome. Of the 11 obstetrical and gynecological physicians, 91% (n=10) report knowledge of the gut microbiome and 9% (n=1) reports no knowledge of the gut microbiome. Of the seven midwives, 86% (n=6) report knowledge of the gut microbiome and 14% (n=1) reports no knowledge of the gut microbiome. Of the 55 nurse practitioners, 80% (n=44) report knowledge of the gut microbiome and 20% (n=11) report no knowledge of the gut microbiome. Of the three doulas, 100% (n=3) report knowledge of the gut microbiome. Of the one maternal-fetal medical physician, he/she also reports knowledge of the gut microbiome.

Of the one participant that reports primarily practicing biomedicine, he/she also reports knowledge of the gut microbiome. Of the 53 participants that report primarily practicing evidence-based medicine, 79% (n=42) report knowledge of the gut microbiome, and 21% (n=11) report no knowledge of the gut microbiome. Of the one participant that reports primarily practicing complementary and alternative medicine he/she also reports knowledge of the gut microbiome. Of the 14 participants that report primarily practicing integrative medicine, 93%

(n=13) report knowledge of the gut microbiome, and 7% (n=1) reports no knowledge of the gut microbiome. Of the six participants that report primarily practicing holistic medicine, 83% (n=5) report knowledge of the gut microbiome, and 17% (n=1) reports no knowledge of the gut microbiome. Of the three participants that report primarily practicing functional medicine, 100% (n=3) report knowledge of the gut microbiome.

Knowledge of IGMD

Sixty-three percent of participants report having knowledge about IGMD, while 20% report having no knowledge of IGMD, and 17% did not answer the question. Of the 11 obstetrical and gynecological physicians, 82% (n=9) report knowledge of IGMD, 9% (n=1) reports no knowledge of IGMD, and 9% (n=1) left the question unanswered. Of the seven midwives, 86% (n=6) report knowledge of IGMD and 14% (n=1) left the question unanswered. Of the 55 nurse practitioners, 53% (n=29) report knowledge of IGMD, 27% (n=15) report no knowledge of IGMD, and 20% (n=11) left the question unanswered. Of the three doulas, 100% (n=3) report knowledge of IGMD. Of the one maternal-fetal medical physician, he/she also reports knowledge of IGMD.

Of the one participant that reports primarily practicing biomedicine, he/she also reports knowledge of IGMD. Of the 53 participants that report primarily practicing evidence-based medicine, 57% (n=30) report knowledge of IGMD, 23% (n=12) report no knowledge of IGMD, and 21% (n=11) left the question unanswered. Of the one participant that reports primarily practicing complementary and alternative medicine, he/she also reports knowledge of IGMD. Of the 14 participants that report primarily practicing integrative medicine, 64% (n=9) report knowledge of IGMD, 29% (n=4) report no knowledge of IGMD, and 7% (n=1) left the question unanswered. Of the six participants that report primarily practicing holistic medicine, 83% (n=5)

report knowledge of IGMD and 17% (n=1) left the question unanswered. Of the three participants that report primarily practicing functional medicine, 100% (n=3) report knowledge of IGMD.

Knowledge of Critical Window of IGMD

Thirty-two percent of participants report having knowledge about the critical window of IGMD, 31% report having no knowledge of the critical window of IGMD, while 37% did not answer the question. Figure 3 displays the knowledge about the critical window of IGMD.

