ASSOCIATION BETWEEN SOCIODEMOGRAPHIC CHARACTERISTICS AND INFANT FEEDING BELIEFS OF ANIMAL MILK AS AN ALTERNATIVE TO HUMAN BREAST MILK AMONG WOMEN OF CHILDBEARING AGE

by

ADELIA NUNNALLY

(Under the Direction of Alex Anderson)

ABSTRACT

This study examined the association between sociodemographic characteristics and knowledge of the use of animal milk as an alternative to human breast milk among women of childbearing age. Although there are known benefits of breastfeeding, disparities in knowledge and practices exist. Using a cross-sectional survey of a national sample of women of childbearing age, we explored the association of education, income, age, and race with awareness of breastfeeding recommendations and laws, as well as perceptions about the appropriateness of animal milk in infant feeding. Logistic regression analyses showed that women with lower socioeconomic status demonstrated significantly lower awareness of breastfeeding legislation and recommendations, including the risks of early introduction of animal milk. The findings highlight critical gaps in maternal knowledge that may influence infant feeding practices. These results underscore the need for targeted education efforts and policy making to promote informed infant feeding decisions and improve public health outcomes for mothers and infants.

INDEX WORDS: Breastfeeding, infant feeding, sociodemographic characteristics, animal milk

ASSOCIATION BETWEEN SOCIODEMOGRAPHIC CHARACTERISTICS AND INFANT FEEDING BELIEFS OF ANIMAL MILK AS AN ALTERNATIVE TO HUMAN BREAST MILK AMONG WOMEN OF CHILDBEARING AGE

by

ADELIA NUNNALLY

BS, James Madison University, 2023

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2025

ASSOCIATION BETWEEN SOCIODEMOGRAPHIC CHARACTERISTICS AND INFANT FEEDING BELIEFS OF ANIMAL MILK AS AN ALTERNATIVE TO HUMAN BREAST MILK AMONG WOMEN OF CHILDBEARING AGE

by

ADELIA NUNNALLY

Major Professor: Alex Anderson
Committee: Sina Gallo
Michelle Parisi

Electronic Version Approved:

Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
The University of Georgia
August 2025

DEDICATION

To my family- Mom, Dad, Lindy, and Joe. Thank you for shaping me into the person I am today. Your endless support, love, and belief in me doesn't go unnoticed. I am truly grateful to have you in my life through every step of this journey.

ACKNOWLEDGEMENTS

Thank you to Dr. Anderson for your guidance, support, and invaluable teaching. I have learned far more than I ever anticipated during this experience. Thank you to my committee members, Dr. Gallo and Dr. Parisi. This growth would not be possible without all the professors and mentors who have supported me during these past two years. Thank you as well to my MS/DI cohort for always being so supportive of me. I'm incredibly grateful to have gone through this journey alongside such an inspiring group of individuals.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

Breastfeeding reduces the risk of infant mortality and infections by increasing the infant's immune response.[1] According to the World Health Organization (WHO), infants should be exclusively breastfed for the first 6 months of life. Complementary feeding alongside breastfeeding can begin at 6 months and continue up to 2 years of age or beyond.[2] Sociodemographic characteristics play an important role in breastfeeding rates. Data from the CDC shows that race/ethnicity, education, age, income, marital status, and geographical location all play a role in the likelihood of breastfeeding.[3] Human breast milk is the optimal food for an infant but in some cases such as, when an infant is diagnosed with classic galactosemia, maple syrup urine disease, or phenylketonuria (PKU), or if a mother has HIV infection, active untreated tuberculosis, human T-cell lymphotropic virus type I or II infection, an alternative feed is needed.[4] Animal milk has been used as an alternative to breast milk for decades, since it has similar properties to human breast milk.[5]

1.1 Benefits of Breastfeeding

There is an abundance of short-term and long-term benefits of breastfeeding for an infant and a mother. Many studies have examined the effects of breastfeeding and have found that it lowers the risk of infant mortality and infections. Higher intelligence and lower rates of obesity and diabetes later in life have also been observed in breastfed infants.[6] Breastfeeding increases an infant’s immune response, which is associated with lower hospitalization rates.[1, 7] Additional benefits to breastfeeding for infants include a lower risk of asthma, leukemia, celiac disease, inflammatory bowel disease (IBD), cavities, sudden infant death syndrome (SIDS), and many more benefits.[8-10] Furthermore, there are many benefits of breastfeeding for a mother, which include lower cost than alternative feeding, lower risk of postpartum depression, potential postpartum weight loss, physical and emotional bonding with baby, quicker recovery from childbirth, lower risk of developing certain cancers, type 2 diabetes, cardiovascular disease, high blood pressure, high cholesterol, among others.[8, 9]

1.2 Composition of Breast Milk

Breast milk contains all the nutrients a newborn infant needs to grow and stay healthy. Because breast milk is crucial for a newborn's health, the World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life.[2] Additionally, complementary feeding alongside breastfeeding is recommended to begin at six months and continue until two years of age or beyond.[2]

Breast milk contains all the right amounts of carbohydrates, fat, protein, and micronutrients for an infant.[1] Breast milk contains roughly 88% of water by volume, 7% of carbohydrates, 1% of protein, and 4 % of fat.[11] Lactose is the most common form of carbohydrate in breast milk, because a newborn infant does not have a developed gastrointestinal tract to digest complex forms of carbohydrates, like starch. Apart from being an easily digestible form of carbohydrate, lactose assists in the development of the gastrointestinal tract and the maintenance of the intestinal microbiota.[11] More specifically, lactose prevents the growth of unwanted bacteria and supports the growth of healthy bacteria in the stomach, which promotes calcium, phosphorus, and magnesium absorption.[12] Whey and casein are the main forms of protein in breast milk, with whey making up approximately 60% and casein making up 40% of the total protein content.[11, 12] Due to the majority of protein in human milk being whey protein, infants are able to digest it more easily and quickly. If an infant consumes milk with a majority of the protein content being casein, it will cause digestive difficulty. Protein aids major functions of the body, such as infant growth and development. Certain proteins found in breast milk have specific antibacterial and antiviral properties, like lactoferrin, secretory IgA, and lysozyme.[11, 12] Triglyceride is the main component of fat in breast milk fat due to it making up approximately 94-98% of all fatty acids in breast milk. Triglycerides are also the primary source of calories. It helps with the development of the central nervous system, brain, and retina.[11, 12] Fat in breast milk aids the absorption of fat-soluble vitamins A, D, E, and K. Without dietary fat, these fat-soluble vitamins would not be absorbed, therefore causing deficiency.[12] Some major vitamins and minerals in breast milk include iron, calcium, phosphorus, magnesium, sodium, potassium, and zinc.[11] Breast milk contains a sufficient amount of micronutrients for an infant to grow and stay healthy. However, vitamin D, K, and iron levels may be inadequate for optimal infant health in certain situations. Supplementation of deficient micronutrients is recommended.[11] Material diet greatly affects vitamin levels in breast milk.[12] It is important for pregnant and nursing mothers to consume a variety of healthy foods to ensure adequate vitamin levels in breast milk. Health professionals may recommend prenatal supplements to ensure the mother and infant are getting sufficient micronutrients.[12]

Breast milk contains many bioactive factors like antibodies, white blood cells, microRNAs, growth factors, and prebiotics.[12, 13] Bioactive factors are non-nutrient elements that affect body function by protecting against infection and inflammation and contribute to overall health.[13] As mentioned previously, certain proteins found in breast milk have specific antibacterial and antiviral properties, like lactoferrin, secretory IgA, IgG, IgM, and lysozyme.[12] Lactoferrin prevents the growth of and destroys iron-dependent bacteria in the gastrointestinal

(GI) tract by regulating iron absorption.[12, 14] Secretory IgA is an immunoglobulin protein, also known as antibodies. It has antibacterial and antiviral effects by coating the intestinal mucosa, which prevents microorganisms from entering the tissue.[12, 15] IgG is another antibody that fights off harmful bacteria and promotes the growth of beneficial bacteria in the GI tract, however, concentrations are lower than IgA in breastmilk.[13, 16] IgM is an additional antibody that breaks down harmful gram-negative bacteria, however, concentrations are lower than IgA and IgG in breast milk.[13, 16] Lysozyme breaks down harmful gram-positive and some gram-negative bacteria in the GI tract.[15] This immune response supports infant immunity and prevents infections. Lysozyme also assists the growth of intestinal microflora and has anti-inflammatory characteristics.[17] White blood cells, or maternal leukocytes, help defend against harmful pathogens/bacteria through phagocytosis.[18] Phagocytosis is a process in which a cell engulfs another foreign substance, bringing it into the cell to degrade.[19] MicroRNAs functionally regulate gene expression when absorbed in the gastrointestinal tract.[20] MicroRNAs do this by binding to the messenger RNA (mRNA) in the cytoplasm of the cell. This binding causes the microRNA to control whether the mRNA destroys its components or preserves it for later translation.[21] Growth factors are an additional bioactive factor that support the growth and healing of the intestinal mucosa, stimulate water and glucose absorption, and increase neuron survival and outgrowth.[13] Lastly, prebiotics are defined as substrates that microorganisms in the GI tract degrade and utilize.[22, 23] Microorganisms in the GI tract provide health benefits if the environment in the GI tract is optimal. Therefore, prebiotics contribute to gastrointestinal tract health indirectly.[22, 23]

Breast milk composition can vary greatly depending on the stage of lactation, the mother's age, the mother’s diet, time during breastfeeding period, the time of day, and environmental factors.[10] There are three stages of lactogenesis, lactogenesis I, lactogenesis II, and lactogenesis III. [24] Lactogenesis I is the secretory initiation stage that begins during the second half of pregnancy and continues until 36-96 hours after delivery.[24, 25] During this stage, epithelial cells in the breast convert into lactocytes, cells that produce and secrete milk in the mammary glands. Production of breast milk can begin in small amounts during this stage, around 16 weeks of gestation. Lactogenesis II is the secretory activation stage that begins 36-96 hours after delivery until roughly nine days postpartum. During this stage, milk production increases and breasts become fuller.[24, 25] Lactogenesis III, also known as galactopoiesis or the maintenance stage of lactation. This stage begins roughly nine days postpartum and continues until breastfeeding ceases. Breast milk continues to be produced until breastfeeding stops.[24] If breastfeeding stops and there is no more stimulation of the breasts, then milk production will stop.[26]

Colostrum is breast milk produced as early as 16 weeks of gestation and continues until roughly five days postpartum, during lactogenesis I.[10, 11, 22] Colostrum is high in protein, antibodies, and other immune-protective components, but low in fat. Transitional milk is breast milk produced roughly between 5 to 15 days postpartum, during lactogenesis II. Transitional milk is produced in higher volumes compared to colostrum, and carbohydrate and fat percentages start to increase. Mature milk is breast milk produced roughly 15 days postpartum, during lactogenesis III. Mature milk is high in fat and carbohydrates, but low in protein.[10, 11, 22] Not only does breast milk composition change depending on the lactation stage, but it also changes during a single feeding session. Foremilk is breast milk produced at the beginning of a breastfeeding session, and it has low levels of fat. However, hindmilk is breast milk produced at the end of a breastfeeding session, and it has high levels of fat to generate satiety in infants. Breast milk can change rapidly to meet an infant's nutritional needs.[11]

1.3 Composition of Animal Milks

Human breast milk is the optimal feed for an infant, but in some cases, an feed may be needed. In the 19th century, wet nurses were used as a breastfeeding alternative.[27] Soon after, animal milk became a popular breast milk alternative. In the 20th century, infant formula was developed and became more popular. To this day, most infant formulas have a cow's milk base.[27] Animal milk is highly prevalent in most breast milk alternatives and should be examined further for the safety of infant health and well-being. Animal milk has a composition similar to human breast milk and is therefore commonly used as a breast milk alternative.[28] Similarly to human breast milk, animal milk composition can vary greatly depending on environmental factors, maternal diet, stage of lactation, species, and genetics.[5] Although it is hard to compare mammals' milk to one another due to the numerous factors that play a role in the composition, on average, cow milk has the most similar fat content to human breast milk. However, cholesterol levels in cow milk are significantly higher.[5] Saturated fatty acids were seen in higher percentages in cow milk than human milk, but monounsaturated and polyunsaturated fatty acids were seen in higher percentages in human milk.[5] When examining protein content, cow milk has significantly more protein (5.63%) than human milk (1.90%) in all lactation stages, but especially in the early lactation stage.[29] Cow milk also has significantly more calcium (112-123 mg/100 mL) compared to human breast milk (28-34 mg/100 mL).[30] Until the end of the 1800s, cow's milk was the most common artificial alternative to human breast milk and continues to be a popular milk for infant feeding today.[29, 31]

Buffalo milk is commonly produced and consumed in Asia.[28, 29] In these areas, buffalo milk is consumed in similar ways to cow's milk and is usually preferred due to its rich flavor.[29] Its production rate had roughly tripled between 1961 and 2018.[28] It has significantly more fat and a noticeably different casein-to-whey ratio compared to human breast milk.[5, 28] Protein content in buffalo milk is higher than protein content in human breast milk with 4.02% in the early lactation stage compared to 1.90% in human milk.[29] Buffalo milk is high in micronutrients, especially high in calcium (112-220 mg/100 mL) due to the amount of casein present.[5, 30, 32] Buffalo milk is also high in phosphorus and magnesium but low in sodium.[5]

Goat's milk is most commonly consumed raw in Africa and South Asia.[28, 32] Similarly to buffalo milk, goat milk has more protein content and disproportionately more casein-to-whey compared to human breast milk.[28, 29] However when human breast milk was nutritionally compared to various animal milk, goat milk was most similar to human breast milk in protein content, with 3.18% protein in goat milk and 1.90% protein in human milk in the early lactation stage. Additionally, in the mature lactation stage, goat milk has roughly 1.10% protein and human milk has roughly 1.00% protein, which are the most similar concentrations observed.[29] When fat concentrations were examined in various animal milks, it was observed that goat milk had a higher percentage of fat compared to human breast milk in all lactation stages.[29] However, goat milk has similar cholesterol concentrations (9.00-18.10 mg/dL) to human breast milk (5.38-12.00 mg/dL).[5] Furthermore, both goat milk and human breast milk cholesterol levels were observed to be lowest in the early lactation stage and increase in the mature lactation stage.[5] The fat molecules in goat milk are smaller than the fat molecules in cow milk, therefore making it easier to digest.[33] This aspect of goat milk is appealing when considering alternative milk for infant feeding. Goat milk has lower iron levels (0.07 ± 0.02 mg/dL) compared to human breast milk (0.20 mg/dL) but higher potassium levels (183.6 ± 17.2 mg/dL vs 71.3 ± 9.0 mg/dL).[5]

Sheep milk is most commonly consumed in the Mediterranean and Middle Eastern regions due to the climate not being suitable for cows and therefore cow milk production.[32, 34] When fat content was examined in various animal milks, sheep milk was observed to have a high fat content of 7.10 ± 3.21 g/dL.[5] High-fat content is appealing when considering alternative infant feeding due to the amount of energy it provides.[5] Sheep milk was also observed to have high cholesterol concentrations (17.07 ± 1.18 mg/dL) compared to other mammalian milk and human breast milk.[5] Additionally, sheep milk was observed to have high levels of saturated fatty acids (77.50 ± 0.92% of total fatty acids) and low levels of monounsaturated and polyunsaturated fatty acids (19.01 ± 1.35%, 3.86 ± 0.49%).[5] Sheep milk also has a high protein content. Sheep milk has roughly 4.52-5.50% protein.[34] This protein content is higher than most other mammalian milks, including buffalo, cow, and goat.[34] Sheep milk has higher concentrations of multiple micronutrients, including calcium (181.70 ± 17.2 mg/dL), potassium (178.6 ± 8.4 mg/dL), sodium (52.10 ± 3.2 mg/dL), and zinc (0.58 ± 2.1 mg/dL).[5] Lastly, sheep milk has multiple bioactive factors, including catechol, vanillin, ferulic acid, and salicylic acid.[35] These bioactive factors help with wound healing, inflammation, skin health, fighting harmful bacteria, eliminating free radicals, potentially fighting off cancers, and relieving fever and pain. [36-40] The amount of bioactive factors in sheep milk is appealing when it comes to infant feeding alternatives.

Lastly, camel milk is mostly consumed in the Middle East and Arabian areas because camels commonly live in these areas.[41] Consumption of camel milk has roughly doubled between 1961 and 2018.[28] The fat content varies but is generally low compared to other animal milks.[41] Camel milk has roughly 1.2 to 4.5% fat. The fat molecules in camel milk are smaller than the fat molecules in cow, buffalo, and goat milk, therefore, it is easy to digest. This is a quality sought after in infant feeding alternatives.[41] Camel milk is high in vitamin C, iron, and unsaturated fatty acids.[30] One source found camel milk to have 27.6–34.3 mg/L of vitamin C, which is higher than most other animal milks.[42] Camel milk has roughly 0.05 mg/100 g of iron compared to cow milk with roughly 0.27 mg/100g of iron.[43] Unsaturated fatty acids are seen to be between 35–50% in camel milk.[44] However, camel milk is highly variable and changes compositionally based on many factors.[45] The inconsistency in composition is not appealing for alternative infant feeding.

As discussed, animal milk has a multitude of factors that play a role in its composition, but they each have attributes that are admirable for infant feeding. However, each animal's milk is species-specific and varies compared to one another and to human breast milk. Due to these differences, human breast milk is the optimal diet for an infant.

1.4 Sociodemographic Characteristics and Infant Feeding

Sociodemographic characteristic is an all-encompassing term that includes socioeconomic status, income, education, occupation, race, social class, living conditions, resources, and more. [46-48] All of these aspects of sociodemographic characteristics affect infant feeding practices. Women of lower SES backgrounds are less likely to initiate breastfeeding and exclusively breastfeed for 6 months.[49] Race also plays a role in infant feeding practices, for example, Non-Hispanic White women are more likely to exclusively breastfeed compared to Non-Hispanic Black and Hispanic women.[50] In addition, women who intend to exclusively breastfeed were more likely to have a bachelor's or master's degree and a higher income.[50] Another study found that Asian and White mothers were more likely to initiate breastfeeding compared to American Indian/Alaska Native and Black mothers in the United States.[51] Additionally, another study found that populations with lower levels of education and income were more likely to stop breastfeeding at 1 month postpartum compared to populations with high levels of education and income.[52] These observations show how much sociodemographic characteristics influence infant feeding practices, which have long-term health effects. Every person has their own unique set of sociodemographic characteristics that influence their knowledge, opinions, and therefore actions.

1.5 Innovation

There is existing literature on animal milk composition in comparison to human breast milk, there is also literature on how sociodemographic characteristics influence infant feeding practices. However, there is no current research on the association between sociodemographic characteristics and the usage of animal milk as a human breast milk alternative in infant feeding. Animal milk is often used as a substitute for human breast milk for many reasons, for instance, when an infant is diagnosed with classic galactosemia, maple syrup urine disease, or phenylketonuria (PKU), or if a mother has HIV infection, active untreated tuberculosis, human T-cell lymphotropic virus type I or II infection.[4] However, the literature does not address this issue as much as it needs to. The outcomes of this study will be beneficial in guiding comprehensive education for mothers, as this study will provide data on certain associations related to infant feeding practices. It is crucial that women and mothers know the safety of using animal milk as a breast milk alternative. This study will provide insight into this association and provide empirical data to guide programs by health organizations in educating women on recommended infant feeding methods.

1.6 Specific Aims and Hypothesis

Many studies have shown that breastfeeding is beneficial not only to the infant but also to the mother, but those same benefits do not translate when an infant is given other animal milks as alternatives to human breast milk. The benefits of breastfeeding for a mother include a lower risk of osteoporosis, cardiovascular disease, obesity, and breast and ovarian cancer.[53, 54] Conversely, human breast milk contains all the nutrients a newborn infant needs to grow and stay healthy. Breast milk contains antibodies, white blood cells, and all the right amounts of carbohydrates, fat, protein, and micronutrients for an infant.[54, 55]

Although breastfeeding has many beneficial qualities, breastfeeding an infant might not be the optimal option for all mothers and infants. For instance, if an infant is diagnosed with classic galactosemia, maple syrup urine disease, or phenylketonuria (PKU), or if a mother has HIV infection, active untreated tuberculosis, human T-cell lymphotropic virus type I or II infection, or taking certain medications that can be passed to the infant via breast milk.[4] All of these conditions would lead to the usage of alternative milk. Although there are instances when women should not breastfeed, most women can.[56] Although most women can breastfeed properly, in the United States, only 25.4% of infants born in 2020 were exclusively breastfed for the first six months of life. One of the Healthy People 2030 Breastfeeding objectives is to increase the proportion of infants who are breastfed exclusively through six months of age to 42.4%.[56] To reach this goal, the United States has a lot of improvement to make in the next five years in order to meet the targets for breastfeeding in the Healthy People 2030 objectives.

There is a multitude of studies done on the broad topic of breastfeeding, more specifically, the influence of sociodemographic factors on breastfeeding. However, there is limited research on how sociodemographic factors are associated with knowledge of animal milk use as an alternative to human breast milk in infant feeding. The goal of this study is to examine areas where a lack of or proficiency in knowledge on the use of animal milk in infant feeding among women of childbearing age exists.

Specific Aim 1: Explore the role of sociodemographic factors on breastfeeding knowledge of women of childbearing age. Hypothesis 1: Women of lower socioeconomic status will have less knowledge of breastfeeding recommendation. Current literature shows knowledge is directly associated with socioeconomic status.[57, 58]

Specific Aim 2: Examine the awareness of breastfeeding laws/legislation among women of childbearing age. Hypothesis 2: Women of lower socioeconomic status will have less awareness of breastfeeding laws, including the Affordable Care Act (ACA) and the Fairness for Breastfeeding Mothers Act of 2019.

Specific Aim 3: Assess women of childbearing age's knowledge of the use of animal milk as a breast milk alternative. Hypothesis 3: Women of lower socioeconomic status will have less knowledge of the inappropriateness of animal milk in an infant's diet.

The long-term goal is to understand mothers' knowledge and which mothers choose animal milk in infant feeding, to guide educational programs/interventions on breastfeeding to promote healthy infant feeding and meet infant feeding recommendations. Upon completion, we will better understand the role of sociodemographic characteristics of women of childbearing age in relation to knowledge of the use of animal milk as a breast milk alternative.

References

1.Meek JY, Noble L. Policy Statement: Breastfeeding and the Use of Human Milk. *Pediatrics*. 2022;150(1). doi:https://doi.org/10.1542/peds.2022-057988

2.World Health Organization. Breastfeeding. World Health Organization. Published 2021. https://www.who.int/health-topics/breastfeeding#tab=tab_2

3.Centers for Disease Control and Prevention. Results: Breastfeeding Rates . cdc.gov. Published 2019. https://www.cdc.gov/breastfeeding/data/nis_data/results.html

4.National Institutes of Health. Are there any special conditions or situations in which I should not breastfeed? http://www.nichd.nih.gov/. Published January 31, 2017. https://www.nichd.nih.gov/health/topics/breastfeeding/conditioninfo/special-conditions

5.Pietrzak-Fiećko R, Kamelska-Sadowska AM. The Comparison of Nutritional Value of Human Milk with Other Mammals' Milk. *Nutrients*. 2020;12(5):1404. doi:https://doi.org/10.3390/nu12051404

6.Victora CG, Bahl R, Barros AJD, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and Lifelong Effect. *The Lancet*. 2016;387(10017):475-490. doi:https://doi.org/10.1016/s0140-6736(15)01024-7

7.Bachrach VRG, Schwarz E, Bachrach LR. Breastfeeding and the Risk of Hospitalization for Respiratory Disease in Infancy. *Archives of Pediatrics & Adolescent Medicine*. 2003;157(3):237. doi:https://doi.org/10.1001/archpedi.157.3.237

8.McCarthy C. Breastfeeding Benefits Your Baby's Immune System. HealthyChildren.org. Published 2020. https://www.healthychildren.org/English/ages-stages/baby/breastfeeding/Pages/Breastfeeding-Benefits-Your-Babys-Immune-System.aspx

9.CDC. About Breastfeeding. Breastfeeding. Published May 2, 2024. https://www.cdc.gov/breastfeeding/php/about/index.html

10.Garwolińska D, Namieśnik J, Kot-Wasik A, Hewelt-Belka W. Chemistry of Human Breast Milk—A Comprehensive Review of the Composition and Role of Milk Metabolites in Child

Development. *Journal of Agricultural and Food Chemistry*. 2018;66(45):11881-11896. doi:https://doi.org/10.1021/acs.jafc.8b04031

11.Kim SY, Yi DY. Components of Human Breast milk: from Macronutrient to Microbiome and microRNA. *Clinical and Experimental Pediatrics*. 2020;63(8):301-309. doi:https://doi.org/10.3345/cep.2020.00059

12.American Pregnancy Association. What's In Breast Milk? American Pregnancy Association. Published April 25, 2012. https://americanpregnancy.org/healthy-pregnancy/first-year-of-life/whats-in-breastmilk/

13.Ballard O, Morrow AL. Human Milk Composition: Nutrients and Bioactive Factors. *Pediatric Clinics of North America*. 2013;60(1):49-74. doi:https://doi.org/10.1016/j.pcl.2012.10.002

14.Kell D, Heyden E, Pretorius E. The Biology of Lactoferrin, an Iron-Binding Protein That Can Help Defend Against Viruses and Bacteria. Frontiers. Published May 27, 2020. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2020.01221/full

15.Palmeira P, Carneiro-Sampaio M. Immunology of breast milk. *Revista da Associação Médica Brasileira*. 2016;62(6):584-593. doi:https://doi.org/10.1590/1806-9282.62.06.584

16.Czosnykowska-Łukacka M, Lis-Kuberka J, Królak-Olejnik B, Orczyk-Pawiłowicz M. Changes in Human Milk Immunoglobulin Profile During Prolonged Lactation. Frontiers in Pediatrics. Published August 6, 2020. https://www.frontiersin.org/journals/pediatrics/articles/10.3389/fped.2020.00428/full

17.Yang B, Wang J, Tang B, et al. Characterization of Bioactive Recombinant Human Lysozyme Expressed in Milk of Cloned Transgenic Cattle. *PLoS ONE*. 2011;6(3). doi:https://doi.org/10.1371/journal.pone.0017593

18.Witkowska-Zimny M, Kaminska-El-Hassan E. Cells of human breast milk. *Cellular & Molecular Biology Letters*. 2017;22(1). doi:https://doi.org/10.1186/s11658-017-0042-4

19.Deshpande OA, Wadhwa R. Phagocytosis. PubMed. Published 2021.

https://www.ncbi.nlm.nih.gov/books/NBK556043/

20.Xu YR, Zhao J, Huang HY, et al. Recent insights into breast milk microRNA: their role as functional regulators. Frontiers in Nutrition. Published April 15, 2024. https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1366435/full

21.The Ohio State University Comprehensive Cancer Center. microRNA - What it is and How it Works | OSUCCC - James. The James - OSUCCC. https://cancer.osu.edu/microrna

22.Plamada D, Vodnar DC. Polyphenols—Gut Microbiota Interrelationship: A Transition to a New Generation of Prebiotics. *Nutrients*. 2022;14(1):137. doi:https://doi.org/10.3390/nu14010137

23.Cremon C, Barbaro MR, Ventura M, Barbara G. Pre- and probiotic overview. *Current Opinion in Pharmacology*. 2018;43:87-92. doi:https://doi.org/10.1016/j.coph.2018.08.010

24.Boersma S, Cozzella T. *How the Breast Works*. https://breastfeedingresourcesontario.ca/sites/default/files/pdf/BFI_How_the_Breast_Works_web.pdf

25.Pillay J, Davis TJ. Physiology, Lactation. PubMed. Published 2021. https://www.ncbi.nlm.nih.gov/books/NBK499981/#:~:text=Lactogenesis%20is%20the%20process%20of