Figure 3. Knowledge of Critical Window of Infant Gut Microbiome Development

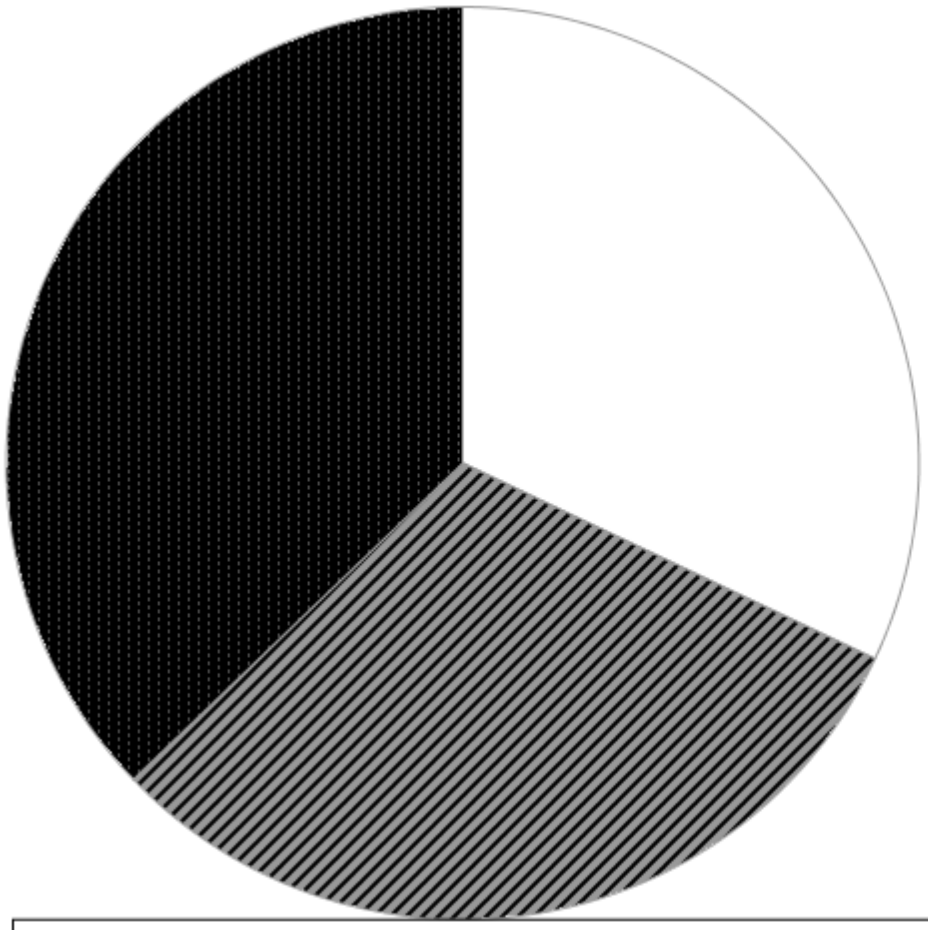

Figure 3. Pie chart displaying practitioners knowledge of the critical window of infant gut microbiome development.

Of the 11 obstetrician and gynecological physician, 27% (n=3) report knowledge of the critical window, 55% (n=6) report no knowledge of the critical window, and 18% (n=2) left the question unanswered. Of the seven midwives, 71% (n=5) report knowledge of the critical window, 14% (n=1) reports no knowledge of the critical window, and 14% (n=1) left the question unanswered. Of the 55 nurse practitioners, 27% (n=15) report knowledge of the critical window, 25% (n=14) report no knowledge of the critical window, and 47% (n=26) left the question unanswered. Of the three doulas, 67% (n=2) report knowledge of the critical window and 33% (n=1) reports no knowledge of the critical window. Of the one maternal-fetal medical physician, he/she also reports no knowledge of the critical window.

Of the 53 participants that report primarily practicing evidence-based medicine, 26% (n=14) report knowledge of the critical window, while 30% (n=16) report no knowledge of the critical window, and 43% (n=23) left the question unanswered. Of the 14 participants that report primarily practicing integrative medicine, 21% (n=3) report knowledge of the critical window, 43% (n=6) report no knowledge of the critical window, and 36% (n=5) left the question unanswered. Of the one participant that reports primarily practicing biomedicine, he/she also reports having knowledge of the critical window. Of the one participant that reports primarily practicing complementary and alternative medicine, he/she also reports having knowledge of the critical window. Of the six participants that report primarily practicing holistic medicine, 50% (n=3) report knowledge of the critical window, 33% (n=2) report no knowledge of the critical window, and 17% (n=1) left the question unanswered. Of the three participants that report primarily practicing functional medicine, 100% (n=3) report knowledge of the critical window.

Fifty-one percent did not identify the critical window of IGMD by leaving the question unanswered while 28% of participants identified the critical window of IGMD as preconception

to three years of age. Twelve percent identify the critical window of IGMD as birth to three years of age, 5% identify the critical window of IGMD as preconception to five years of age, 3% report that the critical window of IGMD cannot be determined, and 1% identify the critical window of IGMD as preconception to six weeks,

When we asked participant to describe the IGM seven midwives, twelve nurse practitioners, one doula, and two obstetrical and gynecological physicians responded. Table 1 shows the categories that participants used to describe IGMD. Answers fell into one or more categories including mode of delivery, colonization of beneficial bacteria, maternal microbiome and nutrition, mother and infant's environment, breastfeeding, infant nutrition, antibiotic and prescription drug overexposure, sterile until birth, and "I don't know."

Table 1.

Category of responses to question: Please describe infant gut microbiome development

Themes Describing Infant Gut Microbiome Development	Number of Practitioners that Identified Theme in Response	Percentage
Mode of Delivery	16	18
Colonization of Beneficial Bacteria	15	17
Maternal Microbiome/Nutrition	14	16
Mother and Infant's Environment	12	13.5
Breastfeeding	12	13.5
Infant Nutrition	8	9
Antibiotic/prescription Drug Overexposure	7	8
I Don't Know	3	3
Sterile Until Birth	2	2

The following responses are descriptions of IGMD from obstetrical and gynecological physicians, midwives, nurse practitioners, and a doula. The responses provide examples of the breadth and diversity of answers we received to this question. We report these responses in order from most detailed to least detailed. Some participants provided a full detailed paragraph while others answered with one word, phrase, or left the question unanswered.

The following response from a midwife was the most detailed of all survey responses for this question:

> *The mother's microbiome influences what the child's future microbiome will be. Birth (vaginal) seeds the infant's microbiome from the mother's vagina, rectum, and skin contact. The breast milk further seeds the microbiome and then, of course, the environment the child lives in and the foods they intake nurture or reduce the microbiome.*

A nurse practitioner also provided a detailed description:

> *Infant's mother preconception needs to have a healthy gut with a clean diet of lots of fruits and vegetables, minerals, vitamins, and foods essential to developing microbes in the gut. Through breastfeeding and introduction to solids, baby develops his/her own microbiome which could or could not predispose the infant to autoimmune disease, chronic disease, etc.*

One doula answered:

> *The infant's gut is very permeable. Breastfeeding helps paint the gut, initially with colostrum, to begin to seal it from invaders. As the baby matures and hopefully continues breastfeeding, their gut will be less susceptible to potential risks. The sooner an infant is fed anything that isn't breast milk, the sooner, and more likely, they are to develop tiny lesions in their gut creating more pathways for permeation.*

One obstetrical and gynecological physician responded:

> *The process in which their gut is colonized. Begins at birth when exposed to their mother's bacterial colony. Further affected by feeding method and maintaining infant gut integrity.*

Another nurse practitioner provided a less detailed answer:

> *Colonizing the guy [sic] with diverse beneficial bacteria.*

A second obstetrical and gynecological physician said only:

Ongoing.

Most participants who answered this question listed the factors that contribute to IGMD, several discussed the mother's role in this process and several listed general facts about the gut microbiome.

When we asked participants to describe the critical window of IGMD seven midwives, twelve nurse practitioners, one doula, and two obstetrical and gynecological physicians responded. Table 2 shows the categories that participants used to describe the critical window of IGMD. We categorized answers into one of the following time frames and answer types: factors of development listed, birth to three days, preconception to three years, birth to three years, birth and during breastfeeding, first six months after birth, and "I don't know."

Table 2.

Response to question: Please describe the critical window of infant gut microbiome development

Themes Describing the Critical Window of Infant Gut Microbiome Development	Number of Practitioners that Identified Themes	Percentage
Listed Factors of Development	13	25
"I don't know"	8	15
Birth to Three Days	4	8
Preconception to Three Years	3	6
Birth to Three Years	2	4
Birth and During Breastfeeding	2	4
First Six Months After Birth	2	4

The following responses are descriptions of the critical window of IGMD from study participants. The responses provide examples to the breadth and diversity of answers we received to this question. They are in order from most detailed to least detailed. Some participants provided a full detailed paragraph while others answered with a short phrase or left the question unanswered.

The following response from a midwife was the most detailed of all survey responses for this question:

> *Critical window is preconception-three years of age of the child. A healthy microbiome needs to be in place prior to conception and then throughout gestation, birth, and growing baby. This is achieved through a healthy clean diet of lots of fruits and vegetables, minerals, vitamins, and foods that promote microbiome building.*

A doula provided the following response:

> *The critical window is the time in which the infant is most susceptible to challenges and gut health because of underdevelopment. As they grow and mature, and are fed foods more appropriate to their level of development, particularly breast milk… and leave them less likely to suffer allergies and illnesses.*

An obstetrical and gynecological physician provided the following answer:

> *I know that vaginal birth and breastfeeding make the bacteria growing in a baby more healthy. I am guessing that if the mom has a bad batch of bacteria, or the baby has a c-section or does not breastfeed, the baby will not get the best bacteria.*

A nurse practitioner responded with a less detailed answer:

> *In utero and first years of life seem to be most critical, again hard to speculate I feel research is still new in this area leaving a lot unknown and the impact it can have on overall health. Overall a very interesting topic and something that seems to have a strong impact in overall health and risk for disease.*

Two obstetrical and gynecological physicians provided less detailed answers:

> *Really don't know. I guess from feeding and suckling this is an important factor. The critical window is around the time of birth.*

One midwife responded with a less detailed answer:

> *Essentially birth through age three. This can be impacted by intrapartum use of antibiotics.*

Most participants who answered this question provided a time range, while others listed factors of infant development or factors that influence IGMD.

Education of patients. Twenty-one percent of participants are educating their patients about the critical window of IGMD, 41% of participants are not educating their patients about the critical window of IGMD, and 38% did not answer the question.

Of the 11 Obstetrical and gynecological physicians, 18% (n=2) report educating patients about the critical window of IGMD, 64% (n=7) report not educating patients about the critical window of IGMD, while 18% (n=2) left the question unanswered. Of the seven midwives, 57% (n=4) report educating patients about the critical window of IGMD, 29% (n=2) report not educating patients of the critical window of IGMD, and 14% (n=1) left the question unanswered. Of the 55 nurse practitioners, 15% (n=8) report educating patients about the critical window of IGMD, 36% (n=20) report not educating patients about the critical window of IGMD, and 49% (n=27) left the question unanswered. Of the three doulas, 67% (n=2) report educating patients about the critical window of IGMD and 33% (n=1) reports not educating patients about the critical window of IGMD.

Of the one participant who reports practicing biomedicine, he/she also reports educating patients about the critical window of IGMD. Of the 53 participants that report practicing evidence-based medicine, 10% (n=5) report educating patients about the critical window of IGMD, 45% (n=24) report not educating patients about the critical window of IGMD, and 45% (n=24) left the question unanswered. Of the one participant that reports practicing complementary and alternative medicine, he/she also reports not educating patients about the

critical window of IGMD. Of the 14 participants that report practicing integrative medicine, 21% (n=3) report educating patients about the critical window of IGMD, 43% (n=6) report not educating patients about the critical window of IGMD, and 36% (n=5) left the question unanswered. Of the six participants that report practicing holistic medicine, 67% (n=4) report educating patients about the critical window of IGMD, 16.5% (n=1) reports not educating patients about the critical window of IGMD, and 16.5% (n=1) left the question unanswered. Of the three participants that report practicing functional medicine, 100% (n=3) report educating patients about the critical window of IGMD.

Of the 27 participants that report practicing in a hospital, 19% (n=5) report educating patients on IGMD, 52% (n=14) report not educating patients on IGMD, and 29% (n=8) left the question unanswered. Of the 63 participants that report practicing in a clinic, 21% (n=13) report educating patients on the IGMD, 33% (n=21) report not educating patients on IGMD, and 46% (n=29) left the question unanswered. Of the one participant that reports practicing in their home, he/she also reports not educating their patients on IGMD. Of the seven participants that report practicing in the patient's home, 71% (n=5) report educating their patients on IGMD, and 29% (n=2) report not educating their patients about IGMD. Of the three participants that report practicing in a wellness center, 33.3% (n=1) reports educating their patients about IGMD, 33.3% (n=1) reports not educating their patients about IGMD, and 33.3% (n=1) left the question unanswered. Of the one participant that reports practicing in a birth center, he/she also reports not educating their patients on IGMD.