26.Patel S. 4 factors that can decrease breast milk supply – and how to replenish it | Your Pregnancy Matters | UT Southwestern Medical Center. Utswmed.org. Published May 16, 2022. Accessed September 17, 2024. https://utswmed.org/medblog/decrease-breast-milk-supply/#:~:text=Getting%20sick

27.Institute of Medicine (US) Committee on the Evaluation of the Addition of Ingredients New to Infant Formula. Comparing Infant Formulas with Human Milk. Nih.gov. Published 2004. https://www.ncbi.nlm.nih.gov/books/NBK215837/

28.Roy D, Ye A, Moughan PJ, Singh H. Composition, Structure, and Digestive Dynamics of Milk From Different Species—A Review. *Frontiers in Nutrition*. 2020;7.

doi:https://doi.org/10.3389/fnut.2020.577759

29.Thakore V, Jain N. Protein and fat examination from the raw milk of different mammalian species (Cow, buffalo, goat, and human) with successive lactation days. *~ 506 ~ The Pharma Innovation Journal*. 2018;7(10):506-510. https://www.thepharmajournal.com/archives/2018/vol7issue10/PartI/7-10-57-423.pdf

30.Claeys WL, Verraes C, Cardoen S, et al. Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. *Food Control*. 2014;42:188-201. doi:https://doi.org/10.1016/j.foodcont.2014.01.045

31.Stevens EE, Patrick TE, Pickler R. A History of Infant Feeding. *Journal of Perinatal Education*. 2009;18(2):32-39. doi:https://doi.org/10.1624/105812409x426314

32.FAO. Dairy production and products: Milk composition. www.fao.org. https://www.fao.org/dairy-production-products/products/milk-composition/en/

33.Lad S, Aparnathi KD, Mehta B, Velpula S. Goat Milk in Human Nutrition and Health – A Review . International Journal of Current Microbiology and Applied Sciences. Published April 17, 2017. Accessed September 23, 2024. https://www.ijcmas.com/6-5-2017/Sachin%20S.%20Lad,%20et%20al.pdf

34.Kalyankar SD, Sarode AR, Khedkar CD, Deosarkar SS, Pawshe RD. Sheep: Milk. Science Direct. Published September 22, 2015. https://www.sciencedirect.com/science/article/abs/pii/B9780123849472006218

35.Flis Z, Molik E. Importance of Bioactive Substances in Sheep's Milk in Human Health. *International Journal of Molecular Sciences*. 2021;22(9):4364. doi:https://doi.org/10.3390/ijms22094364

36.Puertas-Bartolomé M, Włodarczyk-Biegun MK, Campo A del, Vázquez-Lasa B, San Román J. Development of bioactive catechol functionalized nanoparticles applicable for 3D bioprinting. Science Direct. Published October 2021. https://www.sciencedirect.com/science/article/pii/S092849312100655X

37.Lim DY, Shin SH, Lee MH, et al. A natural small molecule, catechol, induces c-Myc degradation by directly targeting ERK2 in lung cancer. *Oncotarget*. 2016;7(23):35001-35014. doi:https://doi.org/10.18632/oncotarget.9223

38.Hu J, Wang Z, Miszuk JM, et al. Vanillin-bioglass cross-linked 3D porous chitosan scaffolds with strong osteopromotive and antibacterial abilities for bone tissue engineering. *Carbohydrate Polymers*. 2021;271:118440. doi:https://doi.org/10.1016/j.carbpol.2021.118440

39.Zduńska K, Dana A, Kolodziejczak A, Rotsztejn H. Antioxidant Properties of Ferulic Acid and Its Possible Application. *Skin Pharmacology and Physiology*. 2018;31(6):332-336. doi:https://doi.org/10.1159/000491755

40.Ding Y, Fan B, Zhu C, Chen Z. Shared and Related Molecular Targets and Actions of Salicylic Acid in Plants and Humans. *Cells*. 2023;12(2):219. doi:https://doi.org/10.3390/cells12020219

41.Swelum AA, El-Saadony MT, Abdo M, et al. Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. *Saudi Journal of Biological Sciences*. Published online February 2021. doi:https://doi.org/10.1016/j.sjbs.2021.02.057

42.Zhao D, Bai Y, Niu Y. Composition and characteristics of Chinese Bactrian camel milk. Science Direct. Published April 2015. https://www.sciencedirect.com/science/article/pii/S0921448815001595?casa_token=-0Ucdel3_VkAAAAA:nTpbmdKR0peBR2DjGTL46pEFQ1SrfNAXmqnpoLQsL5J3R059SDNSpYCiFR8uEaEs1yeAEz2depE

43.AL-Ayadhi L, Halepoto DM. Chapter 30 - Camel Milk as a Potential Nutritional Therapy in Autism. ScienceDirect. Published January 1, 2017. https://www.sciencedirect.com/science/article/abs/pii/B9780128097625000309

44.Izadi A, Khedmat L, Yousef Mojtahedi S. Nutritional and therapeutic perspectives of camel milk and its protein hydrolysates: A review on versatile biofunctional properties. Science Direct. Published July 2019. https://www.sciencedirect.com/science/article/pii/S1756464619303652

45.Halima EH, Zeineb J, Imed S, Amel A, Amel N, Touhami K. Comparison of composition and

whey protein fractions of human, camel, donkey, goat and cow milk. Research Gate. Published July 2015.
https://www.researchgate.net/publication/280494239_Comparison_of_composition_and_whey_protein_fractions_of_human_camel_donkey_goat_and_cow_milk

46.American Psychological Association. Socioeconomic Status. *American Psychological Association*. https://www.apa.org/topics/socioeconomic-status. Published 2022.

47.CDC. Socioeconomic factors . Centers for Disease Control and Prevention. Published 2023. https://www.cdc.gov/dhdsp/health_equity/socioeconomic.htm

48.Vo CQ, Samuelsen PJ, Hilde Leikny Sommerseth, Torbjørn Wisløff, Wilsgaard T, Anne Elise Eggen. Comparing the sociodemographic characteristics of participants and non-participants in the population-based Tromsø Study. *BMC Public Health*. 2023;23(1). doi:https://doi.org/10.1186/s12889-023-15928-w

49.Magnano San Lio R, Maugeri A, La Rosa MC, et al. The Impact of Socio-Demographic Factors on Breastfeeding: Findings from the “Mamma & Bambino” Cohort. *Medicina*. 2021;57(2):103. doi:https://doi.org/10.3390/medicina57020103

50.Baumgartner T, Bhamidipalli SS, Guise D, et al. Psychosocial and Sociodemographic Contributors to Breastfeeding Intention in First-Time Mothers. *Maternal and Child Health Journal*. 2020;24(8):1047-1056. doi:https://doi.org/10.1007/s10995-020-02928-0

51.Chiang KV, Li R, Anstey EH, Perrine CG. Racial and Ethnic Disparities in Breastfeeding Initiation ─ United States, 2019. *MMWR Morbidity and Mortality Weekly Report*. 2021;70(21):769-774. doi:https://doi.org/10.15585/mmwr.mm7021a1

52.Temple Newhook J, Newhook LA, Midodzi WK, et al. Poverty and Breastfeeding: Comparing Determinants of Early Breastfeeding Cessation Incidence in Socioeconomically Marginalized and Privileged Populations in the FiNaL Study. *Health Equity*. 2017;1(1):96-102. doi:https://doi.org/10.1089/heq.2016.0028

53.Centers for Disease Control and prevention. Five Great Benefits of Breastfeeding. Centers for Disease Control and Prevention. Published 2023.

https://www.cdc.gov/nccdphp/dnpao/features/breastfeeding-benefits/index.html#:~:text=Breastfeeding%20can%20help%20protect%20babies

54.NHS. Benefits of breastfeeding. nhs.uk. Published March 7, 2023. https://www.nhs.uk/conditions/baby/breastfeeding-and-bottle-feeding/breastfeeding/benefits/

55.USDA. Breastfeeding benefits | WIC breastfeeding. USDA.gov. Published 2019. https://wicbreastfeeding.fns.usda.gov/breastfeeding-benefits

56.CDC. Facts About Nationwide Breastfeeding Goals. Centers for Disease Control and Prevention. Published August 24, 2021. https://www.cdc.gov/breastfeeding/data/facts.html#:~:text=The%20American%20Academy%20of%20Pediatrics

57.American Psychological Association. Education and socioeconomic status. *American Psychological Association*. https://www.apa.org/pi/ses/resources/publications/education. Published 2017.

58.Tulane University. Social Determinant of Health: Education Is Crucial. Tulane University School of Public Health and Tropical Medicine. Published 2021. https://publichealth.tulane.edu/blog/social-determinant-of-health-education-is-crucial/

CHAPTER 2

LITERATURE REVIEW

2.1 Human Breast Milk

Breast milk is essential for infant survival. It contains all the nutrients an infant needs to grow and stay healthy. Human breast milk contains all three macronutrients, protein, carbohydrates, and fat, along with disease-fighting substances, such as immunoglobulins and microRNAs, which help an infant stay healthy and grow optimally.[1] Breast milk contains roughly 88% water, 7% carbohydrates, 1% protein, and 4 % fat.[1]

2.1.1 Carbohydrates in Human Breast Milk

Lactose is the most common form of carbohydrate in breast milk, this is because a newborn infant does not have a developed gastrointestinal tract to digest complex forms of carbohydrates, like starch.[1] Lactose is broken down by the enzyme, lactase-phlorizin hydrolase, also known as lactase.[1] Lactase breaks lactose down into two monosaccharides, glucose and galactose.[2] Lactase is located in the brush border of the small intestine on the apical surface of enterocytes.[1] Although these cells are along the entire small intestine, it is seen in higher concentrations in the jejunum.[3] Apart from being an easily digestible form of carbohydrate, lactose assists in the development of the gastrointestinal tract and the maintenance of the intestinal microbiota.[1] More specifically lactose prevents the growth of unwanted bacteria and supports the growth of healthy bacteria in the stomach, which promotes calcium, phosphorus, and magnesium absorption.[4] Although lactose is the main form of carbohydrate in breast milk, there are small amounts of glucose present in breast milk.[5] Glucose is usually seen at levels of 255.2 ± 75.3 μg/mL during the first 6 months of lactation, however, glucose levels depend on the volume of milk produced, breast milk flow rate, and material weight.[5-7] In addition to lactose and glucose, there are small amounts of fructose found in breast milk.[6] Fructose concentrations in breast milk are on average, 6.7 μg/mL. However, fructose concentrations in breast milk heavily rely on the maternal diet. Fructose concentration in breast milk was found to have a positive correlation with infant body composition.[6] Lastly, breast milk contains small amounts of oligosaccharides, which is a non-nutritive carbohydrate that has protective effects.[8, 9] It roughly makes up 1 g/dL of breast milk however concentrations rely heavily on material genetic factors.[8] It is genetically determined if a mother has the 'secretory status' associated with higher levels of oligosaccharides.[10] Specifically, some mothers might have the secretor gene that encodes for the 2-fucosyltransferase (FUT2) enzyme and other mothers might have the Lewis gene that encodes for the α1–3/4-fucosyltransferase (FUT3) enzyme. It was shown that mothers that have the secretor gene and therefore produce the FUT2 enzyme, have higher concentrations of oligosaccharides in their breast milk compared to the mothers that have the Lewis gene.[10] Carbohydrates are essential in infant feeding. Carbohydrates support cognitive development, growth, and provide energy.[9, 11] As mentioned previously, oligosaccharides have protective effects and also aid in brain development.[9] Oligosaccharides have been shown to support brain signaling, enhance learning and memory, and serve as prebiotics in the gut microbiome, thereby boosting cognitive performance. However, most research on oligosaccharides and cognition has been conducted in animal models, with limited studies on humans.[9] One study that did assess oligosaccharide levels in human breast milk, examined its association with cognitive development in offspring.[12] The study found that a high concentration of 2'FL oligosaccharide at one month was linked to enhanced cognitive development, although no similar association was observed at six months.[12] Further research is needed to better understand the role of oligosaccharides in brain development in older infants and school-aged children. The association between glucose and cognition has also been studied, with mixed results. Some studies report improvements in attention, memory and/or information processing following glucose supplementation.[13, 14] Another study found that memory for spoken words in young infants improved after glucose supplementation.[15] However, further research is needed to fully understand the effect of glucose on infant brain development.

2.1.2 Protein in Human Breast Milk

Whey and casein are the main forms of protein in breast milk with whey making up approximately 60% and casein making up 40% of the total protein content.[1, 4] Casein enters the stomach as gel-like clusters and is not easily digested, therefore digested more slowly.[8] Whey enters the stomach in a liquid form and is more easily digested.[8] Due to the majority of protein in human milk being whey protein, infants are able to digest it more easily and quickly.[1, 4] If an infant consumes high levels of casein, it would cause digestion difficulty and slow down digestion.[1, 4] Certain proteins found in breast milk have specific antibacterial and antiviral properties like lactoferrin, secretory IgA, α-lactalbumin, serum albumin, and lysozyme.[1, 4, 8] Overall protein content in breast milk decreases over time postpartum.[8] In addition, protein content is highest if an infant is born preterm. However, protein content is not affected by maternal diet but it is affected by maternal BMI.[8] Protein is essential in infant feeding. Protein is the building block of all cells and tissue in the body, it also aids intestinal growth, learning, memory, digestion, building skeletal muscle, regulation of gene expression, and regulation of the immune system.[16-18]

2.1.3 Fat in Human Breast Milk

Triglycerides are the main component of fat in breast milk due to it making up approximately 94-98% of total lipids in breast milk.[1] Triglycerides are also the primary source of calories. It helps with the development of the central nervous system and retina.[1, 4] Triglycerides can be broken down into subunits like monoglycerides, diglycerides, non-esterified fatty acids, saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids.[19] These subunits are also present in breast milk. Saturated fatty acids consist of carbon chains with single bonds between the carbon atoms, where each carbon is bonded to the maximum number of hydrogen atoms.[20] Monounsaturated fatty acids are similar to saturated fatty acids however they have one double bond between two carbons.[21] The majority of monounsaturated fatty acids in breast milk as seen in the forms of oleic acid and palmitoleic acid.[19] Polyunsaturated fatty acids are carbon-carbon chains with multiple double bonds between carbons.[19] Fatty acids aid in infant growth, the development of the nervous system, structural and metabolic functions, as well as provide energy.[19, 22, 23] Cholesterol is an additional form of lipid in breast milk.[19] Cholesterol is found at levels of 0.25–0.34mg/100g in breast milk. Cholesterol aids the synthesis of hormones and essential vitamins, cell membrane structure, and brain development. Other lipids found in breast milk include phospholipids plasmalogens, glycerophospholipids, and sphingolipids. These additional lipids make up approximately 0.2-1% of total lipids and are known as complex lipids. Complex lipids support cell membrane structure, signal transmission, and cell recognition.[19] Fat in breast milk aids the absorption of fat-soluble vitamins A, D, E, and K.[4] Without dietary fat, these fat-soluble vitamins would not be absorbed therefore causing deficiency.[4] In addition, fat provides energy, aids gastrointestinal function, signaling pathways, and lipoprotein metabolism.[19]

2.1.4 Micronutrients in Human Breast Milk

Micronutrients play important roles in infant development and growth, as previously mentioned. However, if infants receive inadequate amounts, then there are harmful impacts on their overall growth and health, making micronutrients an important factor in infant feeding. There are some micronutrient levels in breast milk that are dependent on maternal status and intake, including vitamin B-12, vitamin A, and iodine.[24] Vitamin A, also known as retinol, plays a crucial role in gene expression, reproduction, growth and development, immune function, and vision.[25, 26] A systematic review found retinol concentrations in breast milk were positively associated with maternal vitamin A intake in adequately nourished mothers.[27] When maternal intake was insufficient, breast milk retinol concentrations were more closely linked to plasma retinol levels. Additionally, the fat content in breast milk affects retinol levels, as fat acts as a carrier for retinol. The review also found that retinol concentrations in mature breast milk were positively correlated with milk fat, and retinol-to-fat ratio in breast milk was positively associated with maternal vitamin A intake. [27]

Vitamin B_{12} is an essential micronutrient in breast milk that relies on maternal intake.[24, 28-30] A systematic review found that maternal vitamin B_{12} intake was positively associated with vitamin B_{12} concentrations in breast milk, and supplementation also increases these concentrations.[31] During pregnancy, vitamin B_{12} is delivered from the mother to the fetus via the placenta, and postpartum, it is provided through breast milk.[28] To ensure there is sufficient vitamin B_{12} levels in breast milk, mothers must consume adequate amounts of it. Vitamin B_{12} is primarily found in animal products such as meat, fish, milk, and eggs. However, for mothers following vegetarian or vegan diets, vitamin B_{12} supplementation may be necessary.[28]

Iodine is an essential micronutrient in breast milk that is entirely dependent on maternal intake and is crucial for both the physical and cognitive development of the infant.[24, 32-34] It plays a pivotal role in supporting proper brain growth and overall development, with studies highlighting its significance for neurological function in early life.[32-34] Infants are born with limited stores of iodine, meaning they are highly dependent on external sources, particularly breast milk, to meet their nutritional needs.[32] Given that iodine is critical for thyroid function and the synthesis of thyroid hormones, which regulate various physiological processes, its presence in breast milk directly influences infant growth and health.[32-34] A systematic review has demonstrated that iodine supplementation in lactating women and adequate daily iodine intake are strongly associated with higher iodine concentrations in breast milk, further emphasizing the importance of maternal iodine status.[32] However, despite this evidence, there remains a lack of consensus among health experts and organizations regarding the exact iodine intake requirements for breastfeeding women, leading to variability in recommendations across different guidelines.[32]

Other micronutrients in breast milk that are influenced by maternal diet include thiamin, riboflavin, vitamin B6, choline, and selenium.[35] Thiamin levels in breast milk are closely tied to maternal thiamin status, with concentrations reflecting the level in women who have adequate thiamin intake.[36] Over the first several months postpartum, thiamin concentrations in breast milk increase in response to the infant's needs.[37] In breast milk, thiamin is primarily present as thiamin monophosphate (60%) and free thiamin (30%).[36] Riboflavin levels in breast milk are positively correlated with maternal dietary intake and tend to remain stable for the first three months postpartum in well-nourished mothers, compared to more variable levels in malnourished women.[38] Riboflavin in breast milk exists mainly in the forms of flavin adenine dinucleotide (FAD) and free riboflavin.[39] Vitamin B_6, another important micronutrient, also depends on maternal diet.[35] Its concentrations in breast milk peak during the early postpartum weeks and gradually decline over time.[40] After six months postpartum, breast milk may no longer provide adequate vitamin B6 for infants, highlighting the importance of complementary nutrition.[41] Choline, a critical nutrient for infant development, is also reliant on maternal intake.[35] It is found in breast milk primarily as phosphocholine and glycerophosphocholine, with small amounts of free choline.[42] Research has shown that supplementing with phosphatidylcholine can increase free choline and phosphocholine levels in breast milk.[43] Choline concentrations rapidly rise between 7 and 22 days postpartum and remain stable in mature milk.[44] Lastly, selenium concentrations in breast milk are directly influenced by the selenium content of the local soil where maternal food is grown, meaning geographic location plays a key role in determining selenium levels.[45] In breast milk, selenium is primarily found in the form of glutathione peroxidase.[46] While infants are born with selenium reserves, continued intake through breast milk is crucial for meeting their needs.[45, 47] Selenium concentrations in breast milk are highest in colostrum and decrease as the milk transitions to mature milk.[35, 45, 47]

Although research suggests these associations, more research needs to be done on micronutrient levels in breast milk and micronutrient recommendations during pregnancy, postpartum, and infancy.

Breast milk contains non-nutrient elements called bioactive factors that have protective effects.[8] Bioactive factors include antibodies, white blood cells, microRNAs, growth factors, prebiotics, oligosaccharide, leptin, and ghrelin.[4, 8] As mentioned above, certain proteins found in breast milk have specific antibacterial and antiviral properties like lactoferrin, secretory IgA, IgG, IgM, and lysozyme.[4] Lactoferrin prevents the growth of and destroys iron-dependent bacteria in the gastrointestinal (GI) tract by regulating iron absorption.[4, 48] Secretory IgA is an immunoglobulin protein, also known as antibodies. [4] It has antibacterial and antiviral effects by coating the intestinal mucosa which prevents microorganisms from entering the tissue.[4, 49] IgG is another antibody that fights off harmful bacteria and promotes the growth of beneficial bacteria in the GI tract, however, concentrations are lower than IgA in breastmilk.[8, 50] IgM is an additional antibody that breaks down harmful gram-negative bacteria, however, concentrations are lower than IgA and IgG in breast milk.[8, 50] Lysozyme breaks down harmful gram-positive and some gram-negative bacteria in the GI tract.[49] This immune response supports infant immunity and prevents infections.[49] Lysozyme also assists the growth of intestinal microflora and has anti-inflammatory characteristics.[51] White blood cells, or maternal leukocytes, help defend against harmful pathogens/bacteria through phagocytosis.[52] Phagocytosis is a process when a cell engulfs another foreign substance bringing it into the cell to degrade.[53] MicroRNAs functionally regulate gene expression when absorbed in the gastrointestinal tract.[54] MicroRNAs do this by binding to the messenger RNA (mRNA) in the cytoplasm of the cell.[54] This binding causes the microRNA to control whether the mRNA destroys its components or preserves it for later translation.[55] Growth factors are an additional bioactive factor that support the growth and healing of the intestinal mucosa, stimulate water and glucose absorption, and increase neuron survival and outgrowth.[8] Lastly, prebiotics are defined as substrates that are degraded and utilized by microorganisms in the gastrointestinal (GI) tract.[56, 57] These microorganisms contribute to gastrointestinal health when the environment in the GI tract is optimal, making prebiotics important for gut health through indirect mechanisms.[56, 57] Carbohydrates, proteins, phytochemicals, and other compounds possess prebiotic characteristics.[56] For a food component to be classified as a prebiotic, it must meet specific criteria. It should resist gastric acidity, withstand hydrolysis by mammalian enzymes, avoid absorption in the upper gastrointestinal tract, be fermentable by intestinal bacteria, and stimulate the growth of beneficial microorganisms.[56] Polyphenols, a type of phytochemical, are found in various foods such as vegetables, fruits, cereals, tea, coffee, chocolate, and wine. Other phytochemicals with prebiotic properties include polysaccharides and terpenoids. Phytochemicals can be categorized into absorbed and nonabsorbed fractions. The nonabsorbed fraction acts as a prebiotic, while the absorbed fraction helps induce stress resistance mechanisms in the body.[56] Human milk oligosaccharides (HMOs) are another bioactive factor, however they are also considered prebiotics because they encourage the growth of beneficial organisms in the gastrointestinal tract.[8] HMOs also prevent infections by binding to pathogens and inhibiting them from infecting cells.[8] HMOs were observed to be at the highest concentrations in the early lactation stage compared to later lactation stages.[58] Leptin is a bioactive factor hormone that helps control energy intake and balance.[59] Due to this effect on the body, leptin contributes to infant body composition and growth. Additionally, leptin concentration in breast milk is positively correlated with maternal BMI. Therefore, maternal BMI could have effects on infant body composition and growth.[59] Lastly, ghrelin is a bioactive factor hormone that is present in the stomach and helps regulate appetite, energy intake, gastric acid secretion and gut motility.[60] Similar to leptin, ghrelin contributes to infant body composition and growth.[59]

2.2 Breast Milk and Infant Health

Human breast milk is the best nutritional diet for an infant.[61] However, breast milk has more benefits other than nutritional composition.[62] Breast milk helps infants fight off sicknesses like ear infections, vomiting, diarrhea, respiratory infections, meningitis, pneumonia, and urinary tract infections.[62] Breast milk helps build and strengthen an infant's immune system by providing antibodies.[63] Breast milk contains lactoferrin and interleukin-6, -8, and -10 proteins which help control and regulate inflammation when an infection is encountered. Without these proteins, an infant’s inflammatory response would not be controlled, and too much inflammation could have negative effects.[63] Breast milk also contains probiotics which help with an infant’s gut health. It is thought that probiotics in breast milk help lower the risk of allergies, asthma, diabetes, and obesity.[63] Breast milk is the easiest for an infant to digest compared to other milk types.[64] It has simple nutritional components that infants usually have no problem digesting and absorbing. Breast milk also has economic benefits.[64] Since mothers do not buy breast milk like they do with infant formula, it lowers household expenses. As stated previously, breast milk reduces infection rates and therefore, lowers health costs.[64]

There are many benefits of breastfeeding for a mother. Some benefits include postpartum weight loss, quicker recovery from childbirth, physical and emotional bonding with the baby, lower risk of type 2 diabetes, certain cancers, high blood pressure, high cholesterol, cardiovascular disease, and many more benefits.[62, 63, 65] Ovarian and breast cancers have been linked to prolonged exposure to hormones such as estrogen.[66] Breastfeeding can delay the return of menstrual periods, which reduces a mother’s exposure to estrogen and, in turn, lowers the risk of developing both ovarian and breast cancer.[66] Additionally, breastfeeding has been shown to improve glucose and insulin regulation, thereby reducing a mother’s risk of developing type 2 diabetes.[67] One study, in particular, found that breastfeeding for more than two months is associated with a lower risk of type 2 diabetes.[67] A systematic review also revealed that women who breastfeed for over 12 months experience a 30% reduction in the risk of developing diabetes and a 13% reduction in the risk of hypertension.[68] These findings were adjusted for potential confounding factors, including obesity, smoking, and family history, providing a clearer understanding of the protective effects of breastfeeding on hypertension and diabetes.[68]

2.2.1 Breast Milk Contraindications

It is uncommon for a mother to be unable to breastfeed or an infant unable to receive breast milk, but there are a few special conditions.[69] Infants with classic galactosemia, maple syrup urine disease, or phenylketonuria should not be breastfed.[70] Classic galactosemia is a genetic disorder in which an individual either lack the enzyme galactose-1-phosphate uridyltransferase (GALT) or have a nonfunctional form of it.[71] The GALT enzyme is responsible for metabolizing the sugar galactose.[71] Without this enzyme, infants with this galactosemia are unable to break down galactose, leading to its accumulation in the body when ingested.[71, 72] Symptoms of galactose build up in infants include poor feeding, vomiting, jaundice, lethargy, and cataracts.[71] In addition to these initial signs, children with galactosemia may experience long-term complications, such as learning disabilities, neurological impairments, and ovarian failure.[71] To manage the condition, infants must be fed a galactose-free formula as a substitute for breast milk.[70] Maple syrup urine disease (MSUD) is a genetic disorder in which an individual lacks the branched-chain alpha-keto acid dehydrogenase enzyme complex.[73] This enzyme complex is responsible for breaking down the amino acids leucine, isoleucine, and valine. When these amino acids are not properly metabolized, they accumulate in the blood and urine, leading to potentially harmful effects.[73] These three amino acids have toxic byproducts, ketoacids. The buildup of ketoacids can cause metabolic acidosis.[73] Without prompt treatment, the condition can lead to a range of serious complications, including poor feeding, lethargy, irritability, hypertonia, hypotonia, spasticity, seizures, coma, respiratory failure, and even death. The disease gets its name from the distinctive sweet-smelling urine produced by affected individuals.[73] Infants with MSUD require a special formula that is free from leucine, isoleucine, and valine to manage the condition effectively.[70, 73] Phenylketonuria (PKU) is a genetic disorder caused by a deficiency in the enzyme phenylalanine hydroxylase (PAH).[74] The PAH enzyme is responsible for metabolizing the amino acid phenylalanine. In the absence of this enzyme, phenylalanine accumulates in the blood and brain which could have damaging effects on the nervous system.[74] The signs and symptoms of PKU include intellectual disabilities, decreased IQ, eczema, and seizures. To manage the condition, infants with PKU must be fed a special formula that is free from phenylalanine.[74] All three of these conditions are rare inherited disorders that need to be managed early.[71, 73, 74] If these conditions are not diagnosed and managed in early infancy, complications could arise like intellectual disabilities, speech defects, ovarian failure, high risk of infections, seizures, brain damage, coma, and even death.[71, 73, 74] In addition to infant conditions, there are maternal conditions where a mother should not breastfeed.[70, 72] These include HIV infection, herpes simplex virus type I (HSV-1), human T-cell lymphotropic virus type I or type II infection, untreated active tuberculosis, severe illness, usage of antiretroviral medications, birth-control medications containing estrogen, cancer chemotherapy agents, illegal drugs, migraine medications, mood stabilizer medications, sleep-aid medications, anti-epileptic drugs and opioids, radioactive iodine-131, and topical iodine or iodophors in excessive amounts.[70, 72] Additional circumstances where breastfeeding is substituted or supplemented with other breast milk alternatives include if a child is adopted, if a mother is unable to produce enough milk or pump, and workplace and/or home environment is not adequate for the safe storage of milk.[75]