Of the participants that do not educate their patients about the critical window of IGMD, 75% did not give an explanation as to why they do not provide patient education, and 15% said they do not have enough education on the topic. Six percent report it was not in their scope of

practice, 3% report that the research is anecdotal, and 1% report that there is not adequate time in an appointment to educate their patients.

Figure 4 shows the topics practitioners address with their patients to educate about the development of the IGM. When provided with thirteen choices, the topics practitioners most report discussing with their patients include breastfeeding, skin-to-skin contact, and nutrition for the mother. Fewer practitioners report educating their patients about the implications of antibiotics use, probiotics for mother, stress reduction, implications of a cesarean section, bottle-feeding breast milk, probiotics for infant, microbial wipes, complementary and alternative medicine, probiotic enhanced formula, and psychobiotics for the mother.

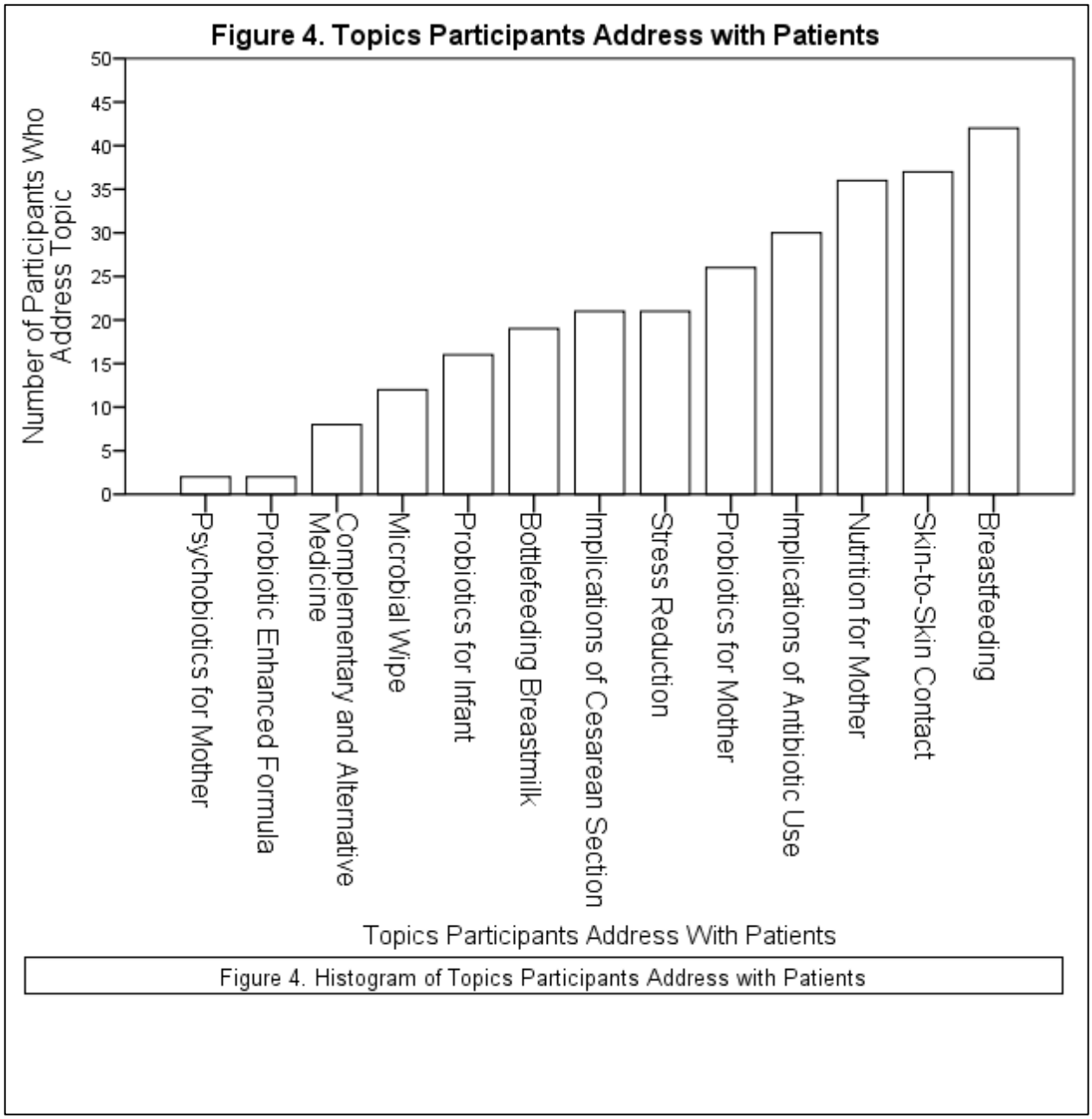

Figure 4. Histogram of Topics Participants Address with Patients

Theories Relevant to Gut Microbiome Research

When we asked participants to describe the gut-brain axis theory 17 (22%) participants accurately articulate the theory in their own words, ten (13%) participants report that they did not know what the gut-brain axis theory is, and 51 (65%) left the question unanswered.

When we asked participants to describe the hygiene hypothesis 41 (38%) participants list some combination of general factors that apply to the hygiene hypothesis (e.g. sterile environment, immune system development, lack of exposure to bacteria, etc.). Nine (9%) participants report that they did not know what the hygiene hypothesis is and 56 (53%) participants left the question unanswered.

When we asked participants to describe the theory of antibiotic resistance, 25 (32%) participants answer correctly (with a varying degree of detail), 2 (3%) participants report that they did not know what the antibiotic resistance theory is, and 51 (65%) participants left the question unanswered.

Discussion

The purpose of this chapter is to interpret our research findings to answer our research question: What do prenatal care practitioners know about IGMD and how are they using the knowledge in their practice? First, we discuss findings that the literature supports, followed by our unexpected findings. Next, we discuss implications of this project for holistic health and future research. This chapter ends with a summary and our conclusion.

Findings Supported by the Literature

Several results of this pilot study are consistent with the literature. In this section, we discuss the results that support the literature findings about the knowledge of the gut microbiome, the knowledge of the critical window of IGMD, and factors of IGMD.

Knowledge about the gut microbiome. Research is increasingly showing the existence of human microbiomes (Christian et al., 2014; NIH 2012). The influence that the gut microbiome has on overall health (Azad et al., 2013; Knight, 2014; Oriach et al., 2016; Robertson et al., 2016;), and that gut microbiome health is best developed and protected in the critical window of preconception to three years of age (Allen-Blevins et al., 2015; Arrieta et al., 2014; Azad et al., 2013; Cassidy-Bushrow et al., 2016; Heijtz et al., 2011; Hooper et al., 2001; Koenig et al., 2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). Our findings demonstrate that there is knowledge about the gut microbiome in the prenatal care field, as 83% of our participants reported they are knowledgeable about the human gut microbiome. Analysis of gut microbiome knowledge by practitioner title and practitioner primary practice philosophy shows that across all practitioner categories and practice philosophies, practitioners report having knowledge of the gut microbiome. Even though most of our population knew of the human gut microbiome, it still concerns us that just under a quarter are not knowledgeable about the gut microbiome, the most

influential microbiome for human health and well-being.

Knowledge about the infant gut microbiome. Sixty-eight percent of participants report primarily practicing evidence-based medicine, but only 63% of participants are knowledgeable about IGMD research. Analysis of IGM knowledge by practitioner title shows that of the 55 nurse practitioners in our sample, 53% (n=29) report having knowledge of the IGM; whereas, in the other practitioner categories most report having knowledge of the IGM (82%-100%). Analysis of IGM knowledge by practice philosophy shows that most practitioners in the sample report primarily practicing evidence-based medicine; of these 53 practitioners, 57% (n=30) report having knowledge about the IGM. Additionally, of the practitioners who report primarily practicing functional medicine and complementary and alternative medicine, 100% of practitioners are knowledgeable of the IGM. These findings are significant because they demonstrate that some areas of medicine may be prioritizing IGM knowledge more than other areas. Furthermore, for practitioners to have knowledge about the critical window of IGMD, the practitioners need to have fundamental knowledge about the human gut microbiome.

Knowledge about the critical window of infant gut microbiome development. There is a critical window for IGMD in the early stages of life: pre-conception to about three years of age (Allen-Blevins et al., 2015; Cassidy-Bushrow et al., 2016; Heijtz et al., 2011; Palmer et al., 2007; Rinne et al., 2005; Sellitto et al., 2012). Our findings show 32% of participants are knowledgeable about the critical window of IGMD. However, only 28% can accurately identify the specific window of time of the critical window of IGMD.

Analysis of the critical window of the IGM knowledge by practitioner title shows that of the 55 nurse practitioners, 27% (n=15) report having knowledge of the critical window of IGMD. Of the 11 obstetrical and gynecological physicians, 27% (n=3) report having knowledge of the

critical window of IGMD; whereas, in the other practitioner categories most (67%-100%) report having knowledge of the critical window of IGMD. These results demonstrate that nurse practitioners and obstetrical and gynecological physicians have the least amount of knowledge about the critical window of IGMD.

Analysis of the critical window of IGMD knowledge by practice philosophy shows that of the one participant who reports primarily practicing biomedicine, he/she also reports having knowledge of the critical window of IGMD. Of the one participant who reports primarily practicing complementary and alternative medicine, he/she also reports having knowledge of the critical window of IGMD. Of the three participants who report primarily practicing functional medicine, 100% (n=3) report knowledge of the critical window; whereas, in the other practitioner categories fewer (21%-50%) report having knowledge of the critical window of IGMD. These results demonstrate that practitioners primarily practicing more conventional philosophies such as of evidence-based medicine and biomedicine have less knowledge of the critical window of IGMD.

Prenatal care practitioners are aware that there is a window of development but are not able to precisely identify the critical window of IGMD. We received a range of answers describing both IGMD and the critical window of IGMD. This variety of answers may exist because previous literature states that the infant's gut is sterile until birth (Bailey et al., 2004; D'Argenio & Salvatore, 2015; Prince et al., 2014). IGM research is in its early stages; the newness of this research topic may be an explanation for why only a third of our population are able to precisely identify the critical window in their own words, as the rest of the population may identify the critical window according to prior research. Additionally, practitioners may have enough general knowledge about gut microbiome development to advise patients despite

not knowing specific details surrounding the critical window of IGMD.