2.2.2 Breastfeeding and Infant Feeding Recommendations

Since infant feeding is key to optimal health and health later in life, regulatory bodies and health organizations have recommendations surrounding infant feeding practices. The World Health Organization (WHO) recommends exclusively breastfeeding for the first six months of life.[61] Additionally, complementary feeding alongside breastfeeding is recommended to begin at six months and continue until two years of age or beyond.[61] The United Nations Children's Fund (UNICEF) has alike recommendations including initiating breastfeeding within the first hour postpartum, exclusively breastfeeding for the first 6 months of life, and complementary feeding alongside breastfeeding beginning at 6 months and continuing until two years of age or beyond.[76] Additionally, the Dietary Guidelines for Americans 2020-2025 share similar recommendations with the WHO and UNICEF.[75] These include exclusively breastfeeding for the first six months of life, providing iron-fortified formula during the first year if breastfeeding is not attainable, and beginning vitamin D supplementation after birth. The guidelines also recommend introducing complementary feeding alongside breastfeeding starting at six months, exposing infants older than six months to a variety of foods, including allergenic foods, and avoiding added sugars and excess sodium during complementary feeding.[75] Healthy People Objectives for breastfeeding are in place to support breastfeeding practices in the United States.[77] The Healthy People 2030 objectives for breastfeeding by The U.S. Departments of Agriculture (USDA) and Health and Human Services (HHS) include increasing the percentage of infants exclusively breastfed for the first six months of life to 42.4% and increasing the percentage of infants breastfed at age one to 54.1%.[77]

The CDC conducted a survey that found that 84.1% of infants were ever breastfed, 59.8% of infants were breastfed at six months, 39.5% of infants were breastfed at one year, 46.5% of infants were exclusively breastfed through three months, and 27.2% of infants were exclusively breastfed through six months.[77] However, these rates differ across different environments and regions of the United States. For example, infants in the Southeast and in rural areas of the United States are less likely to be breastfed.[77] It has also been observed that breastfeeding rates differ by racial group. For example, non-Hispanic Black infants are less likely to be breastfed than Asian, non-Hispanic White, and Hispanic infants.[77] Breastfeeding is crucial for promoting growth and development among infants.[76] Undernourishment is a primary concern for infants who are not breastfed. Undernutrition is associated with 45% of global child deaths.[76] Due to this major concern, regulatory bodies like WHO, UNICEF, CDC, and AAP have made recommendations and goals to help eliminate this concern.[76, 77]

In addition to recommendations and objectives set to increase breastfeeding rates, there are also national laws and regulations. The Affordable Care Act of 2010 revised and updated many acts including the Fair Labor Standards Act (FLSA) of 1938.[78] The FLSA was revised to require businesses/employing bodies to provide break time for employees who need to express breast milk up to one year postpartum. Businesses/employers also need to provide a space that is not a bathroom for employees who need to express breast milk, this is discussed in the FLSA section of the Affordable Care Act.[78] However, the FLSA did not cover all employees of all establishments. The FLSA only covered hourly workers and some salaried workers.[79] In addition to the Affordable Care Act of 2010, in 2019, Congress passed the Fairness for Breastfeeding

Mothers Act.[78] This act requires public places/businesses to provide a space that is not a bathroom for people to be able to express breast milk when needed. This space is required to have a chair, table surface, and an outlet.[78] In 2022, the Consolidated Appropriations Act was signed into law which included the PUMP for Nursing Mothers Act.[80] This act further extended the preexisting rules discussed in the FLSA to more professions like truck and taxi drivers, agricultural workers, and home care workers and managers.[79, 80] All of these laws and regulations that are continuously revised and updated by the United States government are done to provide safe and decent environments for breastfeeding mothers in addition to promoting breastfeeding among working people.

2.3 Comparison of Breastmilk Versus Animal Milk

Human breast milk is considered the optimal diet for infants, but in some cases, alternative feeding methods are necessary. In the 19th century, wet nurses were commonly used as a breastfeeding alternative.[81] Soon after, animal milk became a popular substitute for breast milk.[81] While animal milk gained popularity in the 19th century, evidence suggests that it was used as early as 2000 BC.[82] Archaeological findings, such as clay oblong vessels with nipple-shaped spouts in infants graves, contained casein residue from animal's milk. This suggests that animal milk was used for infant feeding.[82] Over time alternative milk sources have evolved, and in the 20th century, infant formula was developed and gained popularity.[81] Breastfeeding rates in the United States have seen a notable decline in the 21st century.[82] Formula feeding has contributed to this decline and is widely practiced, though it is associated with an increased risk of several common childhood illnesses.[82] To this day, cow’s milk based formula and animal milks are commonly used in infant feeding, especially in developing countries.[81, 83] Given its widespread use, animal milk warrants further examination to ensure the safety of infant health and well-being. Animal milk has a composition similar to human breast milk, which is why it is commonly used as an alternative.[84] Like human breast milk, the composition of animal milk can vary significantly depending on factors such as environmental conditions, maternal diet, stage of lactation, species, and genetics.[85]

Although comparing the milk of different mammals is challenging due to the numerous factors that influence its composition, cow's milk is generally considered to have the most similar fat content to human breast milk.[85] However, cow's milk contains significantly higher levels of cholesterol. In terms of fatty acids, cow's milk has higher percentages of saturated fats, while human milk contains greater amounts of monounsaturated and polyunsaturated fats.[85] Regarding protein content, cow's milk is much higher in protein (4.99%) compared to human milk (1.32%) across all stages of lactation, especially in the early lactation stage.[86] Additionally, cow's milk contains more calcium (112-123 mg/100 mL) than human breast milk (28-34 mg/100 mL).[87] While cow's milk can be a good source of calcium and vitamin D (if fortified) it is not recommended for infants under 12 months due to potential health risks.[87, 88] Infants fed cow's milk before 12 months can face serious health issues.[88, 89] For example, early exposure to cow's milk may lead to intestinal bleeding, as well as iron and vitamin C deficiencies, both of which are crucial for infant development.[88, 89] Furthermore, despite cow's milk being a good source of calcium, excessive consumption can inhibit the absorption of iron, potentially worsening iron deficiency.[89] Another concern with cow's milk is its high casein and mineral content. Excessive casein and minerals in cow's milk are excreted through the urine, which places a high demand on the kidneys and increases water usage to excrete the renal solutes. If this is prolonged, it can lead to dehydration, particularly in infants less than 12 months.[89] For infants over 12 months, cow's milk can be safely introduced as part of a balanced diet, especially when paired with iron-rich foods.[90] At this age cow's milk provides high-quality protein, essential fats, and important micronutrients that support growth and development.[90] However, despite these benefits, it is important to recognize that until the late 1800s, cow's milk was the most commonly used substitute for human breast milk, and it continues to be widely used today, though concerns regarding its early use persist.[82, 86]

Between 1961 and 2018, buffalo milk production roughly tripled, largely due to selective breeding and improved management practices.[84, 91] Buffalo milk has a significantly higher fat content and a notably different casein-to-whey ratio compared to human breast milk.[84, 85] The protein content in buffalo milk is also higher, with 4.02% protein in the early lactation stage, compared to 1.90% in human breast milk.[86] Additionally, buffalo milk is rich in micronutrients, especially calcium (112-220 mg/100 mL), largely due to the high casein content.[85, 87, 92] It is also high in phosphorus and magnesium, but low in sodium.[85] Although buffalo milk is rich in fat, protein, and lactose, it has a lower water content compared to milk from other mammals.[83] While buffalo milk can be beneficial for children and adults, its high nutrient concentrations can pose complications when consumed by young infants.[93]

Goats were among the first animals domesticated for milk and meat around 4000 BC, and evidence suggests that goat milk was used as an infant feeding alternative as early as 3000 BC.[94] Over time, goat milk became a popular choice due to its perceived beneficial properties. However, with advances in science and technology, it is now understood that raw goat milk is not suitable for infant feeding.[94] Like buffalo milk, goat milk contains more protein and a higher casein-to-whey ratio compared to human breast milk.[84, 86] Despite this, when compared nutritionally to various animal milks, goat milk is most similar to human breast milk in terms of protein content.[86] In the early lactation stage, goat milk contains 3.18% protein, while human milk contains 1.90%. In the mature lactation stage, goat milk has approximately 1.10% protein, and human milk has around 1.00%, which is the closest observed match. However, when examining fat content, goat milk consistently has a higher percentage of fat compared to human milk across all lactation stages.[86] Interestingly, the cholesterol levels in goat milk (9.00–18.10 mg/dL) are comparable to those in human milk (5.38–12.00 mg/dL).[85] Both goat and human milk show the lowest cholesterol concentrations in the early lactation stage, with levels increasing during the mature lactation stage.[85] One notable advantage of goat milk is that its fat molecules are smaller than those in cow's milk, which makes it easier to digest—a factor that may be appealing when considering alternatives to breast milk for infant feeding.[95] Despite these similarities, goat milk has certain limitations.[96] For instance, it contains lower levels of iron (0.07 ± 0.02 mg/dL) compared to human breast milk (0.20 mg/dL) but higher potassium levels (183.6 ± 17.2 mg/dL vs. 71.3 ± 9.0 mg/dL).[85] Goat milk protein content is still too high for infants, which can place stress on their kidneys and lead to dehydration due to an excessive renal solute load.[96] Goat milk also contains high levels of electrolytes like potassium, calcium, phosphorus, and chloride, which could cause electrolyte imbalances and harm the kidneys. Moreover, goat milk is deficient in essential micronutrients, including vitamin C, vitamin D, iron, zinc, folate, and B vitamins.[96] Deficiencies in these nutrients can impair brain development, cause rickets, scurvy, poor weight gain, stunted growth, anemia, and weakened immune function.[28, 96-99] Goat milk can also trigger allergic reactions in infants and children, especially those with a cow's milk allergy, although some children may be allergic to goat milk even if they are not allergic to cow's milk.[96] Additionally, raw or unpasteurized goat milk poses a significant risk to infants due to the potential presence of harmful pathogens. Although goat milk is not recommended for direct infant feeding, there are commercial goat milk-based infant formulas available on the market. These formulas are modified and fortified to meet infants' nutritional needs, making them a safer alternative to raw goat milk.[96] However, it is always important to consult a healthcare provider to determine the best feeding option for your infant.

Sheep have been domesticated for thousands of years for their milk, and historically, sheep milk has been highly valued for its ability to make cheese and yogurt.[100] It is also known for its rich nutritional profile. Sheep milk is particularly high in vitamins A, B, and E, as well as essential minerals such as calcium, phosphorus, potassium, and magnesium. Additionally, it contains high levels of conjugated linoleic acid (CLA), which has been shown to fight cancer and reduce fat.[100] In terms of fat content, sheep milk is notable for its relatively high fat concentration of 7.10 ± 3.21 g/dL, which is appealing in the context of infant feeding due to the energy it provides.[85] However, sheep milk also contains higher cholesterol levels (17.07 ± 1.18 mg/dL) compared to other mammalian milks, including human breast milk. Sheep milk has a higher proportion of saturated fatty acids (77.50 ± 0.92% of total fatty acids) and lower levels of monounsaturated and polyunsaturated fatty acids (19.01 ± 1.35% and 3.86 ± 0.49%, respectively).[85] Moreover, sheep milk contains a higher proportion of short- and medium-chain fatty acids, which are easier to digest and could be beneficial for infant nutrition.[100] With a protein content ranging from 4.52% to 5.50%, sheep milk has higher protein levels than most other mammalian milks, including buffalo, cow, and goat.[101] Sheep milk is also notably higher in several essential micronutrients, including calcium (181.70 ± 17.2 mg/dL), potassium (178.6 ± 8.4 mg/dL), sodium (52.10 ± 3.2 mg/dL), and zinc (0.58 ± 2.1 mg/dL).[85] Additionally, sheep milk contains bioactive compounds such as catechol, vanillin, ferulic acid, and salicylic acid.[102] These compounds have various health benefits, including promoting wound healing, reducing inflammation, improving skin health, fighting harmful bacteria, neutralizing free radicals, potentially reducing cancer risks, and alleviating fever and pain.[103-107] Despite its nutritional richness, sheep milk has limitations when it comes to infant feeding. Like goat milk, sheep milk is high in protein and minerals but low in folate, making it unsuitable for infants.[108] The imbalances in these nutrients can lead to health issues, as excessive protein and mineral content may stress an infant's kidneys and cause dehydration, while a lack of folate can impair growth and development.[28, 89, 96]

Lastly, camel milk has been a staple in the Middle East for thousands of years, dating back to the domestication of camels around 3000 BC.[109] Outside of these regions, camel milk was relatively unknown until the late 20th century, when there was a growing interest in traditional and nutritious foods.[109] Camel milk has a fat content that varies but is generally lower compared to other animal milks, ranging from 1.2% to 4.5%.[110] The fat molecules in camel milk are smaller than those in cow, buffalo, and goat milk, making it easier to digest—an important factor when considering alternative milks for infant feeding.[110] Camel milk is also rich in vitamin C, iron, and unsaturated fatty acids.[87] One study found camel milk to contain 27.6–34.3 mg/L of vitamin C, higher than most other animal milks.[111] Additionally, camel milk has approximately 0.05 mg of iron per 100 g, compared to cow milk's 0.27 mg per 100 g.[112] Unsaturated fatty acids account for 35–50% of camel milk's fat content, contributing to its nutritional value.[113] Camel milk is also high in calcium, potassium, and vitamins A, B, D, and E.[109] However, camel milk's composition can vary significantly due to factors such as diet, environment, and breed, leading to inconsistencies in its nutritional content..[114] This variability, along with certain imbalances in nutrients, makes camel milk less appealing as a reliable alternative for infant feeding.[109, 114]

As discussed, the composition of animal milk is influenced by a variety of factors, but each type offers specific attributes that may be beneficial for infant feeding. However, since animal milks are species-specific, they differ from each other and from human breast milk in important ways. These variations highlight why human breast milk remains the optimal diet for infants.

Table 2.1 Studies That Examined Human and Various Animals' Milk Fat, Protein, and Lactose Composition

Author, Date	Animal Species	Mean Fat Percentage
Thankore & Jain, 2018[86] Butts et al., 2018[115] Gantner et al., 2015[116] Ho et al., 2021[117] Ortega-Requena et al., 2018[118]	Human	3.75 3.72 3.05 4.00 4.40
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Roy et al., 2020[119] Ho et al., 2021[117] Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Cow	3.28 4.85 0.14 4.05 3.40 3.40 3.30
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Buffalo	5.85 10.15 9.86 7.50
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Roy et al., 2020[119] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Goat	4.88 5.10 0.19 9.63 3.90
Roy et al., 2020[119] Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Sheep	0.18 5.30 13.72 6.40
Ismaili et al., 2019[122] Elhosseny et al., 2018[123] Ho et al., 2021[117]	Camel	2.72 3.40 3.61
Author, Date	Animal Species	Mean Protein Percentage
Thankore & Jain, 2018[86]	Human	1.32

Gantner et al., 2015[116] Ho et al., 2021[117] Ortega-Requena et al., 2018[118]		1.40 1.20 1.00
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Roy et al., 2020[119] Ho et al., 2021[117] Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Cow	4.99 3.50 4.11 3.50 3.50 4.07 3.30
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Buffalo	3.50 3.70 4.53 4.00
Thankore & Jain, 2018[86] Gantner et al., 2015[116] Roy et al., 2020[119] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Goat	2.04 4.10 3.11 3.99 3.40
Roy et al., 2020[119] Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Sheep	6.87 5.90 4.02 5.60
Ismaili et al., 2019[122] Elhosseny et al., 2018[123] Ho et al., 2021[117]	Camel	2.55 2.70 3.27
Author, Date	Animal Species	Mean Lactose Percentage
Gantner et al., 2015[116] Ho et al., 2021[117] Ortega-Requena et al., 2018[118]	Human	6.65 6.85 6.90
Gantner et al., 2015[116] Roy et al., 2020[119] Ho et al., 2021[117]	Cow	5.00 5.12 4.85

Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]		4.40 3.40 4.70
Gantner et al., 2015[116] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Buffalo	4.05 5.27 4.40
Gantner et al., 2015[116] Roy et al., 2020[119] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Goat	3.85 4.13 4.56 4.40
Roy et al., 2020[119] Ravenwood et al., 2024[120] Arrichiello et al., 2022[121] Ortega-Requena et al., 2018[118]	Sheep	4.98 4.50 5.70 5.10
Ismaili et al., 2019[122] Elhosseny et al., 2018[123] Ho et al., 2021[117]	Camel	4.37 4.70 4.44

2.4 Impacts of Socioeconomic Characteristics on Breastfeeding

Sociodemographic characteristics, including factors such as income, education, occupation, race, social class, living conditions, and available resources, significantly influence infant feeding practices.[124-126] Studies have consistently shown that women from lower socioeconomic backgrounds in the United States are less likely to initiate breastfeeding or exclusively breastfeed for the recommended six months.[127] For example, Non-Hispanic White women are more likely to exclusively breastfeed compared to Non-Hispanic Black and Hispanic women.[128] Additionally, research indicates that Spanish-speaking Hispanic mothers are most likely to initiate breastfeeding (91%) and maintain it for a longer duration (mean of 17.1 weeks) compared to English-speaking Hispanic, White, and Black mothers, with Black mothers having the lowest initiation rate (61%) and the shortest breastfeeding duration (mean of 6.4 weeks).[129] Furthermore, women with higher education levels, such as bachelor's or master's degrees, and higher income are also more likely to intend to exclusively breastfeed.[128]

Racial and socioeconomic disparities in breastfeeding initiation are further evident. Asian and White mothers, for instance, are more likely to begin breastfeeding compared to American Indian/Alaska Native and Black mothers in the United States.[130] Additionally, some ethnic groups, particularly those from lower socioeconomic backgrounds, may be more likely to rely on advice from family members rather than healthcare professionals, increasing their susceptibility to misinformation and malnutrition practices.[131] To address this, culturally competent care is crucial. This can include using interpreters, providing materials in multiple languages, and ensuring that healthcare staff receive training on cultural competence.[131] Such intervention can help build trust and improve breastfeeding outcomes within diverse communities.

Mothers with lower levels of education and income are also more likely to discontinue breastfeeding by one month postpartum.[132] In particular, the timing of breastfeeding cessation is closely linked to the timing of returning to work, suggesting that many women struggle to balance work and breastfeeding.[133] Interestingly, in areas of extreme food insecurity, such as in Haiti, mothers who cannot afford alternative infant food are more likely to exclusively breastfeed.[134] This phenomenon, referred to as "last resort exclusively breastfeeding," reflects the lack of viable alternatives rather than a deliberate choice to breastfeed.[134]

Several factors contribute to these disparities, including lack of social, workplace, and cultural support, language and literacy barriers, and limited access to breastfeeding information.[135-139] Additionally, women in underserved communities often experience higher rates of perinatal depression and preterm births, which can be exacerbated by stressors such as discrimination, economic hardships, and occupational strain.[140, 141] These challenges are linked to poorer maternal and infant health outcomes, particularly among disadvantaged socioeconomic groups, who face barriers such as transportation issues, lack of breastfeeding information and mistrust of the healthcare system.[142, 143] These barriers may be linked to poorer healthcare utilization.[142]

One major barrier minority groups face is inadequate access to accurate breastfeeding information.[143] Studies show that minority women often require more tailored information to address complications during breastfeeding and that they are more likely to experience differential treatment from healthcare providers, including insufficient breastfeeding encouragement.[138]

Social support also plays a critical role in infant feeding practices. Research suggests that when fathers and grandmothers participate in infant care, breastfeeding rates improve, with infants more likely to receive the minimum number of meals per day and have greater meal diversity.[144] This underscores the importance of a strong social network in supporting optimal infant feeding practices.

Workplace policies that support breastfeeding are another key factor.[145] Studies show that U.S. states with breastfeeding legislation between 1990 and 2011 saw a 2.3% increase in breastfeeding rate.[145] Thus, enforcing and expanding breastfeeding-friendly workplace policies is essential for improving breastfeeding outcomes among Americans.

Community-level interventions, such as those provided through the Women, Infants, and Children (WIC) program, healthcare facilities, and community agencies, can help improve breastfeeding perceptions and outcomes among minority women.[146] However, more targeted efforts are needed to understand the unique needs and preferences of these communities to design effective interventions.[146]

Mass media, including television, newspapers, and smartphone apps, also influence public perceptions of breastfeeding.[147] However, there remains a gap in the utilization of mass media to promote positive breastfeeding messages. While online breastfeeding support exists, it is not widely known or accessible to the general public. There is significant potential to improve how mass media can be leveraged to spread positive breastfeeding perceptions.[147]

In conclusion, these findings highlight how sociodemographic characteristics impact infant feeding practices, which, in turn, have significant long-term health implications for both mothers and infants. Addressing the disparities in breastfeeding initiation and duration requires a comprehensive approach that includes policy changes, culturally competent care, community support, and targeted media campaigns. By understanding and addressing the unique needs of different sociodemographic groups, we can work towards reducing breastfeeding disparities and improving maternal and child health outcomes.

2.5 Maternal Sociodemographic Characteristics and Usage of Animal Milks in Infant and Early Child Feeding Practices

Sociodemographic characteristics significantly influence infant feeding practices, including the use of animal milks as alternatives to breast milk.[148, 149] The socioeconomic status (SES) of a household can directly impact whether an infant is breastfed exclusively during the first six months of life, a critical period for infant development.[148] Infants from lower SES backgrounds are less likely to be exclusively breastfed, which can have long-term health consequences.[148] Additionally, when animal milk is used as a substitute for breast milk, it can introduce a range of health risks due to its lack of essential nutrients for infants.[149] Understanding how SES factors affect the use of animal milks in infant feeding is crucial for improving infant health outcomes, as these practices intersect with economic, cultural, and nutritional factors.[89, 148-151]

While animal milks such as cow, buffalo, goat, sheep, and camel's milk are commonly used in some regions, they are not recommended for infants under one year of age.[152] The World Health Organization (WHO) and the American Academy of Pediatrics (AAP) both advise against introducing animal milk before the age of one due to the potential for serious health issues.[152] For instance, cow's milk can lead to iron deficiency, intestinal bleeding, dehydration, and inhibition of iron absorption, all of which can severely impact an infant's development.[89] The early introduction of cow's milk has also been linked to reduced breastfeeding duration and frequency, which further exacerbates the risks of poor nutrition.[151] In developing countries, where exclusive breastfeeding is associated with reduced morbidity and mortality, the early use of animal milks can have especially detrimental effects, including higher rates of anemia, diarrhea, and gastrointestinal issues due to the milk's poor digestibility and nutrient profile.[150, 153]

Despite the nutritional benefits that certain animal milks may offer, for example, calcium in cow and buffalo milk, protein content in goat milk, or bioactive compounds in sheep milk, these milks fall short in providing essential nutrients that infants need for growth.[85, 87, 95, 102, 154] For example, although some animal milks are rich in vitamin D and calcium, they lack adequate amounts of essential fatty acids, essential amino acids, and other micronutrients that breast milk or formula provide.[154] The lack of iron and other critical nutrients in animal milks can lead to iron deficiency anemia and other developmental delays.[89, 151] Moreover, the introduction of animal milks before one year old may interfere with an infant's ability to digest and absorb the nutrients it needs.[152, 154] As such, animal milks should not replace breast milk or infant formula in the first year of life, as the risks outweigh any potential benefits.[89, 152, 154]

The cost of animal milk is often cited as a reason why families, particularly those from low-income households, may choose it over infant formula.[155] In many low- and middle-income countries, animal milks are seen as a more affordable and accessible alternative to formula.[155] However, this cost-effectiveness is short-sighted, as it may result in higher healthcare costs later due to the potential health issues caused by early animal milk consumption.[153] These include the risk of gastrointestinal distress, dehydration, and anemia, all of which disproportionately affect children in lower-income households who may have limited access to healthcare resources.[153] Furthermore, families may lack adequate education or resources to understand the nutritional risks associated with animal milk, leading them to make decisions that harm their child's long-term health.[155]

Good nutrition during the first two years of life is crucial for long-term physical and cognitive development.[156] Children who receive proper nutrition during this critical period have higher rates of school enrollment and completion, which can later influence their earnings and economic productivity as adults.[157] Conversely, poor infant nutrition due to inappropriate feeding practices, such as the early introduction of animal milk, can lead to long-term developmental delays, cognitive deficits, and poorer health outcomes, perpetuating cycles of poverty and disadvantage.[157] Therefore, improving infant feeding practices in low-income households is essential for breaking these cycles and promoting better health and educational outcomes in the future.[157]

In conclusion, the usage of animal milks in infant and early childhood feeding practices is heavily influenced by sociodemographic factors, including economic constraints, cultural beliefs, and access to healthcare.[148-151, 154, 156, 157] While animal milks may offer some nutritional benefits, they are not suitable substitutes for breast milk or infant formula in the first year of life.[154] The risks associated with early animal milk consumption, including iron deficiency, gastrointestinal issues, and developmental delays, underscore the need for improved education and policies to ensure that all infants receive the optimal nutrition for healthy growth and development.[148-151, 154, 156, 157]

2.6 Usage of Animal Milks in Breastfeeding Practices

Cow's milk-based formula and animal milks remain widely used in infant feeding, particularly in developing countries.[81, 83] Animal milk is often used as an alternative due to its composition, which is similar to that of human breast milk.[84] As mentioned previously, animal milk provides a plethora of benefits, such as calcium in cow and buffalo milk, protein content in goat milk, vitamin C in camel milk, and bioactive compounds in sheep milk.[85, 87, 95, 102, 156] However, like human milk, the composition of animal milk can vary considerably based on factors such as environmental conditions, maternal diet, stage of lactation, species, and genetics.[85] Despite the nutritional benefits that certain animal milks may offer, these milks fall short in providing essential nutrients that infants need for growth and are not recommended for infants under one year of age.[85, 87, 95, 102, 154, 156] Given its extensive use, animal milk should be further studied to ensure it supports infant health and well-being.

Buffalo milk is widely consumed in Asia, particularly in Pakistan and India, where it is preferred for its rich flavor and texture.[84, 86] Goat milk is popular in Africa and South Asia, often consumed raw for its perceived health benefits.[84, 92, 94] Sheep milk is commonly consumed in Europe, the Mediterranean, and the Middle East, where the climate is less suitable for cow milk production, making sheep a more reliable source of milk.[92, 101] Camel milk is primarily consumed in the Middle East and Arabian regions, with its popularity significantly increasing in recent years.[84, 110] These animal milks are often more accessible and easier to obtain in these regions, where they have long been part of traditional diets.[84, 91, 94, 100, 109] The convenience of these milk sources, whether due to local availability, cultural preferences, or economic factors, makes them more likely to be used as alternatives to formula in infant feeding practices.