Factors of infant gut microbiome development. Factors that affect IGMD are mother's health, environmental exposure, culture, mode of delivery, nutrition, and medication exposure (Cabrera-Rubio et al., 2012; De Filippo et al., 2010; Dethlefsen et al., 2008; Dominguez-Bello et al., 2010; Schnorr et al., 2014; Sellitto et al., 2012; Vitali et al., 2012; Wu et al., 2011; Zaura et al., 2015; Zijlmans et al., 2015). Our findings suggest that prenatal care practitioners are addressing some factors related to IGMD including breastfeeding, skin-to-skin contact, nutrition for the mother, implications of antibiotic use, and probiotics for mother. The factors that are not being addressed as frequently such probiotics for infant, stress reduction, implications of cesarean section etc. are important for prenatal care practitioners to educate patients about because these strongly impact the development of the infant gut microbiome.

Unexpected Findings

Unexpected findings are any results that do not answer our research question or are not congruent with the literature. In this section, we first discuss what and how prenatal care practitioners are providing education to their patients regarding the critical window of IGMD. Then, we discuss results of the qualitative questions focused on the theories that relate to gut microbiome research.

Education of patients about the critical window of IGMD. There is a lack of literature about the education that prenatal care practitioners provide their patients concerning the critical window of IGMD (Knight, 2014). Our findings suggest that most (41%) prenatal care practitioners are not educating their patients about the critical window of IGMD. This

Analysis of education of patients about the critical window IGMD by practitioner title shows that the practitioners (obstetrical and gynecological physicians and nurse practitioners)

who report less knowledge of the critical window of IGM also report not educating their patients about the critical window of IGMD. Of the 11 obstetrical and gynecological physicians, 18% (n=2) report educating patients about the critical window of IGMD and of the 55 nurse practitioners, 15% (n=8) report educating patients about the critical window of IGMD; whereas, in the other practitioner categories more (57-67%) practitioners report educating their patients about the critical window of IGMD.

Analysis of education of patients about the critical window of IGMD by primary practice philosophy shows a significant level of variance. Participants that report educating their patients about the critical window of IGMD ranges from 10% (n=5) of participants who practice evidence-based medicine to 100% (n=3) of participants who practice functional medicine. Participants with different primary practice philosophies report educating their patients about the critical window of IGMD at varying rates within this range. These results demonstrate that primary practice philosophy may not be as influential as practitioner title in determining if practitioners educate patients about the critical window of IGMD.

Analysis of education of patients about the critical window of IGMD by practice setting show that of the seven participants that report practicing in the patient's home, 71% (n=5) report educating their patients on IGMD. Very few (0-33%) practitioners in all other practice settings report educating patients about the critical window of IGMD. These results demonstrate that practitioners who practice in a less conventional practice setting are more likely to educate their patients about the critical window of IGMD.

A small subset of participants (15%) report that they do not have enough education on the topic to provide their patients with information. The majority (71%) of participants do not provide an explanation as to why they do not educate their patients about the critical window of

IGMD. Participants had the option to choose several other reasons for not educating their patients including not in their scope of practice, research is anecdotal, and not adequate time in an appointment to educate their patients. Very few participants (10%) identify these options as reasons that they do not educate their patients about the critical window of IGMD. The lack of responses for why practitioners do not educate their patients leads us to believe that practitioners do not educate their patients because they feel they do not have enough education on the topic to prioritize and provide their patients with accurate information. These findings are unexpected because there is no literature demonstrating if or how prenatal care practitioners educate their patients about IGMD, so we did not know what results to expect.

Theories relevant to gut microbiome research. We are astounded to learn about the lack of depth in the answers to the qualitative questions about the theories relevant to gut microbiome research. To understand gut microbiome research, the gut-brain axis theory, the hygiene hypothesis theory, and the antibiotic resistance theory are foundational in medicine. However, most of the participants are unable to articulate these theories accurately in their own words. For example, participants state that they are unable to describe a theory or report they do not know, and/or give an incomplete explanation. Specifically, we are confounded that only 22% of participants can describe the gut-brain axis theory accurately. Understanding the gut-brain axis theory is necessary to fully comprehend the importance of the gut microbiome to human health and well-being.

These findings are concerning because they are foundational theories to both our research topic and practicing medicine. Although it is not necessary for a practitioner to precisely define these theories to practice medicine, if practitioners have a working knowledge and general understanding of the theory and how it influences their patients, they should also be able to

provide a basic explanation.

Implications for Holistic Health Practice

Our pilot study results present implications for holistic health and future research. There is currently no evidence in the literature that prenatal care practitioners are focusing on educating their patients about the gut microbiome (Knight, 2014). Our findings also show that most prenatal care practitioners are not educating their patients and do not specify as to why they are not. Consequently, patients are not receiving education about the infant gut microbiome development. In this section, we first discuss the need for gut microbiome curriculum. Next, we discuss how holistic and evidence-based practitioners can work together to support education about gut microbiome development. Lastly, we discuss how a holistic prenatal health coach can benefit gut microbiome education in an integrative care framework.

Our findings demonstrate prenatal care practitioners do not prioritize IGM education with their patients. Practitioners and researchers need to create a curriculum to improve gut microbiome education in the field of medicine. Medical schools, certification programs, and continuing education programs can implement this curriculum with practitioners. This curriculum can extend to create a public health initiative to educate the general population about the critical window of IGMD. Practitioners trained in gut microbiome health can then effectively educate their patients.

Implications for Future Research

Based on the results of this pilot study, we identify implications for future research. In this section, we address how to improve this pilot study and discuss how this will affect future research.