Some minority communities in the United States, such as African Americans, may have perceptions that discourage breastfeeding, with negative views contributing to lower breastfeeding rates.[158] A great deal of what women know about breastfeeding is shaped by their experiences growing up, including media portrayals, family discussions, and community influences, all of which help form their perceptions and experiences around infant feeding.[158, 159] Among the common barriers to breastfeeding are fears that it may lead to infants becoming overly dependent on their mothers, concerns about pain, and feelings of embarrassment or inconvenience.[160-162] Additionally, the cost of animal milk is often a significant factor why families, particularly those from low-income households, may opt for it instead of breast milk or infant formula.[156] In many low- and middle-income countries, animal milks are viewed as a more affordable and accessible alternative to formula.[156]

In conclusion, the widespread use of animal milks for infant feeding, particularly in certain subpopulation groups, underscores the importance of understanding factors influencing their selection, from cultural perceptions to economic considerations.

References

1.Kim SY, Yi DY. Components of Human Breast milk: from Macronutrient to Microbiome and microRNA. *Clinical and Experimental Pediatrics*. 2020;63(8):301-309. doi:https://doi.org/10.3345/cep.2020.00059

2.Heine RG, AlRefaee F, Bachina P, et al. Lactose intolerance and gastrointestinal cow's milk allergy in infants and children – common misconceptions revisited. *World Allergy Organization Journal*. 2017;10(1):41. doi:https://doi.org/10.1186/s40413-017-0173-0

3.Eglash A. The Importance of Lactose in Breastmilk – IABLE. Lacted.org. Published November 19, 2019. Accessed October 3, 2024. https://lacted.org/questions/the-importance-of-lactose-in-breastmilk/

4.American Pregnancy Association. What's In Breast Milk? American Pregnancy Association. Published April 25, 2012. https://americanpregnancy.org/healthy-pregnancy/first-year-of-life/whats-in-breastmilk/

5.Cheema AS, Stinson LF, Rea A, et al. Human Milk Lactose, Insulin, and Glucose Relative to Infant Body Composition during Exclusive Breastfeeding. *Nutrients*. 2021;13(11):3724. doi:https://doi.org/10.3390/nu13113724

6.Goran M, Martin A, Alderete T, Fujiwara H, Fields D. Fructose in Breast Milk Is Positively Associated with Infant Body Composition at 6 Months of Age. *Nutrients*. 2017;9(2):146. doi:https://doi.org/10.3390/nu9020146

7.Ahuja S, Boylan M, Hart SL, et al. Glucose and Insulin Levels are Increased in Obese and Overweight Mothers' Breast-Milk. *Food and Nutrition Sciences*. 2011;02(03):201-206. doi:https://doi.org/10.4236/fns.2011.23027

8.Ballard O, Morrow AL. Human Milk Composition: Nutrients and Bioactive Factors. *Pediatric Clinics of North America*. 2013;60(1):49-74. doi:https://doi.org/10.1016/j.pcl.2012.10.002

9.Berger PK, Plows JF, Demerath EW, Fields DA. Carbohydrate composition in breast milk and its effect on infant health. *Current Opinion in Clinical Nutrition & Metabolic Care*.

2020;23(4):277-281. doi:https://doi.org/10.1097/mco.0000000000000658

10.Bode L. Human milk oligosaccharides: every baby needs a sugar mama. *Glycobiology*. 2012;22(9):1147-1162. doi:https://doi.org/10.1093/glycob/cws074

11.Stephen A, Alles M, de Graaf C, et al. The role and requirements of digestible dietary carbohydrates in infants and toddlers. *European Journal of Clinical Nutrition*. 2012;66(7):765-779. doi:https://doi.org/10.1038/ejcn.2012.27

12.Berger PK, Plows JF, Jones RB, et al. Human milk oligosaccharide 2'-fucosyllactose links feedings at 1 month to cognitive development at 24 months in infants of normal and overweight mothers. Xie L, ed. *PLOS ONE*. 2020;15(2):e0228323. doi:https://doi.org/10.1371/journal.pone.0228323

13.Simmer K, Patole SK, Rao SC. Long-chain polyunsaturated fatty acid supplementation in infants born at term. *The Cochrane database of systematic reviews*. 2008;(1):CD000376. doi:https://doi.org/10.1002/14651858.CD000376.pub2

14.Johnston CC, Filion F, Snider L, et al. Routine sucrose analgesia during the first week of life in neonates younger than 31 weeks' postconceptional age. *Pediatrics*. 2002;110(3):523-528. doi:https://doi.org/10.1542/peds.110.3.523

15.Howlett J, Ashwell M. Glycemic response and health: summary of a workshop. *The American Journal of Clinical Nutrition*. 2008;87(1):212S216S. doi:https://doi.org/10.1093/ajcn/87.1.212s

16.LaPelusa A, Kaushik R. Physiology, Proteins. PubMed. Published 2022. https://www.ncbi.nlm.nih.gov/books/NBK555990/

17.Research I of M (US) C on MN, Poos MI, Costello R, Carlson-Newberry SJ. *The Role of Protein and Amino Acids in Sustaining and Enhancing Performance*. National Academies Press (US); 1999. https://www.ncbi.nlm.nih.gov/books/NBK224683/

18.Donovan SM. Human Milk Proteins: Composition and Physiological Significance. *Nestle Nutrition Institute Workshop Series*. 2019;90:93-101. doi:https://doi.org/10.1159/000490298

19.Delplanque B, Gibson R, Koletzko B, Lapillonne A, Strandvik B. Lipid Quality in Infant Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*. 2015;61(1):8-17. doi:https://doi.org/10.1097/mpg.0000000000000818

20.Moghadasian MH, Shahidi F. Fatty Acids. ScienceDirect. Published January 1, 2017. https://www.sciencedirect.com/science/article/abs/pii/B9780128036785001570

21.Trugo NMF, Torres AG. FATS | Requirements. *wwwsciencedirectcom*. Published online January 1, 2003:2279-2284. doi:https://doi.org/10.1016/B0-12-227055-X/00444-2

22.Criswell RL, Iszatt N, Demmelmair H, et al. Predictors of Human Milk Fatty Acids and Associations with Infant Growth in a Norwegian Birth Cohort. *Nutrients*. 2022;14(18):3858. doi:https://doi.org/10.3390/nu14183858

23.Bobiński R, Bobińska J. Fatty acids of human milk – a review. *International Journal for Vitamin and Nutrition Research*. Published online April 21, 2020:1-12. doi:https://doi.org/10.1024/0300-9831/a000651

24.Allen LH, Dror DK. Introduction to Current Knowledge on Micronutrients in Human Milk: Adequacy, Analysis, and Need for Research. *Advances in Nutrition*. 2018;9(suppl_1):275S277S. doi:https://doi.org/10.1093/advances/nmy018

25.Institute of Medicine (US) Panel on Micronutrients. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. PubMed. Published 2001. https://pubmed.ncbi.nlm.nih.gov/25057538/

26.Basu S. Single megadose vitamin A supplementation of Indian mothers and morbidity in breastfed young infants. *Postgraduate Medical Journal*. 2003;79(933):397-402. doi:https://doi.org/10.1136/pmj.79.933.397

27.Dror DK, Allen LH. Retinol-to-Fat Ratio and Retinol Concentration in Human Milk Show Similar Time Trends and Associations with Maternal Factors at the Population Level: A Systematic Review and Meta-Analysis. *Advances in Nutrition*. 2018;9(suppl_1):332S346S. doi:https://doi.org/10.1093/advances/nmy021

28.CDC. Vitamin B12 and Breastfeeding. Breastfeeding special circumstances. Published May 7, 2024. https://www.cdc.gov/breastfeeding-special-circumstances/hcp/diet-micronutrients/vitamin-b12.html

29.Dror DK, Allen LH. Effect of vitamin B12 deficiency on neurodevelopment in infants: current knowledge and possible mechanisms. *Nutrition Reviews*. 2008;66(5):250-255. doi:https://doi.org/10.1111/j.1753-4887.2008.00031.x

30.Honzik T, Adamovicova M, Smolka V, Magner M, Hruba E, Zeman J. Clinical presentation and metabolic consequences in 40 breastfed infants with nutritional vitamin B12 deficiency – What have we learned? *European Journal of Paediatric Neurology*. 2010;14(6):488-495. doi:https://doi.org/10.1016/j.ejpn.2009.12.003

31.Dror DK, Allen LH. Vitamin B-12 in Human Milk: A Systematic Review. *Advances in Nutrition*. 2018;9(suppl_1):358S366S. doi:https://doi.org/10.1093/advances/nmx019

32.Dror DK, Allen LH. Iodine in Human Milk: A Systematic Review. *Advances in Nutrition*. 2018;9(suppl_1):347S357S. doi:https://doi.org/10.1093/advances/nmy020

33.Zimmermann MB. Iodine deficiency. *Endocrine reviews*. 2009;30(4):376-408. doi:https://doi.org/10.1210/er.2009-0011

34.Kanike N, Groh-Wargo S, Thomas M, et al. Risk of Iodine Deficiency in Extremely Low Gestational Age Newborns on Parenteral Nutrition. *Nutrients*. 2020;12(6):1636. doi:https://doi.org/10.3390/nu12061636

35.Dror DK, Allen LH. Overview of Nutrients in Human Milk. *Advances in Nutrition*. 2018;9(suppl_1):278S294S. doi:https://doi.org/10.1093/advances/nmy022

36.Stuetz W, Carrara VI, McGready R, Lee SJ, Biesalski HK, Nosten FH. Thiamine Diphosphate in Whole Blood, Thiamine and Thiamine Monophosphate in Breast-Milk in a Refugee Population. Wiley AS, ed. *PLoS ONE*. 2012;7(6):e36280. doi:https://doi.org/10.1371/journal.pone.0036280

37.Hampel D, Setareh Shahab-Ferdows, York E, Allen L. Contribution of thiamin and riboflavin vitamers to total breast milk content (623.13). *The FASEB Journal*. 2014;28(S1). doi:https://doi.org/10.1096/fasebj.28.1_supplement.623.13

38.Kodentsova VM, Vrzhesinskaya OA. Evaluation of the vitamin status in nursing women by vitamin content in breast milk. *Bulletin of Experimental Biology and Medicine*. 2006;141(3):323-327. doi:https://doi.org/10.1007/s10517-006-0161-9

39.Roughead ZK, McCormick DB. Flavin composition of human milk. *The American Journal of Clinical Nutrition*. 1990;52(5):854-857. doi:https://doi.org/10.1093/ajcn/52.5.854

40.Chang SJ, Kirksey A. Pyridoxine supplementation of lactating mothers: relation to maternal nutrition status and vitamin B-6 concentrations in milk. *The American Journal of Clinical Nutrition*. 1990;51(5):826-831. doi:https://doi.org/10.1093/ajcn/51.5.826

41.Kaarina Heiskanen, Siimes MA, Jaakko Perheentupa, Salmenperä L. Risk of Low Vitamin B6 Status in Infants Breast-Fed Exclusively Beyond Six Months. *Journal of Pediatric Gastroenterology and Nutrition*. 1996;23(1):38-44. doi:https://doi.org/10.1097/00005176-199607000-00008

42.Holmes H, Snodgrass I, Iles RA. Changes in the choline content of human breast milk in the first 3 weeks after birth. *European Journal of Pediatrics*. 2000;159(3):198-204. doi:https://doi.org/10.1007/s004310050050

43.Fischer LM, da Costa KA, Galanko J, et al. Choline intake and genetic polymorphisms influence choline metabolite concentrations in human breast milk and plasma. *The American Journal of Clinical Nutrition*. 2010;92(2):336-346. doi:https://doi.org/10.3945/ajcn.2010.29459

44.ILCOL Y, OZBEK R, HAMURTEKIN E, ULUS I. Choline status in newborns, infants, children, breast-feeding women, breast-fed infants and human breast milk. *The Journal of Nutritional Biochemistry*. 2005;16(8):489-499. doi:https://doi.org/10.1016/j.jnutbio.2005.01.011

45.Dorea JG. Selenium and breast-feeding. *The British Journal of Nutrition*. 2002;88(5):443-461. doi:https://doi.org/10.1079/BJN2002692

46.Szyller H, Antosz K, Batko J, et al. Bioactive Components of Human Milk and Their Impact on Child's Health and Development, Literature Review. *Nutrients*. 2024;16(10):1487. doi:https://doi.org/10.3390/nu16101487

47.Tamari Y, Kim ES. Longitudinal Study of the Dietary Selenium Intake of Exclusively Breast-fed Infants During Early Lactation in Korea and Japan. *Journal of Trace Elements in Medicine and Biology*. 1999;13(3):129-133. doi:https://doi.org/10.1016/s0946-672x(99)80002-9

48.Kell D, Heyden E, Pretorius E. The Biology of Lactoferrin, an Iron-Binding Protein That Can Help Defend Against Viruses and Bacteria. Frontiers. Published May 27, 2020. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2020.01221/full

49.Palmeira P, Carneiro-Sampaio M. Immunology of breast milk. *Revista da Associação Médica Brasileira*. 2016;62(6):584-593. doi:https://doi.org/10.1590/1806-9282.62.06.584

50.Czosnykowska-Łukacka M, Lis-Kuberka J, Królak-Olejnik B, Orczyk-Pawiłowicz M. Changes in Human Milk Immunoglobulin Profile During Prolonged Lactation. Frontiers in Pediatrics. Published August 6, 2020. https://www.frontiersin.org/journals/pediatrics/articles/10.3389/fped.2020.00428/full

51.Yang B, Wang J, Tang B, et al. Characterization of Bioactive Recombinant Human Lysozyme Expressed in Milk of Cloned Transgenic Cattle. *PLoS ONE*. 2011;6(3). doi:https://doi.org/10.1371/journal.pone.0017593

52.Witkowska-Zimny M, Kaminska-El-Hassan E. Cells of human breast milk. *Cellular & Molecular Biology Letters*. 2017;22(1). doi:https://doi.org/10.1186/s11658-017-0042-4

53.Deshpande OA, Wadhwa R. Phagocytosis. PubMed. Published 2021. https://www.ncbi.nlm.nih.gov/books/NBK556043/

54.Xu YR, Zhao J, Huang HY, et al. Recent insights into breast milk microRNA: their role as functional regulators. Frontiers in Nutrition. Published April 15, 2024. https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1366435/full

55.The Ohio State University Comprehensive Cancer Center. microRNA - What it is and How it Works | OSUCCC - James. The James - OSUCCC. https://cancer.osu.edu/microrna

56.Plamada D, Vodnar DC. Polyphenols—Gut Microbiota Interrelationship: A Transition to a New Generation of Prebiotics. *Nutrients*. 2022;14(1):137. doi:https://doi.org/10.3390/nu14010137

57.Cremon C, Barbaro MR, Ventura M, Barbara G. Pre- and probiotic overview. *Current Opinion in Pharmacology*. 2018;43:87-92. doi:https://doi.org/10.1016/j.coph.2018.08.010

58.Katrine Overgaard Poulsen, Meng F, Lanfranchi E, et al. Dynamic Changes in the Human Milk Metabolome Over 25 Weeks of Lactation. *Frontiers in Nutrition*. 2022;9. doi:https://doi.org/10.3389/fnut.2022.917659

59.Fields DA, Schneider CR, Pavela G. A narrative review of the associations between six bioactive components in breast milk and infant adiposity. *Obesity*. 2016;24(6):1213-1221. doi:https://doi.org/10.1002/oby.21519

60.Müller TD, Nogueiras R, Andermann ML, et al. Ghrelin. *Molecular Metabolism*. 2015;4(6):437-460. doi:https://doi.org/10.1016/j.molmet.2015.03.005

61.World Health Organization. Breastfeeding. World Health Organization. Published 2021. https://www.who.int/health-topics/breastfeeding#tab=tab_2

62.Nemours Kids Health. Breastfeeding vs. Formula Feeding (for Parents) - Nemours KidsHealth. kidshealth.org. https://kidshealth.org/en/parents/breast-bottle-feeding.html#:~:text=Breastfeeding%20helps%20defend%20against%20infections

63.McCarthy C. Breastfeeding Benefits Your Baby's Immune System. HealthyChildren.org. Published 2020. https://www.healthychildren.org/English/ages-stages/baby/breastfeeding/Pages/Breastfeeding-Benefits-Your-Babys-Immune-System.aspx

64.U.S. Department of Agriculture . Breastfeeding Benefits | WIC Breastfeeding Support. Usda.gov. Published 2024. Accessed September 9, 2024. https://wicbreastfeeding.fns.usda.gov/breastfeeding-benefits#:~:text=Health%20Benefits

65.CDC. About Breastfeeding. Breastfeeding. Published May 2, 2024. https://www.cdc.gov/breastfeeding/php/about/index.html

66.Anstey E, Kincaid G. Breastfeeding for Cancer Prevention | | Blogs | CDC. Cdc.gov. Published August 2019. https://blogs.cdc.gov/cancer/2019/08/01/breastfeeding-for-cancer-prevention/

67.American Diabetes Association. Breastfeeding & Diabetes | ADA. Diabetes.org. Published 2024. https://diabetes.org/living-with-diabetes/pregnancy/diabetes-breastfeeding

68.Rameez RM, Sadana D, Kaur S, et al. Association of Maternal Lactation With Diabetes and Hypertension. *JAMA Network Open*. 2019;2(10):e1913401. doi:https://doi.org/10.1001/jamanetworkopen.2019.13401

69.CDC. Facts About Nationwide Breastfeeding Goals. Centers for Disease Control and Prevention. Published August 24, 2021. https://www.cdc.gov/breastfeeding/data/facts.html#:~:text=The%20American%20Academy%20of%20Pediatrics

70.World Health Organization. Acceptable medical reasons for use of breast-milk substitutes. Nih.gov. Published 2014. https://www.ncbi.nlm.nih.gov/books/NBK148964/

71.The Metabolism Program at Boston Children's Hospital. Galactosemia | Boston Children's Hospital. www.childrenshospital.org. https://www.childrenshospital.org/conditions/galactosemia#:~:text=Classic%20galactosemia%20occurs%20when%20an

72.National Institutes of Health. Are there any special conditions or situations in which I should not breastfeed? http://www.nichd.nih.gov/. Published January 31, 2017. https://www.nichd.nih.gov/health/topics/breastfeeding/conditioninfo/special-conditions

73.National Organization for Rare Disorders. Maple Syrup Urine Disease - NORD (National Organization for Rare Disorders). NORD (National Organization for Rare Disorders). Published June 5, 2020. https://rarediseases.org/rare-diseases/maple-syrup-urine-disease/

74.The Metabolism Program at Boston Children's Hospital. Phenylketonuria PKU | Boston Children's Hospital. www.childrenshospital.org. https://www.childrenshospital.org/conditions/phenylketonuria-pku

75.Gov D. *Dietary Guidelines for Americans 2020 -2025 Make Every Bite Count with the Dietary Guidelines*.; 2020. https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf#page=65

76.World Health Organization. Infant and Young Child Feeding. World Health Organization. Published December 20, 2023. https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding

77.CDC. Key Breastfeeding Indicators. Centers for Disease Control and Prevention. Published August 7, 2023. https://www.cdc.gov/breastfeeding/data/facts.html

78.National Conference of State Legislatures . Breastfeeding State Laws. www.ncsl.org. Published 2021. https://www.ncsl.org/health/breastfeeding-state-laws

79.U.S. Department of Agriculture . Your Breastfeeding Rights | WIC Breastfeeding. wicbreastfeeding.fns.usda.gov. https://wicbreastfeeding.fns.usda.gov/your-breastfeeding-rights

80.U.S. Department of Labor. FLSA Protections to Pump at Work | U.S. Department of Labor. www.dol.gov. Published 2023. https://www.dol.gov/agencies/whd/pump-at-work

81.Institute of Medicine (US) Committee on the Evaluation of the Addition of Ingredients New to Infant Formula. Comparing Infant Formulas with Human Milk. Nih.gov. Published 2004. https://www.ncbi.nlm.nih.gov/books/NBK215837/

82.Stevens EE, Patrick TE, Pickler R. A History of Infant Feeding. *Journal of Perinatal Education*. 2009;18(2):32-39. doi:https://doi.org/10.1624/105812409x426314

83.Amr M, Farid A. Impact of cow, buffalo, goat or camel milk consumption on oxidative stress, inflammation and immune response post weaning time. Nature. Published April 30, 2024. https://www.nature.com/articles/s41598-024-59959-8

84.Roy D, Ye A, Moughan PJ, Singh H. Composition, Structure, and Digestive Dynamics of Milk From Different Species—A Review. *Frontiers in Nutrition*. 2020;7. doi:https://doi.org/10.3389/fnut.2020.577759

85.Pietrzak-Fiećko R, Kamelska-Sadowska AM. The Comparison of Nutritional Value of Human Milk with Other Mammals' Milk. *Nutrients*. 2020;12(5):1404. doi:https://doi.org/10.3390/nu12051404

86.Thakore V, Jain N. Protein and fat examination from the raw milk of different mammalian species (Cow, buffalo, goat, and human) with successive lactation days. ~ *506 ~ The Pharma Innovation Journal*. 2018;7(10):506-510. https://www.thepharmajournal.com/archives/2018/vol7issue10/PartI/7-10-57-423.pdf

87.Claeys WL, Verraes C, Cardoen S, et al. Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. *Food Control*. 2014;42:188-201. doi:https://doi.org/10.1016/j.foodcont.2014.01.045

88.CDC. Fortified Cow's Milk and Milk Alternatives . Centers for Disease Control and Prevention. Published December 3, 2018. https://www.cdc.gov/nutrition/infantandtoddlernutrition/foods-and-drinks/cows-milk-and-milk-alternatives.html

89.Ziegler EE. Adverse Effects of Cow's Milk in Infants. *Issues in Complementary Feeding*. 2007;60:185-199. doi:https://doi.org/10.1159/000106369

90.Agostoni C, Turck D. Is Cows' Milk Harmful for a Child's Health? *Journal of Pediatric Gastroenterology and Nutrition*. Published online September 2011:1. doi:https://doi.org/10.1097/mpg.0b013e318235b23e

91.Vargas-Ramella M, Pateiro M, Maggiolino A, et al. Buffalo Milk as a Source of Probiotic Functional Products. *Microorganisms*. 2021;9(11):2303. doi:https://doi.org/10.3390/microorganisms9112303

92.FAO. Dairy production and products: Milk composition. www.fao.org. https://www.fao.org/dairy-production-products/products/milk-composition/en/

93.Ganguly S, Mayuri M, Mukherji C, Garg V, Aggarwal D. Bovine milk usage and feeding practices for infants in India. *Indian Journal of Public Health*. 2012;56(1):75. doi:https://doi.org/10.4103/0019-557x.96982

94.Ausnutria Nutrition Institute. History of goat milk & infant nutrition - Ausnutria Nutrition Institute. Ausnutria Nutrition Institute. Published November 6, 2023. Accessed December 19, 2024. https://ausnutria-nutrition-institute.com/knowledge-base/history/

95.Lad S, Aparnathi KD, Mehta B, Velpula S. Goat Milk in Human Nutrition and Health – A Review . International Journal of Current Microbiology and Applied Sciences. Published April 17, 2017. Accessed September 23, 2024. https://www.ijcmas.com/6-5-2017/Sachin%20S.%20Lad,%20et%20al.pdf

96.Minnesota Department of Health - WIC Program. *Goat Milk Considerations J U N E 8 , 2 0 2 2 Goat Milk Is Not a Safe Choice for Infants*.; 2022. https://www.health.state.mn.us/docs/people/wic/localagency/wedupdate/2022/topic/0608goat.pdf

97.CDC. Vitamin D and Breastfeeding. Breastfeeding special circumstances. Published April 15, 2024. https://www.cdc.gov/breastfeeding-special-circumstances/hcp/diet-micronutrients/vitamin-d.html

98.Johnson L. Vitamin C Deficiency - Disorders of Nutrition. Merck Manual Consumer Version. Published August 2024. https://www.merckmanuals.com/home/disorders-of-nutrition/vitamins/vitamin-c-deficiency#Causes_v45106337

99.Tako E. Addressing Iron and Zinc Deficiency Across the Globe : USDA ARS. www.ars.usda.gov. Published July 12, 2023. https://www.ars.usda.gov/oc/utm/addressing-iron-and-zinc-deficiency-across-the-globe/

100.Woodlands Dairy. Sheep Milk History. Organic Sheep & Goats Milk Yoghurt from Woodlands Dairy. Published June 12, 2019. https://woodlandsdairy.co.uk/sheep-milk-history/

101.Kalyankar SD, Sarode AR, Khedkar CD, Deosarkar SS, Pawshe RD. Sheep: Milk. Science Direct. Published September 22, 2015. https://www.sciencedirect.com/science/article/abs/pii/B9780123849472006218

102.Flis Z, Molik E. Importance of Bioactive Substances in Sheep's Milk in Human Health. *International Journal of Molecular Sciences*. 2021;22(9):4364. doi:https://doi.org/10.3390/ijms22094364

103.Puertas-Bartolomé M, Włodarczyk-Biegun MK, Campo A del, Vázquez-Lasa B, San Román J. Development of bioactive catechol functionalized nanoparticles applicable for 3D bioprinting. Science Direct. Published October 2021. https://www.sciencedirect.com/science/article/pii/S092849312100655X

104.Lim DY, Shin SH, Lee MH, et al. A natural small molecule, catechol, induces c-Myc degradation by directly targeting ERK2 in lung cancer. *Oncotarget*. 2016;7(23):35001-35014. doi:https://doi.org/10.18632/oncotarget.9223

105.Hu J, Wang Z, Miszuk JM, et al. Vanillin-bioglass cross-linked 3D porous chitosan scaffolds with strong osteopromotive and antibacterial abilities for bone tissue engineering. *Carbohydrate Polymers*. 2021;271:118440. doi:https://doi.org/10.1016/j.carbpol.2021.118440

106.Zduńska K, Dana A, Kolodziejczak A, Rotsztejn H. Antioxidant Properties of Ferulic Acid and Its Possible Application. *Skin Pharmacology and Physiology*. 2018;31(6):332-336. doi:https://doi.org/10.1159/000491755

107.Ding Y, Fan B, Zhu C, Chen Z. Shared and Related Molecular Targets and Actions of Salicylic Acid in Plants and Humans. *Cells*. 2023;12(2):219. doi:https://doi.org/10.3390/cells12020219

108.Harton A, Myszkowska-Ryciak J. Types of Milk and/or Its Substitutes Are Given to Children (6–36 Months) in Nurseries in Poland: Data from the Research and Education Project "Eating Healthy, Growing Healthy." *International Journal of Environmental Research and Public Health*. 2018;15(12):2789. doi:https://doi.org/10.3390/ijerph15122789

109.Camel Culture. Where Does Camel Milk Originally Come From? Camel Culture. Published 2024. https://camelculture.org/blogs/news/where-does-camel-milk-come-from

110.Swelum AA, El-Saadony MT, Abdo M, et al. Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. *Saudi Journal of Biological Sciences*. Published online February 2021. doi:https://doi.org/10.1016/j.sjbs.2021.02.057

111.Zhao D, Bai Y, Niu Y. Composition and characteristics of Chinese Bactrian camel milk. Science Direct. Published April 2015.

https://www.sciencedirect.com/science/article/pii/S0921448815001595?casa_token=-0Ucdel3_VkAAAAA:nTpbmdKR0peBR2DjGTL46pEFQ1SrfNAXmqnpoLQsL5J3R059SDNSpYCiFR8uEaEs1yeAEz2depE

112.AL-Ayadhi L, Halepoto DM. Chapter 30 - Camel Milk as a Potential Nutritional Therapy in Autism. ScienceDirect. Published January 1, 2017. https://www.sciencedirect.com/science/article/abs/pii/B9780128097625000309

113.Izadi A, Khedmat L, Yousef Mojtahedi S. Nutritional and therapeutic perspectives of camel milk and its protein hydrolysates: A review on versatile biofunctional properties. Science Direct. Published July 2019. https://www.sciencedirect.com/science/article/pii/S1756464619303652

114.Halima EH, Zeineb J, Imed S, Amel A, Amel N, Touhami K. Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. Research Gate. Published July 2015. https://www.researchgate.net/publication/280494239_Comparison_of_composition_and_whey_protein_fractions_of_human_camel_donkey_goat_and_cow_milk

115.Butts C, Hedderley D, Herath T, et al. Human Milk Composition and Dietary Intakes of Breastfeeding Women of Different Ethnicity from the Manawatu-Wanganui Region of New Zealand. *Nutrients*. 2018;10(9):1231. doi:https://doi.org/10.3390/nu10091231

116.Gantner V, Mijić P, Baban M, Škrtić Z, Turalija A. The overall and fat composition of milk of various species. *Mljekarstvo*. Published online November 2, 2015:223-231. doi:https://doi.org/10.15567/mljekarstvo.2015.0401

117.Ho TM, Zou Z, Bansal N. Camel milk: A review of its nutritional value, heat stability, and potential food products. *Food Research International*. Published online December 7, 2021:110870. doi:https://doi.org/10.1016/j.foodres.2021.110870

118.Ortega-Requena S, Rebouillat S, Pla F. Paving the High-Way to Sustainable, Value Adding Open-Innovation Integrating Bigger-Data Challenges: Three Examples from Bio-Ingredients to Robust Durable Applications of Electrochemical Impacts. ResearchGate. Published January 2018. https://www.researchgate.net/publication/324777703_Paving_the_High-

Way_to_Sustainable_Value_Adding_Open-Innovation_Integrating_Bigger-Data_Challenges_Three_Examples_from_Bio-Ingredients_to_Robust_Durable_Applications_of_Electrochemical_Impacts

119.Roy D, Ye A, Moughan PJ, Singh H. Gelation of milks of different species (dairy cattle, goat, sheep, red deer, and water buffalo) using glucono-δ-lactone and pepsin. *Journal of Dairy Science*. 2020;103(7):5844-5862. doi:https://doi.org/10.3168/jds.2019-17571

120.Ravenwood B, Coad J, Barnes MJ. A comparison of the effects of sheep's milk and cow's milk on recovery from eccentric exercise. *Frontiers in sports and active living*. 2024;5. doi:https://doi.org/10.3389/fspor.2023.1335434

121.Arrichiello A, Auriemma G, Sarubbi F. Comparison of nutritional value of different ruminant milks in human nutrition. *International Journal of Functional Nutrition*. 2022;3(4). doi:https://doi.org/10.3892/ijfn.2022.28

122.Maha Alaoui Ismaili, Saidi B, Zahar M, Hamama A, Raghia Ezzaier. Composition and microbial quality of raw camel milk produced in Morocco. *Journal of the Saudi Society of Agricultural Sciences*. 2019;18(1):17-21. doi:https://doi.org/10.1016/j.jssas.2016.12.001

123.Elhosseny M, Gwida M, Elsherbini M, Abu Samra R, Al Ashmawy M. Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt. MedCrave. Published May 24, 2018. https://www.researchgate.net/profile/Maha-Alashmawy/publication/327221941_JDVAR-07-00197/links/5b811cd4a6fdcc5f8b65f603/JDVAR-07-00197.pdf

124.American Psychological Association. Socioeconomic Status. *American Psychological Association*. https://www.apa.org/topics/socioeconomic-status. Published 2022.