There is a lack of information in the literature on how prenatal care practitioners are

educating and applying infant gut microbiome information in their practices; therefore, this project is a pilot study. After completing a pilot study, we can identify strategies to build upon this research. One strategy to improve this pilot study is to be more strategic in recruitment. Including practitioners that may influence this critical window such as neonatal, pediatricians, and other holistic health care practitioners in the sample population. A larger sample population will provide a more in-depth understanding about how prenatal care practices address gut microbiome health, as well as contribute to developing gut microbiome education curriculum.

Because we allowed participants the option to skip survey questions, another strategy to improve this pilot study would be to make all questions mandatory. Mandatory questions will provide more data. Including a larger sample population will also allow us to gather more data, and conduct inferential statistics. Lastly, the survey can improve by rephrasing the qualitative questions to ask how practitioners apply gut microbiome knowledge in their practice instead of having them define a theory. To more accurately assess a practitioner's knowledge and implementation of gut microbiome education, future research will evaluate practitioners' application of knowledge rather than their ability to memorize and articulate theories. Researchers can replicate our pilot study and influence the next stage of gut microbiome research. Researchers need to explore more about the human gut microbiome which will further direct future research to investigate the critical window of IGMD specifically.

Conclusion

Gut microbiome research is still in its infancy, and researchers need to investigate the critical window of IGMD. Prenatal care practitioners are the first practitioners to influence the development of the infant (CDC, 2014). However, there is no previous research exploring the role prenatal care practitioners have in educating pregnant women specifically about the critical

window of IGMD (Knight, 2014). We used an empirical study with a researcher-developed cross-sectional online survey to measure the knowledge prenatal care practitioners (nurse practitioners, obstetrical and gynecological physicians, midwives, and doulas) have about IGMD and how they are using that knowledge in their practice. Sixty-three percent of participants have knowledge about IGMD; however, only 32% of participants in the study report having knowledge about the critical window of IGMD, and at least 41% of these participants are not educating their patients about the critical window of IGMD.

Based on the finding that only 21% of prenatal care practitioners are educating their patients about the critical window of IGMD, there is an opportunity for prenatal care practitioners to become more knowledgeable. As prenatal care practitioners gain more knowledge about the critical window of IGMD, they may have more motivation to apply this information in their practices. Improper development of the gut microbiota during infancy leads to gut dysbiosis later in life, which contribute to the development of chronic illness (Cassidy-Bushrow et al., 2016; Ghaisas et al., 2016; Koenig et al., 2011; Oriach et al., 2016; Rinne et al., 2005; Scher et al., 2015; Ubeda et al., 2012; Walker & Lawley, 2013;). Providing pregnant women with knowledge of the critical window of IGMD may decrease the prevalence of gut dysbiosis and address the epidemic of chronic illness in the United States.

Practitioners and researchers need to create a curriculum to improve gut microbiome education in the field of medicine. Researchers and practitioners can implement this curriculum in medical schools, certification programs, and continuing education for practitioners. Practitioners knowledgeable about gut microbiome health can then effectively educate their patients. However, researchers need to determine what level of education prenatal care practitioners need to receive about the critical window of IGMD. Replicating and expanding

upon this pilot study can be a logical next step in the literature to help solidify the educational needs for prenatal care practitioners to apply this knowledge in their practice.

Higher awareness of the development of the gut microbiome may help to prevent and treat chronic illness (Cassidy-Bushrow et al., 2016; Ghaisas et al., 2016; Koenig et al., 2011; Oriach, Robertson, Stanton, Cryan, & Dinan, 2016; Rinne et al., 2005; Scher et al., 2015; Ubeda et al., 2012; Walker & Lawley, 2013). Furthermore, supporting prenatal care practitioners with education about IGMD will contribute to more awareness in the pregnancy population about implications of the improper development of the gut microbiome.

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Appendix A

Invitation Email

You are invited to participate in a survey investigating the practices of prenatal care practitioners regarding infant gut microbiome development!

Graduate students at St. Catherine University are conducting this project. The purpose of this survey is to describe what prenatal care practitioners (obstetrical and gynecological physicians, nurse practitioners, midwives and doulas) know about infant gut microbiome development and how they are using the knowledge in their practice. The survey includes open and close-ended questions, and will take approximately 10 minutes to complete.

Your responses to this survey will be confidential, all data will be de-identified and all identifiable data will be destroyed at the study's conclusion by May 17, 2016; all results will be presented in a way that no participant will be identifiable.

Your decision whether or not to participate will not affect your relationships with the researchers or St. Catherine University. If you decide to stop at any time you may do so. You may also skip any item that you do not want to answer. You are permitted to return to any questions during the survey if you wish to change an answer. If you have any questions about this project, please contact Sally St. John at sfstjohn@stkate.edu. By responding to items on this survey you are giving consent to participate.

The survey link will be active until (X date).

Once you have completed the survey, you will automatically be entered in a drawing for a $100 Amazon gift card. Contact information will not be associated with survey data. The winner will be notified via email after the data collection period has closed.

LINK TO SURVEY

Thank you for your contributions,

Sincerely,

Sally St. John, BS, CHHC, FMCHC(Cand)

Kathleen Powers, BA, FMCHC(Cand)

Alexandra Kerlin, BS

Principal Investigators

Graduate students, St. Catherine University

Appendix B

Gut Microbiome Survey

Q1 What is your practitioner title?