125.CDC. Socioeconomic factors . Centers for Disease Control and Prevention. Published 2023. https://www.cdc.gov/dhdsp/health_equity/socioeconomic.htm

126.Vo CQ, Samuelsen PJ, Hilde Leikny Sommerseth, Torbjørn Wisløff, Wilsgaard T, Anne Elise Eggen. Comparing the sociodemographic characteristics of participants and non-participants in the population-based Tromsø Study. *BMC Public Health*. 2023;23(1).

doi:https://doi.org/10.1186/s12889-023-15928-w

127.Magnano San Lio R, Maugeri A, La Rosa MC, et al. The Impact of Socio-Demographic Factors on Breastfeeding: Findings from the “Mamma & Bambino” Cohort. *Medicina*. 2021;57(2):103. doi:https://doi.org/10.3390/medicina57020103

128.Baumgartner T, Bhamidipalli SS, Guise D, et al. Psychosocial and Sociodemographic Contributors to Breastfeeding Intention in First-Time Mothers. *Maternal and Child Health Journal*. 2020;24(8):1047-1056. doi:https://doi.org/10.1007/s10995-020-02928-0

129.McKinney CO, Hahn-Holbrook J, Chase-Lansdale PL, et al. Racial and Ethnic Differences in Breastfeeding. *Pediatrics*. 2016;138(2). doi:https://doi.org/10.1542/peds.2015-2388

130.Chiang KV, Li R, Anstey EH, Perrine CG. Racial and Ethnic Disparities in Breastfeeding Initiation ─ United States, 2019. *MMWR Morbidity and Mortality Weekly Report*. 2021;70(21):769-774. doi:https://doi.org/10.15585/mmwr.mm7021a1

131.American Academy of Pediatrics. Cultural Differences in Infant Feeding. www.aap.org. Published May 31, 2022. https://www.aap.org/en/patient-care/newborn-and-infant-nutrition/cultural-differences-in-infant-feeding/

132.Temple Newhook J, Newhook LA, Midodzi WK, et al. Poverty and Breastfeeding: Comparing Determinants of Early Breastfeeding Cessation Incidence in Socioeconomically Marginalized and Privileged Populations in the FiNaL Study. *Health Equity*. 2017;1(1):96-102. doi:https://doi.org/10.1089/heq.2016.0028

133.Kimbro RT. On-the-Job Moms: Work and Breastfeeding Initiation and Duration for a Sample of Low-Income Women. *Maternal and Child Health Journal*. 2006;10(1):19-26. doi:https://doi.org/10.1007/s10995-005-0058-7

134.Lesorogol C, Bond C, Dulience SJL, Iannotti L. Economic determinants of breastfeeding in Haiti: The effects of poverty, food insecurity, and employment on exclusive breastfeeding in an urban population. *Maternal & Child Nutrition*. 2017;14(2):e12524. doi:https://doi.org/10.1111/mcn.12524

135.Forste R, Weiss J, Lippincott E. The Decision to Breastfeed in the United States: Does Race Matter? *PEDIATRICS*. 2001;108(2):291-296. doi:https://doi.org/10.1542/peds.108.2.291

136.Ramos DE. Breastfeeding: A Bridge to Addressing Disparities in Obesity and Health. *Breastfeeding Medicine*. 2012;7(5):354-357. doi:https://doi.org/10.1089/bfm.2012.0076

137.Hurst CG. Addressing Breastfeeding Disparities in Social Work. *Health & Social Work*. 2007;32(3):207-210. doi:https://doi.org/10.1093/hsw/32.3.207

138.Ringel-Kulka T, Jensen E, McLaurin S, et al. Community-Based Participatory Research of Breastfeeding Disparities in African American Women. *ICAN: Infant, Child, & Adolescent Nutrition*. 2011;3(4):233-239. doi:https://doi.org/10.1177/1941406411413918

139.Nommsen-Rivers LA, Chantry CJ, Cohen RJ, Dewey KG. Comfort with the Idea of Formula Feeding Helps Explain Ethnic Disparity in Breastfeeding Intentions Among Expectant First-Time Mothers. *Breastfeeding Medicine*. 2010;5(1):25-33. doi:https://doi.org/10.1089/bfm.2009.0052

140.Clarke LS, Riley HE, Corwin EJ, Dunlop AL, Hogue CJR. The unique contribution of gendered racial stress to depressive symptoms among pregnant Black women. *Women's Health*. 2022;18:174550572211046. doi:https://doi.org/10.1177/17455057221104657

141.Girardi G, Longo M, Bremer AA. Social determinants of health in pregnant individuals from underrepresented, understudied, and underreported populations in the United States. *International Journal for Equity in Health*. 2023;22(1). doi:https://doi.org/10.1186/s12939-023-01963-x

142.Grand-Guillaume-Perrenoud JA, Origlia P, Cignacco E. Barriers and facilitators of maternal healthcare utilisation in the perinatal period among women with social disadvantage: a theory-guided systematic review. *Midwifery*. 2021;105:103237. doi:https://doi.org/10.1016/j.midw.2021.103237

143.Jones KM, Power ML, Queenan JT, Schulkin J. Racial and Ethnic Disparities in Breastfeeding. *Breastfeeding Medicine*. 2015;10(4):186-196. doi:https://doi.org/10.1089/bfm.2014.0152

144.Mukuria AG, Martin SL, Egondi T, Bingham A, Thuita FM. Role of Social Support in Improving Infant Feeding Practices in Western Kenya: A Quasi-Experimental Study. *Global Health: Science and Practice*. 2016;4(1):55-72. doi:https://doi.org/10.9745/ghsp-d-15-00197

145.Hauck K, Miraldo M, Singh S. Integrating motherhood and employment: A 22-year analysis investigating impacts of US workplace breastfeeding policy. *SSM - Population Health*. 2020;11. doi:https://doi.org/10.1016/j.ssmph.2020.100580

146.Segura-Pérez S, Hromi-Fiedler A, Adnew M, Nyhan K, Pérez-Escamilla R. Impact of breastfeeding interventions among United States minority women on breastfeeding outcomes: a systematic review. *International Journal for Equity in Health*. 2021;20(1). doi:https://doi.org/10.1186/s12939-021-01388-4

147.Underwood H. *ScholarWorks@UARK ScholarWorks@UARK the Eleanor Mann School of Nursing Undergraduate Honors Theses the Eleanor Mann School of Nursing 12-2021 Breastfeeding in Public and the Impact of Mass Media on Breastfeeding in Public and the Impact of Mass Media on Breastfeeding: An Expanded Literature Review Breastfeeding: An Expanded Literature Review*.; 2021. https://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1169&context=nursuht

148.Gibbs BG, Forste R. Socioeconomic status, infant feeding practices and early childhood obesity. *Pediatric Obesity*. 2013;9(2):135-146. doi:https://doi.org/10.1111/j.2047-6310.2013.00155.x

149.Dror DK, Allen LH. The Importance of Milk and other Animal-Source Foods for Children in Low-Income Countries. *Food and Nutrition Bulletin*. 2011;32(3):227-243. doi:https://doi.org/10.1177/156482651103200307

150.Bhandari N, Kabir AKMI, Salam MA. Mainstreaming nutrition into maternal and child health programmes: scaling up of exclusive breastfeeding. *Maternal & Child Nutrition*. 2008;4(s1):5-23. doi:https://doi.org/10.1111/j.1740-8709.2007.00126.x

151.Brunken GS, Silva SM, França GVA, Escuder MM, Venâncio SI. Risk factors for early interruption of exclusive breastfeeding and late introduction of complementary foods among infants in midwestern Brazil. *Jornal de Pediatria*. 2006;82(6):445-451. doi:https://doi.org/10.2223/jped.1569

152.American Academy of Pediatrics. The Use of Whole Cow's Milk in Infancy. *Pediatrics*. 1992;89(6):1105-1109. doi:https://doi.org/10.1542/peds.89.6.1105

153.Mills AF. Surveillance for anaemia: risk factors in patterns of milk intake. *Archives of Disease in Childhood*. 1990;65(4):428-431. doi:https://doi.org/10.1136/adc.65.4.428

154.Fernández-Gaxiola A, De-Regil L, Gallegos-Lecona S. *Animal Milks Compared to Follow-on Formula, Low-Fat Milk, Plant-Based Milk or Fortified Milk and Its Associated Outcomes in Children 12-23 Months of Age*.; 2020. Accessed January 3, 2025. https://cdn.who.int/media/docs/default-source/nutrition-and-food-safety/complementary-feeding/cf-guidelines/systematic-review-milks-12-23-months.pdf?sfvrsn=f968c9f2_3

155.Naudé SP, Prinsloo JG, Haupt CE. Comparison between a humanized cow's milk and a soy product for premature infants. *South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde*. 1979;55(24):982-986. https://pubmed.ncbi.nlm.nih.gov/572996/

156.Bank W. *Repositioning Nutrition as Central to Development : A Strategy for Large Scale Action*. Washington, DC; 2006. https://openknowledge.worldbank.org/entities/publication/dce7323d-6988-5236-9e86-4b05de8a8233

157.Alderman H. Long term consequences of early childhood malnutrition. *Oxford Economic Papers*. 2006;58(3):450-474. doi:https://doi.org/10.1093/oep/gpl008

158.Asiodu I, Flaskerud JH. Got Milk? A Look at Breastfeeding from an African American Perspective. *Issues in Mental Health Nursing*. 2011;32(8):544-546. doi:https://doi.org/10.3109/01612840.2010.544842

159.Weintz EW. The politics of exclusion and paranoia: The Know Nothing Party as a case study in frustration-aggression analysis. *ProQuest*. 2007;13(1). https://www.proquest.com/docview/220300951?fromopenview=true&pq-origsite=gscholar&sourcetype=Scholarly%20Journals

160.Deubel TF, Miller EM, Hernandez I, Boyer M, Louis-Jacques A. Perceptions and Practices of Infant Feeding among African American Women. *Ecology of Food and Nutrition*. 2019;58(4):301-316. doi:https://doi.org/10.1080/03670244.2019.1598977

161.Simpson A. Redirecting. ScholarWorks @ Georgia State University. Published 2025. Accessed January 7, 2025. https://www.google.com/url?q=https://scholarworks.gsu.edu/nutrition_theses/41/&sa=D&source=docs&ust=1736277005458872&usg=AOvVaw3pFrOPcANTZupTVm3oqKtp

162.Ware JL, Webb L, Levy M. Barriers to Breastfeeding in the African American Population of Shelby County, Tennessee. *Breastfeeding Medicine*. 2014;9(8):385-392. doi:https://doi.org/10.1089/bfm.2014.0006

CHAPTER 3

ASSOCIATION BETWEEN SOCIODEMOGRAPHIC CHARACTERISTICS AND INFANT FEEDING BELIEFS OF ANIMAL MILK AS AN ALTERNATIVE TO HUMAN BREAST MILK AMONG WOMEN OF CHILDBEARING AGE[1]

[1] Nunnally, Adelia. To be submitted to *The Journal of Midwifery and Women's Health*

Abstract

Background: The CDC and the Dietary Guidelines for Americans recommend exclusive breastfeeding for the first six months, with continued breastfeeding for up to one year or beyond yet in 2021, only 27.2% of US infants were exclusively breastfed for six months. One of the Healthy People 2030 breastfeeding objectives is to increase the percentage of infants exclusively breastfed for the first six months of life to 42.4%. To achieve this goal, the United States must make significant progress over the next five years. But if infants are not exclusively breastfed during this critical period, what are they being fed? One common substitute for breast milk is animal milk, which is often chosen for reasons such as convenience, breastfeeding challenges, infections, or other health issues. However, many mothers are unaware of the potential risks associated with using animal milk as a breast milk substitute (BMS).

Objectives: This study examined the association between sociodemographic characteristics and knowledge of breastfeeding recommendations, laws and legislation awareness, and perceptions of animal milk as breast milk alternative among childbearing age women in the United States.

Methods: This study was a cross-sectional online national survey of women of childbearing age across the United States hosted on Qualtrics.

Results: Out of the 842 participants, the majority were over 20 years old, white, married/cohabiting, with a college degree or higher, resided in the Southern US, worked full time, and had an annual household income above $100,000. Sixty-two percent of participants correctly identified the 6-month exclusive breastfeeding recommendation, with knowledge highest among women aged 30–39 (51.1%). Although no significant associations were observed

between sociodemographic factors and awareness of this recommendation, other aspects of breastfeeding knowledge, like the necessity of water and nutrient supplements during exclusive breastfeeding, did show significant associations with age, marital status, and race ($p < 0.05$). Awareness of breastfeeding laws varied by region, employment status, income, age, marital status, household size, and number of children. Unemployed participants were less likely to know workplace pumping rights ($OR = 0.55$, $p = 0.005$), while those from households with five or more members had greater awareness ($OR = 4.45$, $p = 0.030$). Participants reported two or more animal milks (cow, goat, sheep, camel, and/or buffalo milk) as appropriate for infant feeding. However, for the reason to feed animal milk as an alternative to breast milk to infants, nearly half (44.1%) of the participants gave reasons ranging from unsure, convenience, infant having acid reflux, and mother having had double mastectomy, among others. Married (89%) and White (74%) participants demonstrated higher awareness of the recommendation on when to introduce cow's milk.

Conclusions: This study reveals significant disparities in infant feeding knowledge and awareness of breastfeeding laws among U.S. women of childbearing age by income, employment, and marital status. Lower-income and single women were less aware of breastfeeding guidelines/recommendations and legislation, which may be contributing to lower breastfeeding rates. Additionally, misinformation about animal milk as breast milk alternative was more common in smaller households and among women without children. The findings emphasize the need for targeted interventions, stronger workplace policies, and accessible infant feeding education to better support mothers, especially those in underserved communities.

3.1 Introduction

Breastfeeding reduces the risk of infant mortality and infections by increasing the infant's immune response.[1] Although the World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months of life, followed by complementary feeding alongside breastfeeding from 6 months and continuing up to 2 years, unfortunately this is not always known or followed by mothers.[2] Sociodemographic factors, such as race/ethnicity, education, age, income, marital status, and geographic location have been reported as key determinants of breastfeeding rates and success. According to data from the CDC, these factors influence the likelihood of breastfeeding.[3] In situations where alternative feeding is necessary, animal milk has been used as an alternative due to perceived similar nutritional properties to human breast milk.[4]

Breastfeeding offers numerous short- and long-term benefits for both infants and mothers. Studies show that breastfeeding promotes higher intelligence and lower rates of obesity and diabetes later in life.[5] It boosts the infant's immune response, leading to fewer hospitalizations and a reduced risk of conditions such as asthma, leukemia, celiac disease, inflammatory bowel disease (IBD), cavities, and sudden infant death syndrome (SIDS).[1, 6-9] For mothers, breastfeeding is cost-effective, lowers the risk of postpartum depression, aids in postpartum weight loss, and promotes physical and emotional bonding.[7, 8] It also accelerates recovery, reduces the risk of certain cancers, type 2 diabetes, cardiovascular diseases, and high blood pressure.[7, 8]

Breast milk provides all the essential nutrients a newborn needs for growth and health.[2] It contains optimal levels of carbohydrates, fats, proteins, and micronutrients, with lactose being the primary carbohydrate, which aids digestion and supports intestinal microbiota.[10] Whey and casein are the main proteins, with whey being easier to digest, and certain proteins like lactoferrin, secretory IgA, and lysozyme offer antibacterial and antiviral benefits.[10, 11] Triglycerides, the main fat component, are crucial for brain and central nervous system development, and for the absorption of fat-soluble vitamins.[10, 11] While breast milk provides sufficient micronutrients for most infants, supplementation may be necessary for vitamin D, K, and iron.[10, 11] Bioactive factors like white blood cells, microRNAs, growth factors, and prebiotics support immune function and gut health.[11, 12]

The composition of breast milk varies based on the stage of lactation, the mother's diet, and environmental factors. Lactation progresses through three stages, lactogenesis I (activation from third trimester of pregnancy), lactogenesis II (activation after birth), and lactogenesis III (maintenance).[13, 14] The three stages of breast milk include colostrum which is nutrient-dense and low in fat, transitional milk which increases in volume and fat, and mature milk which provides high fat for satiety.[9, 10, 15] Additionally, milk composition changes during a feeding session, with foremilk being lower in fat and hindmilk higher in fat to satisfy the infant's needs.[10]

Human breast milk is the optimal infant feed, but in certain cases, alternatives are necessary.[16] In the 19th century, wet nurses and later animal milk became popular substitutes, before the development of infant formula in the 20th century.[17] Animal milk, especially cow milk, is commonly used due to its similar composition to human milk, although it can vary based on species, environment, and maternal diet.[4, 18] For example, cow's milk contains more protein, calcium, cholesterol, and saturated fat than human milk.[4, 19, 20] Buffalo milk, often consumed in Asia, has more fat and protein than human milk and is rich in calcium and phosphorus.[4, 18-20, 31] Goat milk, popular in Africa and South Asia, closely mirrors human milk in protein content and fat structure, making it easier to digest, though it has less iron.[4, 18, 19, 21, 22] Sheep milk, with its high fat and protein content, as well as bioactive factors, offers energy and health benefits, but has higher cholesterol levels than human breast milk.[4, 23-29] Camel milk, consumed in the Middle East, is low in fat but high in vitamin C, iron, and unsaturated fatty acids, though its composition varies vastly.[18, 20, 30-34] While each animal milk has desirable qualities, they are not identical to human breast milk, making human milk the optimal choice for infant nutrition.

Sociodemographic characteristics, including factors such as socioeconomic status, income, education, race, and living conditions, significantly impact infant feeding practices.[35-37] Women from lower socioeconomic backgrounds are less likely to initiate breastfeeding or breastfeed exclusively for six months.[38] Race also influences feeding behaviors, with Non-Hispanic White women more likely to breastfeed exclusively compared to Non-Hispanic Black and Hispanic women.[39] Higher education levels and income are associated with a greater likelihood of intending to breastfeed exclusively.[39] Studies also show that Asian and White mothers are more likely to initiate breastfeeding compared to American Indian/Alaska Native and Black mothers, while lower education and income levels correlate with earlier cessation of breastfeeding.[40, 41] These findings highlight how sociodemographic factors shape infant feeding practices, which have lasting health implications.

Although previous research has shown disparities in breastfeeding initiation and duration among some groups, less is known about how sociodemographic characteristics are associated with knowledge of women in the U.S., specifically regarding breastfeeding recommendations, laws, and use of animal milk as breast milk alternative. There is limited research on the association of sociodemographic characteristics and awareness of U.S. breastfeeding laws and legislation. Additionally, there is limited research on the association of sociodemographic characteristics and awareness of the appropriate use of animal milk in infant feeding. Addressing this gap in knowledge is important to inform programs and policies to improve infant feeding practices and infant health.

This study investigated the association between sociodemographic characteristics and the knowledge of breastfeeding recommendations, knowledge of breastfeeding laws/legislation, and use of animal milk as an alternative to human breast milk among women of childbearing age. The first aim examined the role of sociodemographic factors in women's knowledge of breastfeeding recommendations. The second aim focused on assessing women's awareness of breastfeeding laws and legislation, such as the Affordable Care Act and the Fairness for Breastfeeding Mothers Act of 2019. The third aim assessed women's knowledge regarding the appropriateness and safety of using animal milk as a substitute for breast milk.

3.2 Methods

3.2.1 Study Design

This was a cross-sectional, online national survey hosted on the Qualtrics platform. A link or QR code of a virtual flyer was sent to various Facebook groups, including parenting and mothers' groups, as well as breastfeeding organizations such as breastfeeding coalitions, lactation clinics, and birth centers. The study was reviewed and approved by the Human Subject Institutional Review Board of the University of Georgia (PROJECT00008823). Participants consented to the study after reading the consent letter prior to answering the survey questions. The survey was initially launched on February 2, 2024, and remained open until October 2, 2024. Participants were initially contacted via Facebook groups. Follow-up messages with the flyer were sent out once a month. Additionally, breastfeeding organizations were contacted to help reach more participants.

3.2.2 Participant Recruitment and Analytical Sample

The study was conducted nationally in the United States. For eligibility, participants had to be between 18 and 49 years old, identified as female, and lived in the United States. Screener questions at the beginning of the survey filtered out ineligible participants. The screener questions included, "What do you identify as?" "Do you reside in the United States?" (yes or no) and "Which category below includes your age?" These three eligibility questions ensured that the survey was completed by only the target population. A subsample of 842 participants who completed at least 80% of the survey was included in the data analysis.

3.2.3 Survey Instrument

Questions used for the study questionnaire were adopted from validated previously used questionnaires that assessed sociodemographic and infant feeding knowledge.[42-46] Key questions from these surveys were utilized as the foundation, supplemented by additional questions designed to meet the specific objectives of this study. The study questionnaire consisted of five main sections preceded by the eligibility screener questions. 18 questions on sociodemographic factors were asked at the beginning of the survey. The following six questions assessed participants' breastfeeding knowledge of recommendations. The next five questions were on breastfeeding laws and regulations. The following 11 questions were on breastfeeding alternatives, specifically animal milk. The final set of questions were answered only by women who were parents or guardians. This section covered 12 breastfeeding questions for mothers. The survey included 52 questions, consisting of multiple-choice, text-entry, and matrix table formats, and was designed to take approximately 15-30 minutes to complete.

3.2.4 Measures

Sociodemographic Characteristics

The section on sociodemographic characteristics consisted of 18 questions adapted from validated sources, including a National Institute for Health and Care Research (NIHR) randomized controlled trial on the assessment of nausea in chemotherapy research, the Centers for Disease Control and Prevention (CDC) infant feeding practices study, and the American Academy of Family Physicians (AAFP) short-form social needs screening tool.[42-44] Two food security-related questions were adopted from the AAFP short-form social needs screening tool.[44]

Breastfeeding Knowledge

The breastfeeding knowledge block consisted of six open-ended text-entry questions designed to assess participants' knowledge of key breastfeeding practices and recommendations, with some adapted from the Bright Futures Nutrition Questionnaire.[45] These questions included (1) the recommended number of months to exclusively breastfeed, (2) signs that indicate an infant is hungry, (3) the frequency of feeding an infant, (4) the appropriate age to cease breastfeeding, (5) whether additional water is needed for exclusively breastfeeding infants, and (6) the necessity of nutrient supplements during exclusive breastfeeding.

The questions were developed based on current guidelines and breastfeeding education priorities. Responses were reviewed and coded (scoring rubric 1= accurate knowledge, 2= inaccurate knowledge) to categorize answers as correct or incorrect. For instance, responses to nutrient supplements being necessary were scored as correct if they aligned with current health recommendations (e.g., "supplemental vitamin D"). Responses falling outside the recommended range were categorized as incorrect. By including text-entry questions, we aimed to capture participants' unprompted knowledge, avoiding potential biases introduced by multiple-choice formats. While this approach provided richer qualitative data, it required manual coding for analysis.

Breastfeeding Laws and Regulations

The breastfeeding laws and regulations section of the survey consisted of four open-ended text-entry questions and one multiple-choice question designed to assess participants' knowledge of current laws and workplace policies related to breastfeeding. These questions addressed critical areas such as the accommodations employers are required to provide for breastfeeding employees, whether break times for breastfeeding or pumping are paid or unpaid, and the locations where breastfeeding is legally permitted for postpartum mothers within the working setting.

Understanding breastfeeding laws and regulations is a fundamental aspect of creating supportive environments for breastfeeding mothers, particularly in workplaces where compliance with such laws can significantly impact a mother's ability to balance breastfeeding with employment.

Breast Milk Alternatives

The breast milk alternatives block contained 11 questions to assess participants' knowledge of the appropriateness of animal milk in infant feeding practices. The first two questions ask which, if any, animal milk can be used as an alternative to human breast milk. The following questions explored maternal consumption of animal milk, reasons for feeding infants animal milk, infants' allergic reactions to animal milk, CDC guidelines on introducing animal milk, the role of cow’s milk in an infant’s diet, and whether whole or lower-fat cow’s milk is more suitable for infants. Understanding these behaviors and beliefs is crucial for identifying gaps in education and providing a foundation for future efforts to improve infant feeding practices and align them with evidence-based recommendations.

Participants with Young Children

Breastfeeding questions for mothers’ block contained 12 multiple-choice, open-ended text-entry, and matrix table questions to assess participants’ experiences and knowledge related to childbirth. More specifically, these 12 questions consisted of 10 multiple-choice, one open-ended text-entry, and 1 matrix table questions. These questions covered topics such as multiple or preterm births, NICU stays for the youngest child, the child’s age, WIC enrollment, attendance at breastfeeding classes, breastfeeding support from doctors or staff, experiences and support at the hospital or birth center, resources provided, and feeding method at discharge. Several questions were adapted from the UNICEF/WHO Questionnaire for Breastfeeding Mothers.[46] This section was essential for identifying gaps in breastfeeding support and education, providing a foundation for targeted interventions to improve maternal and infant health outcomes.