- Obstetrical and gynecological physician (1)
- Nurse midwife (2)
- Nurse practitioner (3)
- Doula (4)
- Other (please specify) (5) _____

Q2 Are you 19 years of age or older?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q3 Are you currently practicing in prenatal care, or have you practiced in prenatal care within the last 5 years?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q4 How many years have you been in practice?

- 1-5 (1)
- 5-10 (2)
- 10-15 (3)
- 15-20 (4)
- 20+ (5)

Q5 What is your practice setting? Please check all that apply.

- Hospital (1)
- Clinic (2)
- Your home (3)
- Patient's home (4)
- Wellness center (5)
- Other (please specify) (6) _____

Q6 What are the healing philosophies of your practice? Please check all that apply.

- Biomedical medicine (the practice of using the principles of the natural sciences, especially biology and physiology) (1)
- Evidence-based medicine (the practice of using modern best evidence) (2)

- Complementary and alternative medicine (the practice of using healthcare approaches developed outside of mainstream western and conventional medicine) (3)
- Integrative medicine (the practice of using both conventional and complementary and alternative approaches) (4)
- Holistic medicine (the practice of using a whole system approach wherein interdependent, physical, mental, emotional, social, and spiritual aspects cannot be discretely seperate, reduced, observed, or measured without consideration to the whole) (5)
- Functional medicine (the practice of using a systems oriented approach to identify the underlying causes of disease) (6)
- Naturopathic medicine (the practice of using vitalism and promoting self healing through homepathy, herbalism, nutrition, and lifestyle counseling) (7)

Q7 Do you know about the human gut microbiome?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q8 Do you know about infant gut microbiome development?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q9 Do you know about the critical window of infant gut microbiome development?

- Yes (1)
- No (2)

Q10 Please choose the critical window of infant gut microbiome development.

- Preconception-3 years (1)
- Preconception-5 years (2)
- Birth-3 years (3)
- Birth-5 years (4)
- Cannot be determined (5)
- None of the above (please specify) (6) _____
- I don't know (7)

Q11 Please describe infant gut microbiome development.

Q12 Please describe the critical window of infant gut microbiome development.

Q13 Are you educating patients about the critical window of infant gut microbiome development?

- Yes (1)

- No (2)

Display This Question:
If Are you educating patients about the critical window of infant gut microbiome development? No Is Selected
Q14 Please explain why you do not educate your patients about the critical window of infant gut microbiome development.

Q15 What topics do you currently address with your patients. Check all that apply.

- Probiotics (i.e oligiosaccharides, lactobacillus, etc.) for mother (1)
- Probiotics (i.e oligiosaccharides, lactobacillus, etc.) for infant (2)
- Nutrition for mother (3)
- Breastfeeding (4)
- Bottle feeding breastmilk (5)
- Probiotic enhanced formula (6)
- Microbial wipe "Baby Seeding" at cesarean section birth (swabbing newborn with mother's vaginal fluid immediately after birth) (7)
- Stress reduction techniques/mind-body medicine (i.e. meditation) (8)
- Implications of cesarean section (9)
- Complementary and alternative therapies (please specify) (10) _____
- Implications of antibiotic use (11)
- Infant and parent skin-to-skin contact immediately after birth (12)
- Other (please specify) (13) _____
- None of the above (14)

Q16 Please describe the Gut-Brain Axis Theory.

Q17 Please describe the Hygiene Hypothesis Theory.

Q18 Please describe the antibiotic resistance theory.

Appendix C

Reminder Email

Time is running out! Please take a few minutes to share your experience with us by taking the Human Gut Microbiome Survey

You are invited to participate in a survey investigating the practices of prenatal care practitioners regarding infant gut microbiome development!

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Your decision whether or not to participate will not affect your relationships with the researchers or St. Catherine University. If you decide to stop at any time you may do so. You may also skip any item that you do not want to answer. You are permitted to return to any questions during the survey if you wish to change an answer. If you have any questions about this project, please contact Sally St. John at sfstjohn@stkate.edu. By responding to items on this survey you are giving consent to allow us to use your responses for research and educational purposes.

The survey link will be active until (X date).

Once you have completed the survey, you will automatically be entered into a drawing for a $100 Amazon gift card. Contact information will not be associated with survey data. The winner will be notified via email after the data collection period has closed.

LINK TO SURVEY

Thank you for your contributions,

Sincerely,

Sally St. John, BS, CHHC, FMCHC(Cand)

Kathleen Powers, BA, FMCHC(Cand)

Alexandra Kerlin, BS

Principal Investigators

Graduate students, St. Catherine University

Appendix D

Thank You Email

Thank you for participating in our survey. We hope our study will contribute to further research and create more awareness about the infant gut microbiome.

We sincerely appreciate your time and energy!

Sincerely,

Sally St. John, BS, CHHC, FMCHC(Cand)

Kathleen Powers, BA, FMCHC(Cand)

Alexandra Kerlin, BS

Principal Investigators

Master of Arts in Holistic Health Studies

St. Catherine University

Appendix E

Incentive Winner Announcement Email

Thank you for participating in: Development of the infant gut microbiome during the Critical Window: A Survey of Prenatal Care Practitioners.

We would like to congratulate you on winning a $100 Amazon gift card! To gather your prize, please reply to this message within one week that you accept this prize. You will receive the gift card within a few days via email after providing us your confirmation.

Thank you again for participating in our survey and congratulations on winning!

Sincerely,

Sally St. John, BS, CHHC, FMCHC(Cand)

Kathleen Powers, BA, FMCHC(Cand)

Alexandra Kerlin, BS

Principal Investigators

Master of Arts in Holistic Health Studies

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