3.2.5 Statistical Analysis

All analyses were conducted using IBM SPSS Statistical software version 29. For analysis, a p-value of < 0.05 was considered as a criterion for statistical significance. The dataset was downloaded from Qualtrics and imported into SPSS, coded, cleaned, and checked for missing responses. Participants who did not complete 80% or more of the survey were excluded from the data analysis. Certain variables were recoded based on participant responses and small sample size. The education variable was originally coded as 1 = less than 12th grade, 2 = high school graduate or GED, 3 = some college/technical school training, 4 = college graduate (BA or BS), 5 = Graduate school degree, and 6 = other (please specify). Based on responses, the education variable was recoded as 1 = ≤ high school/GED, 2 = some college/technical school training, 3 = college graduate, and 4 = graduate school or higher. The employment variable was originally coded as 1 = works full-time, 2 = works part-time, 3 = temporarily unemployed, and 4 = not employed, which was recoded based on participant responses as 1 = full-time, 2 = part-time, and 3 = unemployed. The race variable was originally coded as 1 = White, 2 = Black/African American, 3 = American Indian or Alaska Native, 4 = Asian, 5 = Native Hawaiian or other Pacific Islander, and 6 = Other (please specify). This variable was recoded as 1 = White, 2 = Black/African American, 3 = Other/multiracial. Household annual income variable was originally coded as 1 = < $5,000, 2 = $5,000-19,999, 3 = $20,000-49,999, 4 = $50,000-99,999, 5 = $100,000-149,999, 6 = ≥ $150,000, 7 = don't know, and 8 = choose not to answer. This variable was recoded as 1 = < $20,000, 2 = $20,000-49,999, 3 = $50,000-99,999, 4 = $50,000-99,999, and 5 = ≥ $100,000. The variable assessing which animal milk is appropriate for infants under six months was initially coded as follows: 1 = cow milk, 2 = buffalo milk, 3 = goat milk, 4 = sheep milk, 5 = camel milk, 6 = none of these are suitable alternatives to human breast milk, and 7 = two or more animal milks. It was later recoded into four categories: 1 = cow milk, 2 = goat milk, 3 = sheep milk, and 4 = two or more milks. Similarly, the variable assessing appropriate animal milk for infants aged 6–12 months was originally coded with the same seven categories. It was then recoded into five categories: 1 = cow milk, 2 = goat milk, 3 = sheep milk, 4 = camel milk, and 5 = two or more milks.

Participants self-reported their state of resident in the U.S. Based on the reported state of resident, we grouped them into geographical regions. The U.S. Census Bureau divides the U.S. into four regions; Northeast, Midwest, South, and West. The Northeast geographical region included Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania. The Midwest geographical region includes Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. The South geographical region included Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas. The West geographical region included Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, and Washington.

To prepare the data for logistic regression analysis, response categories were consolidated into 'accurate' and 'inaccurate' classifications. The variable on recommended age to introduce cow's milk into a child’s diet was coded as “inaccurate” (<1 year/unsure/other) and “accurate” (1 year/>1 year). The variable on a woman’s right to pump breast milk at work after giving birth was coded as “inaccurate” (<1 year/unsure) and “accurate” (1 year/>1 year). The variable on legislation surrounding paid or unpaid break time to pump breast milk was coded as “inaccurate” (breaks are not paid/unsure/depends/other) and “accurate” (breaks are paid). The variable on employer provisions for workers expressing breast milk at the workplace was coded as “inaccurate” (a room/break time/other) and “accurate” (a room and break time). These adjustments were made to distinguish correct responses from incorrect ones.

Food insecurity was assessed using two yes/no questions: (1) 'Within the past 12 months, I have worried whether my food would run out before I had money to buy more,' and (2) 'Within the past 12 months, the food I bought just didn’t last, and I didn’t have money to get more.' A score of 1 was assigned for each 'yes' response and 0 for each 'no' response, resulting in total scores ranging from 0 to 2. Scores of 0 indicated food security, and 1 and 2 indicated food insecurity.[47]

Descriptive statistics using chi-square were conducted to examine categorical associations between sociodemographic characteristics and infant feeding knowledge and awareness of breastfeeding laws. Multivariate logistic regression was conducted to determine independent predictors of outcomes adjusting for participant age. Hosmer-Lemeshow Test was conducted to assess the stability of the multivariate logistic regression models.

3.3 Results

3.3.1 Characteristics of Study Participants

A total of 1,169 national sample of women of childbearing age attempted the Qualtrics survey. Participants represented all but four states, including Montana, Rhode Island, South Dakota, and Vermont. This includes 22% from the Northeast region, 8% from the Midwest region, and 8% from the West region of the U.S. not represented in this study. 327 women completed less than 80% of the survey and were excluded from the final participant count and analysis. Of the 842 participants included in the analytical sample, 99% were over 20 years old (20% 20-29, 50% 30-39, and 29% 40-49 years old), 86% were married/cohabiting, 79% were white, 82% had a college degree or higher, 89% were not students, 65% resided in the Southern U.S., 62% worked full time, and 45% reported annual household income above $100,000 (Table1). Among all participants, 20% were recipients of some form of food assistance. Of these, 8% relied exclusively on food banks or pantries, while the remainder utilized a combination of SNAP, WIC, and/or food banks or pantries. Among participants in the current study, 88 (10.5%) were food insecure, while 751 (89.5%) were food secure.

Table 1 Sociodemographic Characteristics of Participants (N= 842)

	n (%)
Age of Participant	
18-20	9 (1.1)
21-29	168 (20.0)
30-39	422 (50.1)
40-49	243 (28.9)
Marital Status	
Married/Cohabiting	722 (85.7)
Single	119 (14.1)
Prefer not to answer	1 (0.1)
Education	
≤ HS/GED	22 (2.6)
Some college/Technical school training	127 (15.1)
College graduate	369 (43.8)
≥ Graduate school degree	324 (38.5)
Geographical Region	
Northeast	90 (10.7)
South	548 (65.4)
Midwest	101 (12.1)
West	99 (11.8)
Household Size	
1	16 (1.9)
2	101 (12.1)
3	226 (27.0)
4	284 (33.9)
≥ 5	210 (25.1)
Housing	
Mobile home or trailer	5 (0.6)
One family house detached	689 (82.1)
One family house attached to others	64 (7.6)
A building for two families	11 (1.3)
A building for three or more families	45 (5.4)
Other	25 (3.0)
Home Ownership	
Owned	688 (79.6)
Rented	162 (19.3)
Occupied without rent	8 (1.0)
No permanent residence	1 (0.1)

	n (%)
Employment	
Full time	517 (61.5)
Part-time	137 (16.3)
Not employed	187 (22.2)
Student	
Yes	96 (11.4)
No	743 (88.6)
Race	
White	664 (79.3)
Black/African American	102 (12.2)
Other[a]/Multiracial	71 (8.5)
Hispanic/Latino/Spanish Origin	
Yes	69 (8.3)
No	764 (91.7)
Health Insurance	
Government funding	80 (9.6)
Insured through employer	623 (74.5)
Private insurance	117 (14.0)
Uninsured	16 (1.9)
Household Annual Income	
< $20,000	21 (2.6)
$20,000-49,999	45 (5.7)
$50,000-99,999	167 (21.0)
> $100,000	562 (70.7)
Recipient of Food Assistance Program	
Yes	169 (20.1)
No	670 (79.9)
Worried About Food Running Out	
Yes	84 (10.0)
No	755 (90.0)
Food Didn't Last	
Yes	57 (6.8)
No	783 (93.2)
How Many Children	
None	158 (18.8)
1	228 (27.1)
2	287 (34.2)

	n (%)
3 4 or more	117 (13.9) 50 (6.0)

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

3.3.2 Role of Sociodemographic Factors on Breastfeeding Knowledge

Sixty-two percent (62%) of participants knew the recommendation for how many months to exclusively breastfeed an infant (6 months) (Figure 1). In Figure 1, the 30–39 age group had the highest number of correct responses (215/842). The 18–20 age group had the fewest correct responses (4). Table 2 explores additional sociodemographic factors related to the perceived number of months to exclusively breastfeed an infant, with no factors having a significant association with knowledge of the recommendation. Table 3 shows participant opinions on whether infants need water during exclusive breastfeeding, with significant associations found for age, marital status, household size, employment, race, and number of children ($p < 0.05$). Notably, participants aged 30-39 (53%) and those who were married/cohabiting (90%) provided the correct response (infants do not need water during exclusive breastfeeding). Table 4 examines participant opinions on whether exclusively breastfed infants need nutrient supplements, with significant associations for age, marital status, education, household size, race, income, and number of children ($p < 0.05$). The higher income group (≥ $100,000, 82%) and married participants (96%) were most likely to recognize vitamin D as a necessary nutrient supplement during exclusive breastfeeding. Table 5 examines maternal perceptions of when infants should stop breastfeeding. Age, marital status, household size, race, number of children, and food assistance program participation showed significant associations ($p < 0.05$). Non-recipients of food assistance program (86%) and married participants (82%) were most likely to report 12-23 months.

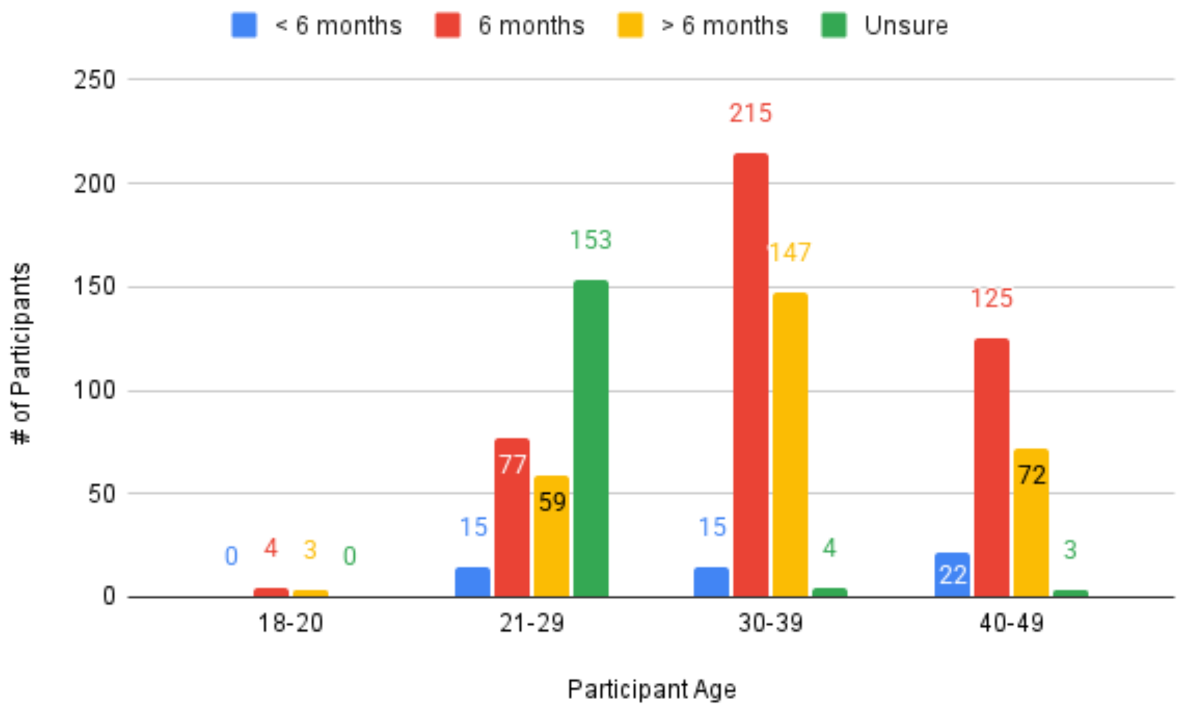

Figure 1 Perceived Months of Exclusively Breastfeeding by Participant Age

Table 2 Perceived Months of Exclusively Breastfeeding by Participant Characteristics

	< 6 months n (%)	6 months n (%)	> 6 months n (%)	Unsure n (%)	P-value
Age					0.165
18-20	0 (0.0)	4 (1.0)	3 (1.1)	0 (0.0)	
21-29	15 (28.8)	77 (18.3)	59 (21.0)	153 (20.1)	
30-39	15 (3.9)	215 (51.1)	147 (52.3)	4 (44.4)	
40-49	22 (42.3)	125 (29.7)	72 (25.6)	3 (33.3)	
Marital Status					0.290
Married/cohabiting	42 (80.8)	370 (87.9)	235 (83.6)	8 (88.9)	
Single	10 (19.2)	51 (12.1)	46 (16.4)	1 (11.1)	
Education					0.186
≤ HS/GED	0 (0.0)	10 (2.4)	7 (2.5)	1 (11.1)	
Some college/Technical training	10 (19.2)	61 (14.5)	41 (14.6)	0 (0.0)	
College graduate	20 (38.5)	173 (41.1)	135 (48.0)	6 (66.7)	
≥ Graduate school degree	22 (42.3)	177 (42.0)	98 (34.9)	2 (22.2)	
Geographical Region					0.140
Northeast	3 (5.8)	48 (11.4)	29 (10.4)	0 (0.0)	
South	44 (84.6)	268 (63.8)	187 (66.8)	8 (88.9)	
Midwest	2 (3.8)	48 (11.4)	36 (12.9)	1 (11.1)	
West	3 (5.8)	56 (13.3)	28 (10.0)	0 (0.0)	
Household Size					0.832
1	1 (1.9)	9 (2.2)	5 (1.8)	0 (0.0)	
2	8 (15.4)	46 (11.0)	40 (14.3)	3 (33.3)	
3	12 (23.1)	114 (27.3)	75 (26.9)	2 (22.2)	
4	15 (28.8)	145 (34.7)	87 (31.2)	2 (22.2)	
≥ 5	16 (30.8)	104 (24.9)	72 (25.8)	2 (22.2)	

Employment					0.512
Full time	28 (53.8)	257 (61.0)	179 (63.7)	4 (44.4)	
Part time	12 (23.1)	66 (15.7)	47 (16.7)	3 (33.3)	
Unemployed	12 (23.1)	98 (23.3)	55 (19.6)	2 (22.2)	
Race					0.075
White	47 (92.2)	336 (80.2)	210 (75.0)	9 (100.0)	
Black/African American	2 (3.9)	51 (12.2)	39 (13.9)	0 (0.0)	
Other[a]/Multiracial	2 (3.9)	32 (7.6)	31 (11.1)	0 (0.0)	
Hispanic/Latino/Spanish Origin					0.653
Yes	5 (9.6)	31 (7.4)	28 (10.1)	1 (11.1)	
No	47 (90.4)	386 (92.6)	250 (89.9)	8 (88.9)	
Health Insurance					0.609
Government funding	4 (7.7)	42 (10.0)	25 (9.0)	0 (0.0)	
Insured through employer	40 (76.9)	316 (75.4)	206 (73.8)	8 (88.9)	
Private insurance	8 (15.4)	50 (11.9)	45 (16.1)	1 (11.1)	
Uninsured	0 (0.0)	11 (2.6)	3 (1.1)	0 (0.0)	
Household Annual Income					0.204
<$20,000	4 (8.0)	7 (1.8)	7 (2.7)	0 (0.0)	
$20,000-$49,999	0 (0.0)	22 (5.2)	15 (5.4)	0 (0.0)	
$50,000-$99,999	7 (13.5)	85 (20.2)	57 (20.4)	2 (22.2)	
≥ $100,000	39 (78.0)	285 (71.4)	185 (70.1)	7 (77.8)	
Number of Children					0.170
None	14 (26.9)	69 (16.4)	67 (23.8)	3 (33.3)	
1	11 (21.2)	115 (27.3)	74 (26.3)	3 (33.3)	
2	15 (28.8)	155 (36.8)	81 (28.8)	2 (22.2)	
3	10 (19.2)	53 (12.6)	44 (15.7)	0 (0.0)	
≥ 4	2 (3.8)	29 (6.9)	15 (5.3)	1 (11.1)	

Recipient of Food Assistance Program Yes No	 4 (7.7) 48 (92.3)	 93 (22.1) 327 (77.9)	 52 (18.5) 229 (81.5)	 2 (22.2) 7 (77.8)	0.087

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 3 Opinion About Infants Needing Water During Exclusively Breastfeeding by Participant Characteristics

	Infants do not need it n (%)	It is ok for Infants n (%)	Depends if they need it n (%)	No opinion/unsure/ Other[a] n (%)	P-value
Age					<0.001
18-20	3 (0.5)	2 (4.9)	0 (0.0)	2 (2.5)	
21-29	105 (17.1)	14 (34.1)	8 (32.0)	24 (30.4)	
30-39	324 (52.9)	15 (36.6)	11 (44.0)	30 (38.0)	
40-49	181 (29.5)	10 (24.4)	6 (24.0)	23 (29.1)	
Marital Status					<0.001
Married/Cohabiting	552 (90.0)	27 (65.9)	20 (80.0)	54 (68.4)	
Single	61 (10.0)	14 (34.1)	5 (20.0)	25 (31.6)	
Education					0.14
≤ HS/GED	14 (2.3)	0 (0.0)	0 (0.0)	4 (5.1)	
Some college/Technical training	75 (12.2)	10 (24.4)	5 (20.0)	17 (21.5)	
College graduate	266 (43.4)	22 (53.7)	13 (52.0)	35 (44.3)	
≥ Graduate school degree	258 (42.1)	9 (22.0)	7 (28.0)	23 (29.1)	
Geographical Region					0.014
Northeast	68 (11.1)	5 (12.2)	2 (8.0)	4 (5.1)	
South	386 (63.2)	28 (68.3)	21 (84.0)	67 (84.4)	
Midwest	79 (12.9)	2 (4.9)	1 (4.0)	4 (5.1)	

West	78 (12.8)	6 (14.6)	1 (4.0)	4 (5.1)	
Household Size					<0.001
1	8 (1.3)	2 (4.9)	2 (8.3)	2 (2.5)	
2	55 (9.0)	10 (20.8)	5 (20.8)	23 (29.1)	
3	163 (26.8)	12 (29.3)	4 (16.7)	21 (26.6)	
4	212 (34.8)	12 (29.3)	7 (29.2)	20 (25.3)	
≥ 5	171 (28.1)	5 (12.2)	6 (25.0)	13 (16.5)	
Employment					0.002
Full time	372 (60.7)	29 (70.7)	9 (36.0)	52 (65.8)	
Part-time	104 (17.0)	7 (17.1)	5 (20.0)	11 (13.9)	
Temporarily unemployed	16 (2.6)	3 (7.3)	4 (16.0)	1 (1.3)	
Not employed	121 (19.7)	2 (4.9)	7 (28.0)	15 (19.0)	
Race					0.034
White	490 (80.3)	26 (63.4)	23 (92.0)	60 (76.9)	
Black/African American	76 (12.5)	8 (19.5)	0 (0.0)	8 (10.3)	
Other[b]/Multiracial	44 (7.2)	7 (17.1)	2 (8.0)	10 (12.8)	
Hispanic/Latino/Spanish Origin					0.175
Yes	47 (7.7)	5 (12.2)	1 (4.0)	11 (14.1)	
No	560 (92.3)	36 (87.8)	24 (96.0)	67 (85.9)	
Health Insurance					0.666
Government funding	53 (8.7)	6 (14.6)	5 (20.0)	7 (9.0)	
Insured through employer	460 (75.4)	27 (65.9)	17 (68.0)	61 (78.2)	
Private insurance	84 (13.8)	7 (17.1)	3 (12.0)	9 (11.5)	
Uninsured	13 (2.1)	1 (2.4)	0 (0.0)	1 (1.3)	
Household Annual Income					0.751
< $20,000	13 (2.2)	1 (2.6)	1 (4.0)	3 (4.3)	
$20,000-$49,999	26 (4.4)	3 (7.7)	2 (8.0)	6 (8.6)	
$50,000-$99,999	121 (20.7)	8 (20.5)	6 (24.0)	17 (24.3)	

≥ $100,000	425 (72.6)	27 (69.2)	16 (64.0)	44 (62.9)	
Number of Children					<0.001
None	85 (13.9)	20 (48.8)	7 (28.0)	34 (43.0)	
1	162 (26.4)	9 (22.0)	9 (36.0)	21 (26.6)	
2	227 (37.0)	8 (19.5)	5 (20.0)	16 (20.3)	
3	96 (15.7)	3 (7.3)	2 (8.0)	5 (6.3)	
≥ 4	43 (7.0)	1 (2.4)	2 (8.0)	3 (3.8)	

[a]Other includes, "I only gave water once baby started eating table food," "That's odd," "You need to drink a lot of water," and "None of my business"
[b]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 4 Opinion of Infants Needing Nutrient Supplements During Exclusively Breastfed by Participants Characteristics

	Don't need it n (%)	Need vitamin D n (%)	Need vitamin D + other supplements n (%)	Other Supplement excluding Vitamin D n (%)	Unsure/Depends[a] n (%)	P-value
Age						<0.001
18-20	2 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	5 (3.1)	
21-29	40 (15.2)	30 (13.5)	7 (24.1)	19 (28.4)	51 (32.1)	
30-39	119 (45.1)	147 (65.9)	17 (58.6)	27 (40.3)	67 (42.1)	
40-49	103 (39.0)	46 (20.6)	5 (17.2)	21 (31.3)	36 (22.6)	
Marital Status						<0.001
Married/Cohabiting	233 (88.3)	214 (96.0)	26 (89.7)	58 (86.6)	110 (69.2)	
Single	31 (11.7)	9 (4.0)	3 (10.3)	9 (13.4)	49 (30.8)	
Education						<0.001
≤ HS/GED	4 (1.5)	2 (0.9)	1 (3.4)	4 (6.0)	4 (2.5)	

Some college/Technical training	42 (15.9)	22 (9.9)	2 (6.9)	15 (22.4)	26 (16.4)	
College graduate	125 (47.3)	88 (39.5)	11 (37.9)	22 (32.8)	82 (51.6)	
≥ Graduate school degree	93 (35.2)	111 (49.8)	15 (51.7)	26 (38.8)	47 (29.6)	
Geographical Region						0.161
Northeast	26 (9.9)	29 (13.0)	4 (13.8)	6 (9.0)	14 (8.8)	
South	165 (63.0)	138 (61.9)	17 (58.6)	47 (70.1)	123 (77.4)	
Midwest	33 (12.6)	29 (13.0)	4 (13.8)	9 (13.4)	11 (6.9)	
West	38 (14.5)	27 (12.1)	4 (13.8)	5 (7.5)	11 (6.9)	
Household Size						<0.001
1	2 (0.8)	0 (0.0)	1 (3.4)	2 (3.0)	8 (5.1)	
2	34 (13.0)	5 (2.3)	5 (17.2)	10 (14.9)	38 (24.1)	
3	62 (23.8)	70 (31.5)	8 (27.6)	13 (19.4)	43 (27.2)	
4	82 (31.4)	84 (37.8)	11 (37.9)	26 (38.8)	43 (27.2)	
≥ 5	81 (31.0)	63 (28.4)	4 (13.8)	16 (23.9)	26 (16.5)	
Employment						0.174
Full time	163 (61.7)	138 (61.9)	11 (37.9)	49 (73.1)	94 (59.1)	
Part-time	45 (17.0)	32 (14.3)	8 (27.6)	8 (11.9)	31 (19.5)	
Temporarily unemployed	6 (2.3)	6 (2.7)	1 (3.4)	3 (4.5)	7 (4.4)	
Not employed	50 (18.9)	47 (21.1)	9 (31.0)	7 (10.4)	27 (17.0)	
Race						0.004
White	203 (77.5)	179 (80.6)	23 (79.3)	53 (79.1)	127 (80.4)	
Black/African American	40 (15.3)	33 (14.9)	0 (0.0)	4 (6.0)	13 (8.2)	
Other[b]/Multiracial	19 (7.3)	10 (4.5)	6 (20.7)	10 (14.9)	18 (11.4)	
Hispanic/Latino/Spanish Origin						0.155
Yes	22 (8.5)	15 (6.8)	6 (20.7)	7 (10.4)	13 (8.2)	
No	238 (91.5)	206 (93.2)	23 (79.3)	60 (89.6)	145 (91.8)	
Health Insurance						0.107
Government funding	24 (9.2)	14 (6.3)	2 (6.9)	5 (7.5)	23 (14.6)	

Insured through employer Private insurance Uninsured	192 (73.3) 37 (14.1) 9 (3.4)	180 (81.1) 27 (12.2) 1 (0.5)	23 (79.3) 4 (13.8) 0 (0.0)	52 (77.6) 10 (14.9) 0 (0.0)	108 (68.4) 22 (13.9) 5 (3.2)	
Household Annual Income						<0.001
< $20,000	5 (2.0)	4 (1.8)	0 (0.0)	2 (3.4)	6 (3.9)	
$20,000-$49,999	13 (5.2)	4 (1.8)	0 (0.0)	0 (0.0)	17 (11.2)	
$50,000-$99,999	55 (22.1)	32 (14.7)	9 (32.1)	19 (32.8)	36 (23.7)	
≥ $100,000	176 (70.7)	177 (81.6)	19 (67.9)	37 (63.8)	93 (61.2)	
Number of Children						<0.001
None	53 (20.1)	6 (2.7)	7 (24.1)	16 (23.9)	62 (39.0)	
1	62 (23.5)	72 (32.3)	7 (24.1)	18 (26.9)	38 (23.9)	
2	86 (32.6)	87 (39.0)	12 (41.4)	24 (35.8)	41 (25.8)	
3	40 (15.2)	39 (17.5)	0 (0.0)	9 (13.4)	15 (9.4)	
≥ 4	23 (8.7)	19 (8.5)	3 (10.3)	0 (0.0)	3 (1.9)	

[a]Depends includes, “If recommended by a pediatrician,” “Depends if they need it,” “If medically advised,” and “Depends on mother’s health”

[b]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 5 Maternal Perception of When Infants Should Stop Breastfeeding by Participant Characteristics

	<12 months n (%)	12-23 months n (%)	≥ 24 months n (%)	Mother and baby’s choice n (%)	Unsure n (%)	P-value
Age						<0.001
18-20	0 (0.0)	5 (2.6)	1 (1.0)	1 (0.2)	0 (0.0)	
21-29	13 (54.2)	46 (24.2)	28 (28.3)	65 (14.8)	2 (22.2)	
30-39	4 (16.7)	81 (42.6)	46 (46.5)	246 (55.9)	5 (55.6)	
40-49	7 (29.2)	58 (30.5)	24 (24.2)	128 (29.1)	2 (22.2)	

Marital Status						<0.001
Married/Cohabiting	12 (50.0)	156 (82.1)	75 (75.8)	404 (91.8)	8 (88.9)	
Single	12 (50.0)	34 (17.9)	24 (24.2)	36 (8.2)	1 (11.1)	
Education						0.449
≤ HS/GED	1 (4.2)	4 (2.1)	1 (1.0)	11 (2.5)	0 (0.0)	
Some college/Technical training	5 (20.8)	32 (16.8)	16 (6.2)	57 (13.0)	2 (22.2)	
College graduate	13 (54.2)	88 (46.3)	42 (42.4)	187 (42.5)	6 (66.7)	
≥ Graduate school degree	5 (20.8)	66 (34.7)	40 (40.4)	185 (42.0)	1 (11.1)	
Geographical Region						0.329
Northeast	2 (8.3)	18 (9.5)	12 (12.2)	49 (11.2)	0 (0.0)	
South	17 (70.8)	141 (74.2)	58 (59.2)	281 (64.0)	8 (88.9)	
Midwest	3 (12.5)	18 (9.5)	12 (12.2)	53 (12.1)	0 (0.0)	
West	2 (8.3)	13 (6.8)	16 (16.3)	56 (12.8)	1 (11.1)	
Household Size						<0.001
1	0 (0.0)	8 (4.2)	4 (4.1)	3 (0.7)	0 (0.0)	
2	6 (25.0)	35 (18.5)	15 (15.3)	36 (8.2)	3 (33.3)	
3	14 (58.3)	47 (24.9)	31 (31.6)	109 (24.9)	1 (1.1)	
4	3 (12.5)	51 (27.0)	27 (27.6)	167 (38.2)	3 (33.3)	
≥ 5	1 (4.2)	48 (25.4)	21 (21.4)	122 (27.9)	2 (22.2)	
Employment						0.604
Full time	12 (50.0)	123 (64.7)	55 (55.6)	271 (61.6)	4 (44.4)	
Part-time	5 (20.8)	29 (15.3)	16 (16.2)	73 (16.6)	3 (33.3)	
Unemployed	7 (29.2)	38 (20.0)	28 (28.3)	96 (21.8)	2 (22.2)	
Race						0.008
White	20 (83.3)	152 (80.0)	73 (73.7)	349 (80.0)	8 (88.9)	
Black/African American	0 (0.0)	14 (7.4)	15 (15.2)	62 (14.2)	1 (11.1)	
Other[a]/Multiracial	4 (16.7)	24 (12.6)	11 (11.1)	25 (5.7)	0 (0.0)	
Hispanic/Latino/Spanish Origin						0.227

Yes	3 (12.5)	20 (10.6)	12 (12.1)	28 (6.5)	1 (11.1)	
No	21 (87.5)	169 (89.4)	87 (87.9)	406 (93.5)	8 (88.9)	
Health Insurance						0.298
Government funding	1 (4.2)	13 (6.8)	14 (14.1)	43 (9.9)	0 (0.0)	
Insured through employer	18 (75.0)	143 (75.3)	67 (67.7)	334 (76.6)	6 (66.7)	
Private insurance	5 (20.8)	31 (16.3)	16 (16.2)	49 (11.2)	3 (33.3)	
Uninsured	0 (0.0)	3 (1.6)	2 (2.0)	10 (2.3)	0 (0.0)	
Household Annual Income						0.171
< $20,000	1 (5.6)	6 (3.3)	3 (3.2)	8 (1.9)	0 (0.0)	
$20,000-$49,999	0 (0.0)	9 (4.9)	11 (11.7)	17 (4.1)	0 (0.0)	
$50,000-$99,999	5 (27.8)	40 (22.0)	18 (19.1)	86 (20.5)	4 (44.4)	
≥ $100,000	12 (66.7)	127 (69.8)	62 (66.0)	308 (73.5)	5 (55.6)	
Number of Children						<0.001
None	15 (62.5)	66 (34.7)	26 (26.3)	42 (9.5)	3 (33.3)	
1	7 (29.2)	45 (23.7)	31 (31.3)	116 (26.4)	1 (11.1)	
2	2 (8.3)	42 (22.1)	26 (26.3)	182 (41.4)	4 (44.4)	
3	0 (0.0)	26 (13.7)	9 (9.1)	69 (15.7)	1 (11.1)	
≥ 4	0 (0.0)	11 (5.8)	7 (7.1)	31 (7.0)	0 (0.0)	
Recipient of Food Assistance Program						0.008
Yes	1 (4.2)	26 (13.7)	28 (28.3)	94 (21.4)	1 (11.1)	
No	23 (95.8)	164 (86.3)	71 (71.7)	345 (78.6)	8 (88.9)	

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

3.3.3 Awareness of Breastfeeding Laws and Legislation

Table 6 examines awareness of employer obligations for workers expressing milk at work. The correct response, employers should provide both a room and break time, was, significantly associated with region of resident ($p = 0.021$), with participants from the South reporting the highest awareness (61%). Table 7 presents awareness of regulations regarding paid break time for pumping. Employment status and household income were significantly associated with awareness of paid breaks for breastfeeding or milk expression at the workplace, with full-time workers (70%; $p = 0.008$) and higher-income individuals (70%; $p = 0.030$) showing greater awareness. Table 8 presents awareness of the allowable duration a woman has to pump at work after childbirth. The correct response, 1 year, was most commonly reported. Age, marital status, household size, and number of children were significantly associated with awareness of the allowable duration of women being able to express their milk at work after childbirth ($p < 0.05$). Figure 2 further illustrates participants response to various questions related to breastfeeding laws and recommendations. Table 9 presents multivariate logistic regression models examining sociodemographic predictors of knowledge of workplace pumping rights and awareness of paid break regulations for pumping at work. For awareness of workplace pumping rights, significant predictors included employment and household size. Unemployed participants were less likely to be aware (OR = 0.55, 95% CI: 0.36-0.83, $p = 0.005$) compared to their full-time employed counterparts. Participants from households with five or more members had higher odds of awareness of workplace pumping rights (OR = 4.45, 95% CI: 1.16-17.17, $p = 0.030$). For awareness of paid breaks, part-time workers were more likely to be aware compared to full-time workers (OR = 2.09, 95% CI: 1.10-3.97, $p = 0.024$). Higher household income was also a significant predictor, with those earning $50,000-$99,999 (OR = 4.64, 95% CI: 1.40-15.37, p =

0.012) and ≥$100,000 (OR = 4.53, 95% CI: 1.36-15.10, p = 0.014) having greater awareness of paid breaks for breast milk expression laws. Lastly, Table 10 presents multivariate logistic regression models for predictors of knowledge on general breastfeeding recommendations and U.S. breastfeeding laws. For general breastfeeding recommendations, participants residing in the West region were less likely to be knowledgeable compared to those in the Northeast (OR = 0.49, 95% CI: 0.25-0.93, p = 0.030). Marital status showed borderline significance, with married/cohabiting participants being more knowledgeable (OR = 1.66, p = 0.053). For knowledge of U.S. breastfeeding laws, unemployed participants had significantly higher odds of being knowledgeable compared to full-time workers (OR = 2.41, 95% CI: 1.30-4.47, p = 0.005).

Table 6 Awareness of What an Employer Should Provide to Workers Who Need to Express by Participant Characteristic

	A room n (%)	Break time n (%)	A room and break time n (%)	Other[a]/unsure n (%)	P-value
Age					0.270
18-20	4 (0.8)	1 (7.1)	1 (0.4)	0 (0.0)	
21-29	91 (19.3)	2 (14.3)	51 (22.5)	5 (19.2)	
30-39	231 (48.9)	6 (42.9)	118 (52.0)	14 (53.8)	
40-49	146 (30.9)	5 (35.7)	57 (25.1)	7 (26.9)	
Marital Status					0.359
Married/Cohabiting	399 (84.5)	13 (92.9)	202 (89.0)	23 (88.5)	
Single	73 (15.5)	1 (7.1)	25 (11.0)	3 (11.5)	
Education					0.245
≤ HS/GED	9 (1.9)	1 (7.1)	5 (2.2)	2 (7.7)	
Some college/Technical training	67 (14.2)	2 (14.3)	33 (14.5)	6 (23.1)	
College graduate	210 (44.5)	8 (57.1)	95 (41.9)	13 (50.0)	
≥ Graduate school degree	186 (39.4)	3 (21.4)	94 (41.4)	5 (19.2)	
Geographical Region					0.021
Northeast	53 (11.3)	0 (0.0)	23 (10.1)	3 (11.5)	
South	322 (68.5)	12 (85.7)	138 (60.8)	15 (57.7)	
Midwest	47 (10.0)	0 (0.0)	38 (16.7)	1 (3.8)	
West	48 (10.2)	2 (14.3)	28 (12.3)	7 (26.9)	
Household Size					0.692
1	12 (2.6)	0 (0.0)	2 (0.9)	1 (3.8)	
2	61 (13.1)	3 (21.4)	29 (12.8)	2 (7.7)	
3	122 (26.1)	2 (14.3)	63 (27.8)	7 (26.9)	
4	159 (34.0)	7 (50.0)	71 (31.3)	7 (26.9)	
≥ 5	113 (24.2)	2 (14.3)	62 (27.3)	9 (34.6)	

Employment					0.149
Full time	305 (64.6)	9 (64.3)	129 (56.8)	13 (50.0)	
Part-time	70 (14.8)	4 (28.6)	39 (17.2)	7 (26.9)	
Unemployed	97 (20.6)	1 (7.1)	59 (26.0)	6 (23.1)	
Race					0.603
White	373 (79.4)	11 (78.6)	179 (79.2)	21 (84.0)	
Black/African American	63 (13.4)	2 (14.3)	24 (10.6)	1 (4.0)	
Other[b]/Multiracial	34 (7.2)	1 (7.1)	23 (10.2)	3 (12.0)	
Hispanic/Latino/Spanish Origin					0.663
Yes	43 (9.2)	0 (0.0)	18 (8.0)	2 (7.7)	
No	424 (90.8)	13 (100.0)	208 (92.0)	24 (92.3)	
Health Insurance					0.058
Government funding	42 (9.0)	2 (14.3)	20 (8.8)	5 (19.2)	
Insured through employer	359 (76.5)	7 (50.0)	172 (76.1)	17 (65.4)	
Private insurance	63 (13.4)	5 (35.7)	26 (11.5)	3 (11.5)	
Uninsured	5 (1.1)	0 (0.0)	8 (3.5)	1 (3.8)	
Household Annual Income					0.526
< $20,000	12 (2.7)	0 (0.0)	3 (1.4)	2 (8.3)	
$20,000-$49,999	25 (5.6)	1 (8.3)	8 (3.6)	1 (4.2)	
$50,000-$99,999	92 (20.6)	2 (16.7)	52 (23.6)	3 (12.5)	
≥ $100,000	318 (71.1)	9 (75.0)	157 (71.4)	18 (75.0)	
Number of Children					0.471
None	96 (20.3)	5 (35.7)	42 (18.5)	7 (26.9)	
1	125 (26.5)	2 (14.3)	58 (25.6)	7 (26.9)	
2	161 (34.1)	6 (42.9)	78 (34.4)	4 (15.4)	
3	65 (13.8)	1 (7.1)	30 (13.2)	5 (19.2)	
4 or more	25 (5.3)	0 (0.0)	19 (8.4)	3 (11.5)	
Recipient of Food Assistance Program					0.834

Yes	99 (21.0)	3 (21.4)	41 (18.1)	5 (19.2)	
No	372 (79.0)	11 (78.6)	186 (81.9)	21 (80.8)	

[a]Other includes, "Yes" (did not specify what should be provided), "Anything they want," "Varies by state."
[b]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 7 Awareness of the Regulations Surrounding Paid Break Time to Pump by Participant Characteristics

	Paid breaks n (%)	Non-paid breaks n (%)	Unsure/Other[a] n (%)	P-value
Age				0.400
18-20	1 (0.8)	0 (0.0)	5 (1.0)	
21-29	30 (23.1)	22 (23.2)	92 (18.9)	
30-39	64 (49.2)	53 (55.8)	238 (48.9)	
40-49	35 (26.9)	20 (21.1)	152 (31.2)	
Marital Status				0.204
Married/Cohabiting	107 (82.3)	86 (90.5)	412 (86.4)	
Single	23 (17.7)	9 (9.5)	66 (13.6)	
Education				0.968
≤ HS/GED	3 (2.3)	3 (3.2)	9 (1.8)	
Some college/Technical training	19 (14.6)	14 (14.7)	67 (13.8)	
College graduate	57 (43.8)	38 (40.0)	219 (45.0)	
≥ Graduate school degree	51 (39.2)	40 (42.1)	192 (39.4)	
Geographical Region				0.077
Northeast	10 (7.7)	13 (13.7)	51 (10.5)	
South	89 (68.5)	50 (52.6)	333 (68.7)	
Midwest	16 (12.3)	18 (18.9)	50 (10.3)	
West	15 (11.5)	14 (14.7)	51 (10.5)	
Household Size				0.140

1 2 3 4 ≥ 5	1 (0.8) 19 (14.7) 45 (34.9) 41 (31.8) 23 (17.8)	1 (1.1) 11 (11.7) 27 (28.7) 30 (31.9) 25 (26.6)	12 (2.5) 60 (12.4) 112 (23.1) 167 (34.5) 133 (27.5)	
Employment				0.008
Full time	91 (70.0)	63 (66.3)	287 (58.9)	
Part-time	16 (12.3)	21 (22.1)	77 (15.8)	
Unemployed	23 (17.7)	11 (11.6)	123 (25.3)	
Race				0.107
White	102 (79.1)	69 (72.6)	393 (81.2)	
Black/African American	17 (13.2)	19 (20.0)	49 (10.1)	
Other[b]/Multiracial	10 (7.8)	7 (7.4)	42 (8.7)	
Hispanic/Latino/Spanish Origin				0.079
Yes	15 (11.6)	3 (3.2)	41 (8.5)	
No	114 (88.4)	91 (96.8)	441 (91.5)	
Health Insurance				0.860
Government funding	14 (10.8)	10 (10.5)	45 (9.3)	
Insured through employer	99 (76.2)	70 (73.7)	362 (74.9)	
Private insurance	16 (12.3)	14 (14.7)	64 (13.3)	
Uninsured	1 (0.8)	1 (1.1)	12 (2.5)	
Household Annual Income				0.030
< $20,000	6 (4.9)	3 (3.2)	8 (1.7)	
$20,000-$49,999	6 (4.9)	6 (6.4)	22 (4.8)	
$50,000-$99,999	25 (20.3)	9 (9.6)	112 (24.3)	
≥ $100,000	86 (69.9)	76 (80.9)	318 (69.1)	

Number of Children				0.331
None	29 (22.3)	14 (14.7)	98 (20.1)	
1	41 (31.5)	26 (27.4)	117 (24.0)	
2	44 (33.8)	35 (36.8)	165 (33.9)	
3	11 (8.5)	13 (13.7)	73 (15.0)	
≥ 4	5 (3.8)	7 (7.4)	34 (7.0)	
Recipient of Food Assistance Program				0.306
Yes	20 (15.4)	22 (23.2)	99 (20.4)	
No	110 (84.6)	73 (76.8)	387 (79.6)	

[a]Other includes, "Depends on your state," "Depends on the policy at a job," "Depends on salaried vs hourly vs contract workers," "This was detailed in the PUMP Act," "Must allow breaks" (did not specify paid or unpaid)
[b]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 8 Awareness of Allowable Duration a Women Has to Pump at Work After Childbirth by Participant Characteristic

	< 1 year n (%)	1 year n (%)	> 1 year n (%)	Unsure[a]/Other[b] n (%)	P-value
Age					0.008
18-20	1 (3.7)	2 (0.9)	1 (2.9)	2 (0.5)	
21-29	11 (40.7)	51 (21.8)	10 (29.4)	75 (17.4)	
30-39	9 (33.3)	123 (52.6)	18 (52.9)	212 (49.3)	
40-49	6 (22.2)	58 (24.8)	5 (14.7)	141 (32.8)	
Marital Status					<0.001
Married/Cohabiting	15 (55.6)	205 (87.6)	30 (88.2)	378 (87.9)	
Single	12 (44.4)	29 (12.4)	4 (11.8)	52 (12.1)	
Education					0.107
≤ HS/GED	1 (3.7)	4 (1.7)	0 (0.0)	11 (2.6)	
Some college/Technical training	5 (18.5)	28 (12.0)	7 (20.6)	64 (14.9)	

College graduate ≥ Graduate school degree	16 (59.3) 5 (18.5)	99 (42.3) 103 (44.0)	9 (26.5) 18 (52.9)	196 (45.6) 159 (37.0)	
Geographical Region					0.161
Northeast	3 (11.1)	29 (12.4)	3 (9.1)	42 (9.8)	
South	20 (74.1)	149 (63.7)	19 (57.6)	292 (68.1)	
Midwest	3 (11.1)	32 (13.7)	2 (6.1)	47 (11.0)	
West	1 (3.7)	24 (10.3)	9 (27.3)	48 (11.2)	
Household Size					<0.001
1	4 (14.8)	3 (1.3)	0 (0.0)	7 (1.6)	
2	4 (14.8)	21 (9.0)	1 (2.9)	67 (15.7)	
3	4 (14.8)	65 (27.9)	10 (29.4)	107 (25.1)	
4	11 (40.7)	81 (34.8)	14 (41.2)	138 (32.4)	
≥ 5	4 (14.8)	63 (27.0)	9 (26.5)	107 (25.1)	
Employment					0.135
Full time	16 (59.3)	158 (67.5)	18 (52.9)	255 (59.3)	
Part-time	4 (14.8)	38 (16.2)	9 (26.5)	68 (15.8)	
Unemployed	7 (25.9)	38 (16.2)	7 (20.6)	107 (24.9)	
Race					0.559
White	20 (74.1)	183 (78.2)	27 (79.4)	341 (80.0)	
Black/African American	4 (14.8)	36 (15.4)	3 (8.8)	47 (11.0)	
Other[c]/Multiracial	3 (11.1)	15 (6.4)	4 (11.8)	38 (8.9)	
Hispanic/Latino/Spanish Origin					0.286
Yes	4 (14.8)	14 (6.0)	4 (11.8)	37 (8.7)	
No	23 (85.2)	219 (94.0)	30 (88.2)	387 (91.3)	
Health Insurance					0.312
Government funding	5 (18.5)	20 (8.6)	4 (11.8)	40 (9.4)	
Insured through employer	15 (55.6)	181 (77.7)	26 (76.5)	320 (74.9)	
Private insurance	6 (22.2)	25 (10.7)	4 (11.8)	61 (14.3)	

Uninsured	1 (3.7)	7 (3.0)	0 (0.0)	6 (1.4)	
Household Annual Income					0.259
< $20,000	2 (8.3)	6 (2.7)	2 (5.9)	7 (1.7)	
$20,000-$49,999	2 (8.3)	12 (5.4)	3 (8.8)	18 (4.4)	
$50,000-$99,999	7 (29.2)	51 (23.1)	6 (17.6)	81 (19.8)	
≥ $100,000	13 (54.2)	152 (68.8)	23 (67.6)	304 (74.1)	
Number of Children					0.003
None	13 (48.1)	34 (14.5)	6 (17.6)	91 (21.2)	
1	1 (3.7)	67 (28.6)	7 (20.6)	113 (26.3)	
2	10 (37.0)	85 (36.3)	17 (50.0)	136 (31.6)	
3	3 (11.1)	36 (15.4)	2 (5.9)	58 (13.5)	
≥ 4	0 (0.0)	12 (5.1)	2 (5.9)	32 (7.4)	
Recipient of Food Assistance Program					0.549
Yes	7 (25.9)	42 (17.9)	9 (26.5)	87 (20.3)	
No	20 (74.1)	192 (82.1)	25 (73.5)	342 (79.7)	

[a]Unsure includes, “Depends on the woman,” Depends what job she has,” “Depends on the employer”
[b]Other includes, “Immediately/as soon as she returns” (did not answer the question correctly)
[c]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

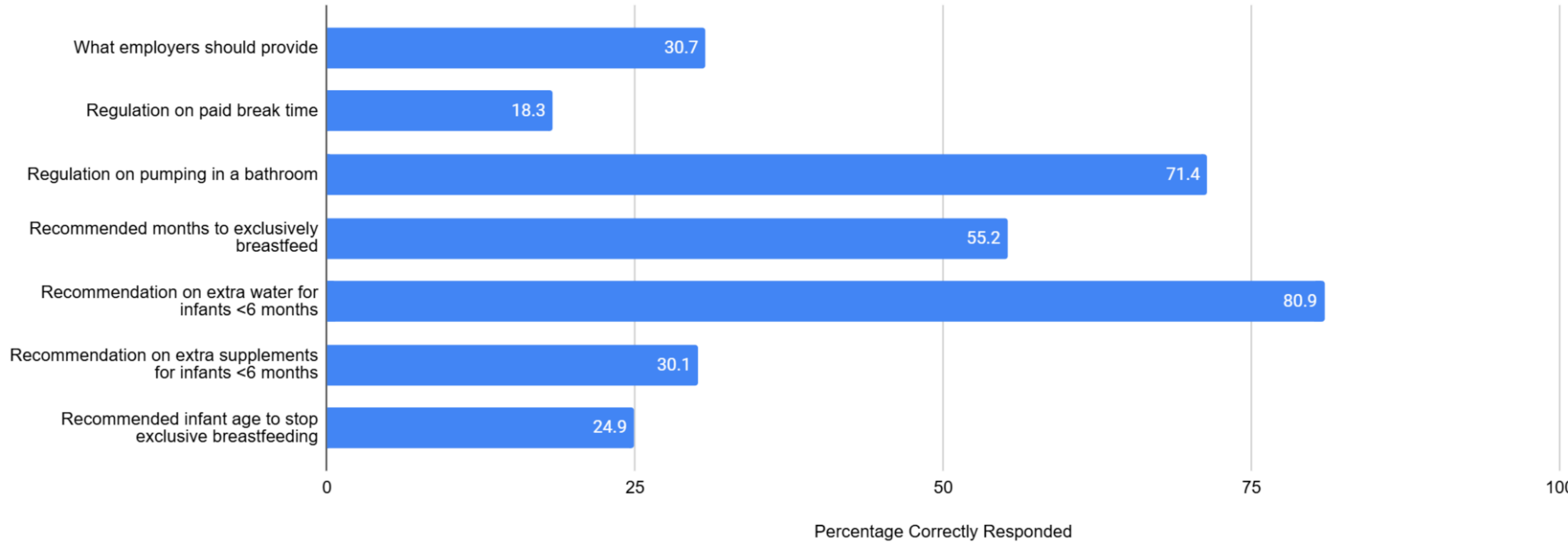

Figure 2 Correct Response for Breastfeeding Laws and Recommendation

Table 9 Multivariate Logistic Regression Models for Sociodemographic Predictors of Knowledge on Workplace Pumping Rights for Mothers and Paid vs. Unpaid Break Legislation for Pumping at Work

	Workplace Pumping Rights[a]				Awareness of Break Time Paid Pumping[b]			
	n	Odds Ratio	95% C.I.	p-value	n	Odds Ratio	95% C.I.	p-value
Education								
≤ HS/GED	16	1.00						
Some college/Technical	102	1.82	0.53, 6.25	0.343				
College graduate	317	2.06	0.63, 6.77	0.233				
≥ Graduate school	285	2.93	0.89, 9.64	0.078				

Employment								
Full time	445	1.00			416	1.00		
Part-time	118	0.94	0.61, 1.45	0.773	109	2.09	1.10, 3.97	0.024
Unemployed	157	0.55	0.36, 0.83	0.005	145	1.58	0.93, 2.67	0.088
Household Size								
1	14	1.00						
2	93	1.37	0.34, 5.42	0.659				
3	186	3.52	0.93, 13.36	0.064				
4	244	3.62	0.95, 13.71	0.059				
≥ 5	183	4.45	1.16, 17.17	0.030				
Home Ownership								
Owned					541	1.00		
Rented					122	1.57	0.83, 2.95	0.166
Occupied without rent					7	-	-	-
Ethnicity								
Hispanic					56	1.00		
Non-Hispanic					614	1.80	0.94, 3.44	0.075
Household Annual Income								
< $20,000					17	1.00		
$20,000-49,999					34	3.62	0.90, 14.61	.070
$50,000-99,999					144	4.64	1.40, 15.37	.012
> $100,000					475	4.53	1.36, 15.10	.014

Adjusted for age of participant

[a]Hosmer-Lemeshow Test chi-square 7.56, p-value 0.474

[b]Hosmer-Lemeshow Test chi-square 8.73, p-value 0.189

Table 10 Multivariate Logistic Regression Models for Sociodemographic Predictors of Knowledge on General Breastfeeding Recommendations and Knowledge of US Breastfeeding Laws

	General Breastfeeding Recommendations[a]	Knowledge of US Breastfeeding Laws[b]

	n	Odds Ratio	95% C.I.	p-value	n	Odds Ratio	95% C.I.	p-value
Home Ownership								
Owned	586	1.00			537	1.00		
Rented	133	1.16	0.75, 1.79	0.518	124	1.24	0.65, 2.34	0.518
Occupied without rent	8	4.15	0.49, 35.18	0.192	7	-	-	-
Household Size								
1	12	1.00			12	1.00		
2	92	1.31	0.34, 5.01	0.698	87	0.73	0.08, 6.46	0.777
3	194	0.86	0.23, 3.22	0.822	173	0.27	0.03, 2.22	0.222
4	241	0.84	0.22. 3.17	0.797	225	0.36	0.04, 3.00	0.344
≥ 5	189	0.76	0.20, 2.90	0.686	171	0.32	0.04, 2.73	0.299
Education								
≤ HS/GED	15	1.00						
Some college/Technical	103	0.74	0.23, 2.40	0.615				
College graduate	322	0.69	0.22, 2.16	0.528				
≥ Graduate school	288	0.46	0.15, 1.46	0.189				
Marital Status								
Married/cohabiting	628	1.00						
Single	100	1.66	0.99, 2.77	0.053				
Geographical Region								
Northeast	77	1.00						
South	481	0.89	0.54, 1.48	0.655				
Midwest	86	0.61	0.32, 1.15	0.127				
West	84	0.49	0.25, 0.93	0.030				
Employment								
Full time					415	1.00		
Part-time					108	1.29	0.71, 2.34	0.396
Unemployed					145	2.41	1.30, 4.47	0.005
Household Annual Income								

< $20,000					17	1.00	0.74, 16.19	0.116
$20,000-49,999					34	3.46	0.62, 7.32	0.230
$50,000-99,999					143	2.13	0.92, 11.29	0.069
> $100,000					474	3.21		

Adjusted for age of participant
[a]Hosmer-Lemeshow Test chi-square 9.33, p-value 0.315
[b]Hosmer-Lemeshow Test chi-square 6.03, p-value 0.536

3.3.4 Knowledge of the Use of Animal Milk as Breast Milk Alternative

Perceptions of suitable animal milk for infants, by infant age group are presented in Figure 3. Among infants under 6 months, goat milk was the most reported option (41%), while multiple animal milks were the most reported choice (40%) for those aged 6-12 months. Overall, two or more animal milks was the most reported option with a slight increase in the older age group. Nearly half of the participants gave different reasons to feed animal milk to infants (Figure 4). Reasons given for feeding animal milk included responses like “convenience,” “infant has acid reflux,” “because of infection,” “double mastectomy,” and “to avoid formula.” Table 11 shows that most participants correctly reported that animal milk is not recommended for infant feeding before 12 months of age, with awareness significantly associated with age, marital status, household size, and number of children ($p < 0.05$). Participants aged 30-39 (51%) and married (87%) demonstrated greater awareness of timing of feeding animal milk. Awareness of the recommendations on feeding raw/unpasteurized animal milk was significantly associated with education, household size, employment, race, Hispanic/Latino origin, insurance, and income ($p < 0.05$) (Table 12), with non-Hispanic (92%) and employer-insured (75%) participants showing greater awareness. Table 13 presents awareness of recommendations on introducing cow’s milk to infants. Significant associations were observed for awareness of recommendations for introduction of cow’s milk to infants with participant age, marital status, household size, race, insurance, and number of children, with married (89%) and White (74%) participants demonstrating higher awareness. Most participants were aware that whole cow’s milk is more appropriate for children older than 12 months old (Table 14). Awareness was significantly associated with participant age, marital status, household size, race, Hispanic/Latino origin, insurance, income, number of children, and food assistance program participation ($p < 0.05$).

Non-Hispanic (92%) and married (87%) participants were more likely to be aware of the correct recommendation. Lastly, Table 15 presents a multivariate logistic regression model predicting knowledge of the recommended age for introducing cow's milk to infants. Single participants had significantly higher odds of correct knowledge (OR: 4.49, 95% CI: 1.56–12.94, $p = 0.005$). Having one child (OR: 3.06, $p = 0.011$) or two children (OR: 2.24, $p = 0.042$) was also associated with greater knowledge compared to participants who did not have a child.

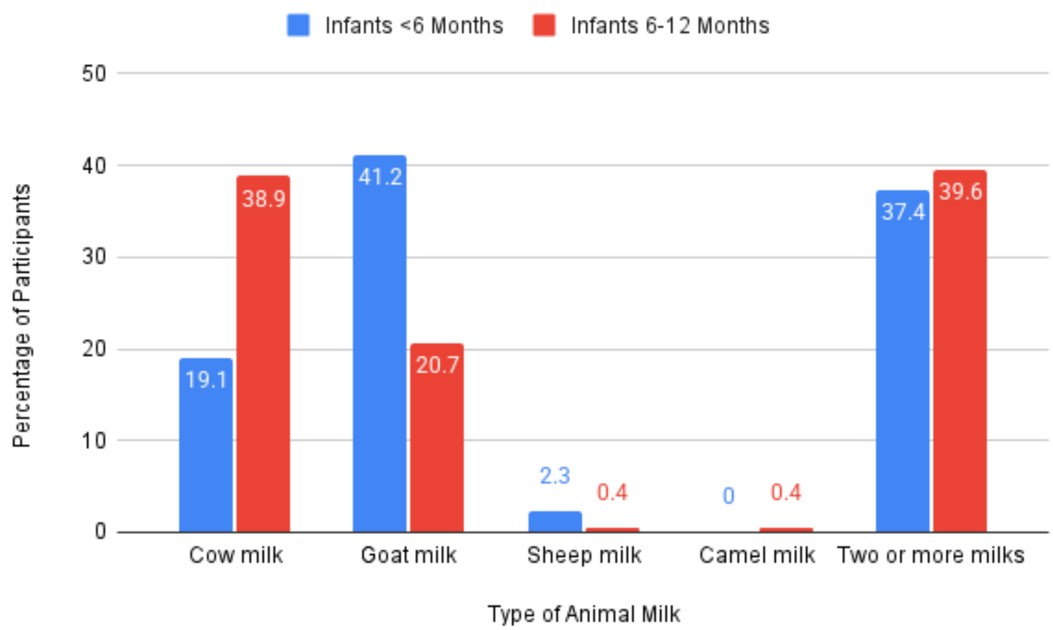

Figure 3 Perceptions of Suitable Animal Milk for Infants by Age Group

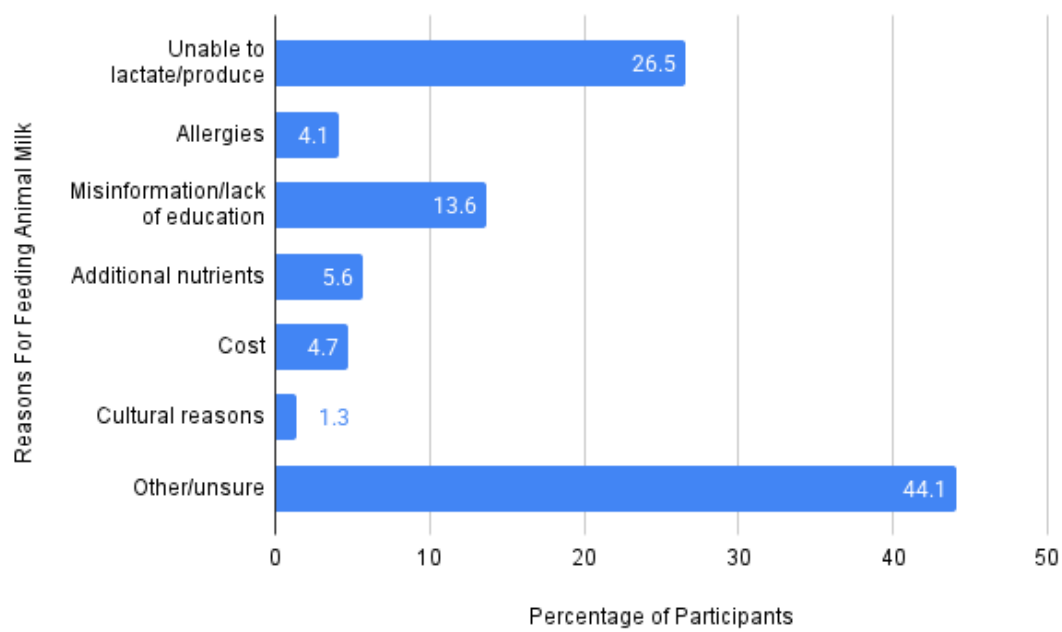

Figure 4 Reasons for Feeding Animal Milk
Other reasons to feed animal milk include two or more listed reasons, "convenience," "infant has acid reflux," "because of infection," "last resort," "to transition from breast milk," "double mastectomy," "to avoid formula," "adoption."

Table 11 Awareness of CDC Recommendation on Animal Milk Feeding by Participant Characteristics

	CDC Recommends Animal Milk Before 12 Months Old n (%)	CDC Does Not Recommend Animal Milk Before 12 Months Old n (%)	P-value
Age			0.017
18-20	2 (2.7)	4 (0.6)	
21-29	23 (31.5)	121 (19.1)	
30-39	32 (43.8)	321 (50.8)	
40-49	16 (21.9)	186 (29.4)	
Marital Status			0.002
Married/Cohabiting	54 (74.0)	552 (87.3)	
Single	19 (26.0)	80 (12.7)	
Education			0.137
≤ HS/GED	1 (1.4)	14 (2.2)	
Some college/Technical training	15 (20.5)	90 (14.2)	
College graduate	37 (50.7)	274 (43.4)	
≥ Graduate school	20 (27.4)	254 (40.2)	
Geographical Region			0.290
Northeast	11 (15.1)	66 (10.5)	
South	51 (69.9)	414 (65.6)	
Midwest	5 (6.8)	76 (12.0)	
West	6 (8.2)	75 (11.9)	
Household Size			< 0.001
1	3 (4.1)	11 (1.8)	
2	19 (26.0)	70 (11.1)	
3	11 (15.1)	176 (28.0)	
4	26 (35.6)	208 (33.1)	

≥ 5	14 (19.2)	163 (26.0)	
Employment			0.380
Full time	44 (60.3)	393 (62.2)	
Part-time	15 (20.5)	93 (14.7)	
Unemployed	14 (19.2)	146 (23.1)	
Race			0.815
White	57 (79.2)	498 (79.2)	
Black/African American	8 (11.1)	81 (12.9)	
Other[a]/Multiracial	7 (9.7)	50 (7.9)	
Hispanic/Latino/Spanish Origin			0.933
Yes	6 (8.3)	54 (8.6)	
No	66 (91.7)	572 (91.4)	
Health Insurance			0.122
Government funding	6 (8.2)	62 (9.9)	
Insured through employer	49 (67.1)	478 (76.1)	
Private insurance	16 (21.9)	78 (12.4)	
Uninsured	2 (2.7)	10 (1.6)	
Household Annual Income			0.340
< $20,000	3 (4.2)	14 (2.3)	
$20,000-$49,999	5 (7.0)	28 (4.7)	
$50,000-$99,999	19 (26.8)	128 (21.3)	
≥ $100,000	44 (62.0)	431 (71.7)	
Number of Children			< 0.001
None	29 (39.7)	115 (18.2)	
1	13 (17.8)	169 (26.7)	
2	21 (28.8)	218 (34.5)	
3	6 (8.2)	89 (14.1)	
≥ 4	4 (5.5)	41 (6.5)	

Recipient of Food Assistance Program			0.276
Yes	11 (15.1)	129 (20.4)	
No	62 (84.9)	502 (79.6)	

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 12 Awareness of CDC Recommendation on Raw/Unpasteurized Animal Milk Feeding by Participant Characteristics

	CDC Recommends Feeding Raw/Unpasteurized Animal Milk	CDC Does Not Recommend Feeding Raw/Unpasteurized Animal Milk	P-value
Age			0.745
18-20	0 (0.0)	6 (0.8)	
21-29	2 (40.0)	143 (20.2)	
30-39	2 (40.0)	354 (50.1)	
40-49	1 (20.0)	204 (28.9)	
Marital Status			0.693
Married/Cohabiting	4 (80.0)	609 (86.1)	
Single	1 (20.0)	98 (13.9)	
Education			< 0.001
≤ HS/GED	1 (20.0)	15 (2.1)	
Some college/Technical training	4 (80.0)	101 (14.3)	
College graduate	0 (0.0)	313 (44.3)	
≥ Graduate school	0 (0.0)	278 (39.3)	
Geographical Region			0.658
Northeast	0 (0.0)	78 (11.0)	
South	4 (80.0)	464 (65.7)	
Midwest	1 (20.0)	81 (11.5)	
West	0 (0.0)	83 (11.8)	

Household Size			0.041
1	0 (0.0)	14 (2.0)	
2	0 (0.0)	91 (12.9)	
3	0 (0.0)	187 (26.6)	
4	5 (100.0)	233 (33.1)	
≥ 5	0 (0.0)	178 (25.3)	
Employment			0.006
Full time	0 (0.0)	440 (62.2)	
Part-time	3 (60.0)	108 (15.3)	
Unemployed	2 (40.0)	159 (22.5)	
Race			0.005
White	1 (25.0)	560 (79.5)	
Black/African American	1 (25.0)	88 (12.5)	
Other[a]/Multiracial	2 (50.0)	56 (8.0)	
Hispanic/Latino/Spanish Origin			0.011
Yes	2 (40.0)	58 (8.3)	
No	3 (60.0)	642 (91.7)	
Health Insurance			0.002
Government funding	3 (60.0)	66 (9.4)	
Insured through employer	1 (20.0)	530 (75.4)	
Private insurance	1 (20.0)	93 (13.2)	
Uninsured	0 (0.0)	14 (2.0)	
Household Annual Income			0.035
< $20,000	1 (25.0)	16 (2.4)	
$20,000-$49,999	0 (0.0)	34 (5.0)	
$50,000-$99,999	1 (25.0)	147 (21.8)	
≥ $100,000	2 (50.0)	477 (70.8)	
Number of Children			0.731

None	1 (20.0)	145 (20.5)	
1	1 (20.0)	181 (25.6)	
2	3 (60.0)	241 (34.1)	
3	0 (0.0)	95 (13.4)	
≥ 4	0 (0.0)	45 (6.4)	
Recipient of Food Assistance Program			0.261
Yes	2 (40.0)	140 (19.8)	
No	3 (60.0)	566 (80.2)	

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 13 Awareness of When Cow's Milk is Recommends by Participant Characteristics

	< 1 Year Old	1 Year Old	> 1 Year Old	Unsure/Other[a]	P-value
Age					< 0.001
18-20	1 (2.7)	3 (0.5)	2 (3.8)	0 (0.0)	
21-29	10 (27.0)	99 (17.0)	24 (45.3)	9 (26.5)	
30-39	19 (51.4)	305 (52.5)	17 (32.1)	10 (29.4)	
40-49	7 (18.9)	174 (29.9)	10 (18.9)	15 (44.1)	
Marital Status					< 0.001
Married/Cohabiting	32 (86.5)	518 (89.2)	28 (52.8)	31 (91.2)	
Single	5 (13.5)	63 (10.8)	25 (47.2)	3 (8.8)	
Education					0.915
≤ HS/GED	1 (2.7)	13 (2.2)	1 (1.9)	1 (2.9)	
Some college/Technical training	3 (8.1)	84 (14.5)	10 (18.9)	7 (20.6)	
College graduate	15 (40.5)	256 (44.1)	23 (43.4)	14 (41.2)	
≥ Graduate school	18 (48.6)	228 (39.2)	19 (35.8)	12 (35.3)	
Geographical Region					0.122
Northeast	8 (21.6)	61 (10.5)	5 (9.4)	2 (5.9)	

South Midwest West	19 (51.4) 7 (18.9) 3 (8.1)	389 (67.1) 63 (10.9) 67 (11.6)	39 (73.6) 5 (9.4) 4 (7.5)	19 (55.9) 6 (17.6) 7 (20.6)	
Household Size 1 2 3 4 ≥ 5	 0 (0.0) 5 (13.5) 8 (21.6) 16 (43.2) 8 (21.6)	 10 (1.7) 55 (9.5) 161 (27.9) 202 (34.9) 150 (26.0)	 4 (7.7) 18 (34.6) 10 (19.2) 13 (25.0) 7 (13.5)	 0 (0.0) 10 (29.4) 5 (14.7) 6 (17.6) 13 (38.2)	< 0.001
Employment Full time Part-time Unemployed	 24 (64.9) 6 (16.2) 7 (18.9)	 355 (61.1) 91 (15.7) 135 (23.2)	 36 (67.9) 8 (15.1) 9 (17.0)	 20 (58.8) 6 (17.6) 8 (23.5)	0.949
Race White Black/African American Other[b]/Multiracial	 31 (86.1) 3 (8.3) 2 (5.6)	 465 (80.4) 74 (12.8) 39 (6.7)	 33 (62.3) 5 (9.4) 15 (28.3)	 25 (73.5) 7 (20.6) 2 (5.9)	< 0.001
Hispanic/Latino/Spanish Origin Yes No	 3 (8.1) 34 (91.9)	 48 (8.3) 527 (91.7)	 8 (15.1) 45 (84.9)	 2 (6.1) 31 (93.9)	0.375
Health Insurance Government funding Insured through employer Private insurance Uninsured	 3 (8.1) 32 (86.5) 1 (2.7) 1 (2.7)	 60 (10.4) 436 (75.4) 74 (12.8) 8 (1.4)	 2 (3.8) 37 (71.2) 12 (23.1) 1 (1.9)	 4 (11.8) 20 (58.8) 7 (20.6) 3 (8.8)	0.008
Household Annual Income < $20,000 $20,000-$49,999	 0 (0.0) 3 (8.6)	 14 (2.5) 23 (4.1)	 2 (4.2) 4 (8.3)	 1 (3.3) 4 (13.3)	0.194

$50,000-$99,999 ≥ $100,000	10 (28.6) 22 (62.9)	115 (20.6) 405 (72.7)	10 (20.8) 32 (66.7)	9 (30.0) 16 (53.3)	
Number of Children None 1 2 3 ≥ 4	 9 (24.3) 9 (24.3) 14 (37.8) 3 (8.1) 2 (5.4)	 84 (14.5) 163 (28.1) 215 (37.0) 79 (13.6) 40 (6.9)	 35 (66.0) 6 (11.3) 7 (13.2) 5 (9.4) 0 (0.0)	 14 (41.2) 4 (11.8) 6 (17.6) 8 (23.5) 2 (5.9)	< 0.001
Recipient of Food Assistance Program Yes No	 5 (13.5) 32 (86.5)	 125 (21.6) 455 (78.4)	 4 (7.5) 49 (92.5)	 8 (23.5) 26 (76.5)	0.66

[a]Other includes, "never," "when they are old enough to eat solids," "when you finish breastfeeding,"
[b]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 14 Opinion on the Appropriateness of Different Cow's Milk by Participant Characteristics

	Whole Cow's Milk is More Appropriate for Children >12 Months Old	Lower Fat Cow's Milk is More Appropriate for Children >12 Months Old	P-value
Age 18-20 21-29 30-39 40-49	 6 (0.9) 121 (18.4) 338 (51.4) 193 (29.3)	 0 (0.0) 24 (44.4) 14 (25.9) 16 (29.6)	< 0.001
Marital Status Married/Cohabiting Single	 575 (87.4) 83 (12.6)	 37 (68.5) 17 (31.5)	< 0.001
Education			0.274

≤ HS/GED Some college/Technical training College graduate ≥ Graduate school	15 (2.3) 92 (14.0) 286 (43.5) 265 (40.3)	1 (1.9) 12 (22.2) 25 (46.3) 16 (29.6)	
Geographical Region Northeast South Midwest West	 70 (10.7) 441 (67.1) 75 (11.4) 71 (10.8)	 7 (13.0) 31 (57.4) 6 (11.1) 10 (18.5)	0.313
Household Size 1 2 3 4 ≥ 5	 15 (2.3) 77 (11.8) 173 (26.5) 224 (34.3) 165 (25.2)	 0 (0.0) 15 (27.8) 14 (25.9) 15 (27.8) 10 (18.5)	0.013
Employment Full time Part-time Unemployed	 408 (62.0) 102 (15.5) 148 (22.5)	 35 (64.8) 8 (14.8) 11 (20.4)	0.914
Race White Black/African American Other[a]/Multiracial	 531 (81.1) 71 (10.8) 53 (8.1)	 31 (57.4) 16 (29.6) 7 (13.0)	< 0.001
Hispanic/Latino/Spanish Origin Yes No	 50 (7.7) 601 (92.3)	 9 (16.7) 45 (83.3)	0.022
Health Insurance Government funding	 57 (8.7)	 11 (20.4)	0.049

Insured through employer Private insurance Uninsured	496 (75.8) 88 (13.5) 13 (2.0)	35 (64.8) 7 (13.0) 1 (1.9)	
Household Annual Income < $20,000 $20,000-$49,999 $50,000-$99,999 ≥ $100,000	 13 (2.1) 30 (4.8) 131 (20.9) 454 (72.3)	 4 (8.2) 4 (8.2) 17 (34.7) 24 (49.0)	0.002
Number of Children None 1 2 3 ≥ 4	 124 (18.8) 171 (26.0) 235 (35.7) 86 (13.1) 42 (6.4)	 25 (46.3) 11 (20.4) 9 (16.7) 7 (13.0) 2 (3.7)	< 0.001
Recipient of Food Assistance Program Yes No	 125 (19.0) 532 (81.0)	 17 (31.5) 37 (68.5)	0.028

[a]Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander

Table 15 Multivariate Logistic Regression Model for Sociodemographic Predictors of Knowledge on Recommended Age for Introducing Cow's Milk to Infants

	n	Odds Ratio	95% C.I.	p-value
Marital Status Married/cohabiting Single	 581 85	 1.00 4.49	 1.56, 12.94	 0.005
Geographical Region Northeast	 70	 1.00		

South Midwest West	442 76 78	2.04 0.81 1.51	0.90, 4.59 0.31, 2.13 0.53, 4.29	0.087 0.674 0.436
Student				
Yes	70	1.00		
No	596	2.02	0.90, 4.55	0.091
Health Insurance				
Government funding	63	1.00		
Insured through employer	506	0.78	0.28, 2.17	0.634
Private insurance	85	1.04	0.31, 3.52	0.948
Uninsured	12	0.13	0.03, 0.64	0.012
Household Annual Income				
< $20,000	17	1.00		
$20,000-49,999	34	0.15	0.01, 1.54	0.109
$50,000-99,999	141	0.35	0.04, 3.26	0.355
> $100,000	474	0.70	0.07, 6.65	0.755
How Many Children				
None	131	1.00		
1	171	3.06	1.30, 7.20	0.011
2	230	2.24	1.03, 4.89	0.042
3	90	1.48	0.61, 3.60	0.384
4 or more	44	2.71	0.78, 9.45	0.118

Adjusted for age of participant
Hosmer-Lemeshow Test chi-square 3.27, p-value 0.916

3.4 Discussion

This study explored knowledge of infant feeding recommendations and perceptions of breastfeeding, awareness of breastfeeding legislation, and knowledge and use of animal milk as breast milk or infant formula alternative among women of childbearing age. Our sample included women who were majority 30-39 years old, married, White, non-Hispanic, college educated, resided in the South, lived in four person households in one family detached houses, homeowners, worked full time, not students, insured through employer, earning over $100,000 annually, food secure, and mothers of 2 children. While our target population was childbearing age women in the U.S., our sample differs from national averages in some areas. In 2023, 34.5% of childbearing age women were 30-39 years old.[48] However, this source defines childbearing age as 15-44 years old. In 2022, roughly 46% of women were married.[49] In 2024, 75% of U.S. women were White.[50] Additionally, 39% of U.S. women completed four years of college or more in 2022.[51] In 2023, the average number of people per household in the U.S. was 2.5.[52] Roughly 66% of the U.S. population owned their home in 2024, and 66% of women were employed full time in 2022.[53, 54] In 2023, 41% of U.S. households were making > $100,000 annually and 87% were food secure.[55, 56] As of 2014, 41% of mothers aged 40-44 had 2 children.[56] Our sample population compared to the target population overrepresented women who were 30-39 years old, married, highly educated, came from a household with more members, owned their home, and had higher household incomes. This difference shows that our sample may include more socioeconomically advantaged women, which could limit generalizability to a more diverse group of women in the U.S.

The results suggest that while a majority of the participants were aware of exclusive breastfeeding recommendation for the first six months of life, no significant associations were observed between sociodemographic factors and awareness of this recommendation. However, other aspects of breastfeeding knowledge, like the necessity of water and nutrient supplements during exclusive breastfeeding, did show significant associations with age, marital status, and race. Additionally, awareness of breastfeeding legislation varied, with higher awareness among married/cohabiting participants, those with full-time employment, and higher income. Although two or more animal milks (cow, goat, sheep, camel, or buffalo milk) were the types of animal milk reported as appropriate for infant feeding, most participants were unsure of the reason and recommendation to feed animal milk to infants. Significant associations existed between understanding the appropriateness of animal milk and sociodemographic factors like marital status ($p < 0.001$) and race ($p < 0.001$).

The results suggest that knowledge of breastfeeding recommendation is not consistent across women of childbearing age who participated in this study. These trends in the results provide insight into potential disparities. For example, being younger, non-white, and lower income, was associated with less awareness of breastfeeding recommendation. A recent study found that older, non-black women with higher levels of education and income were more likely to intend to breastfeed.[39] Although this study by Baumgartner et al. (2022) did not look at awareness of breastfeeding recommendations, it is known that women who are more aware of breastfeeding recommendations are more likely to intend to breastfeed their child.[39] This highlights potential disparities in access and exposure to reliable information, which could be due to differences in educational exposure, healthcare access, and cultural beliefs surrounding infant feeding practices.[38-40] Awareness of the recommendation for exclusive breastfeeding duration was higher among older participants compared to their younger counterparts. This trend highlights a potential correlation between age and awareness of breastfeeding recommendations. However, there was a lack of significant associations between other sociodemographic characteristics and awareness of exclusive breastfeeding duration, which indicates that general knowledge of the six-month recommendation is widely known. Nevertheless, deeper gaps exist in understanding the nuances of infant feeding practices, such as supplementation with water or additional nutrients during exclusive breastfeeding. Most participants (80.9%) correctly reported the recommendation on the timing of introducing extra water during exclusive breastfeeding. Similarly, the majority of participants (69.5%) correctly knew the recommendation for the use of extra nutrient supplements for exclusively breastfeeding infants less than six months old. Knowledge of the recommendation for the introduction of water and nutrient supplements during exclusive breastfeeding was significantly associated with participant age, marital status, household size, race, and number of children. An article by Newhook et al. (2017) found that being unmarried was a key determinant among mothers that had a higher likelihood to stop breastfeeding after one month.[41] Similarly, another study done in Kenya showed that if fathers and grandmothers increase their knowledge of infant feeding and are encouraged to provide social support for the mother, infant feeding practices are more likely to improve.[57] These associations show the importance of demographic characteristic of women of childbearing age and their awareness of appropriate infant feeding practices.

A key finding from the current study is the significant association between income and awareness of breastfeeding laws. Higher-income participants reported more aware of their rights as required under both state and federal breastfeeding legislation, potentially reflecting their access to breastfeeding programs and resources, employer accommodation, and better workplace environments. Conversely, lower-income participants may not have the same access to breastfeeding knowledge and resources, and may have issues with job insecurity, emphasizing the need for policy initiatives to fill this gap in awareness of breastfeeding laws.[40, 41, 58] The US Department of Labor released a report acknowledging lower income workers are less likely to have knowledge of their workplace rights than higher income workers.[58] Previous research also acknowledges that lower income women have less access to breastfeeding support and education, face greater childcare workload, and experience cultural shame for breastfeeding in public.[59] Lower wage jobs often provide little to no lactation support for mothers, however, higher wage jobs often provide lactating women with an abundant of resources and support.[58] This disparity is observed in this study. These burdens make it even more difficult for a woman to successfully breastfeed her child for the recommended duration. Marital status was another demographic factor significantly associated with awareness of breastfeeding laws in the United States. As mentioned previously, marital status plays a crucial role in infant feeding and infant health. Additionally, Figure 2 illustrates the correct response rates to various questions related to breastfeeding laws and recommendations. Most participants correctly reported that a bathroom cannot be the designated room to pump breast milk, however, only 18% of participants were aware of the legislation on paid break time to pump at work. These findings highlight areas where there may be a lack of understanding and underscores the importance of awareness in promoting breastfeeding practices that comply with established laws and recommendations. Moreover, there was a strong association between employment status and awareness of breastfeeding laws. One study found that women who were employed, specifically employed full-time, were more likely to follow breastfeeding recommendation compared to unemployed women.[38] This association suggests that strengthening workplace lactation policies and expanding outreach efforts could improve compliance and provide additional support for working breastfeeding mothers. Investing more effort into employer education on breastfeeding rights/laws could address these disparities by ensuring all employees, regardless of income or job type, are aware of their legal protections and rights. Increasing employer education and support could lead to better workplace environments for new mothers, ultimately contributing to higher breastfeeding rates and reducing barriers for working mothers.

There were disparities in awareness of the appropriate use of animal milk in infant feeding among the sociodemographic groups; however, participants from households with more members and have children were more likely to be aware of the recommendations on animal milk alternatives. Most participants thought two or more animal milks (cow, goat, sheep, camel, or buffalo milk) were appropriate for infants less than 12 months old, however, they gave various reasons for feeding animal milk to infants. Previous literature also observed that first-time parents had less awareness of breastfeeding recommendation.[57] This highlights the importance of educating caregivers and first-time parents on safer infant feeding alternatives, as CDC guidelines recommend that infants under 12 months should not consume animal milk due to potential health risks.[8] Misinformation about infant feeding practices poses public health risks. Addressing these misconceptions through targeted education could help ensure that first-time parents make informed infant feeding decisions based on evidence-based guidelines and recommendations.

The association between marital status and breastfeeding knowledge has been reported in the literature, indicating that social support plays a critical role in infant feeding practices and decisions.[39, 59] Married or cohabiting women's awareness of breastfeeding recommendations and laws, could be attributed to shared decision-making and support from partners or family.

Conversely, single parents or parents without support may experience greater challenges in accessing maternal resources or social reinforcement that support breastfeeding. This calls attention to an area where community-based breastfeeding support interventions could be valuable.

Findings from the current study support existing literature while also providing new insights into the relationship between sociodemographic characteristics and infant feeding knowledge. Existing literature report on the relationship between higher socioeconomic status and greater access to healthcare, maternal education, and social support.[35, 36, 38] However, this study provides new insights into gaps in awareness related to the appropriateness of animal milk in infant feeding, emphasizing the need for tailored public health education campaigns.

While the findings are consistent with existing literature on breastfeeding knowledge disparities, they also suggest that general breastfeeding recommendations are more widely understood. There was a lack of significant association between knowledge of the recommended duration for exclusive breastfeeding with sociodemographic characteristics. This suggests that awareness of this recommendation is more widely known than previously thought. However, this finding should be interpreted with caution due to the characteristics of participants in the current study. Nevertheless, we observed significant associations between sociodemographic characteristics and knowledge of breastfeeding laws and alternative feeding practices among women of childbearing age. Targeted interventions are needed to address the knowledge gap in this area of infant feeding.

These findings emphasize the need for improved workplace policies that support breastfeeding mothers, especially those of lower income. Employers should be equipped with the knowledge of breastfeeding rights and motivation to encourage mothers to feel comfortable pumping in the workplace. Employers should also be aware of public health initiatives that aim to bridge the knowledge gap among lower-income and single mothers. Moreover, healthcare professionals and health educators should focus on targeted maternal education campaigns that address misconceptions about infant feeding practices, ensuring that parents receive reliable and accessible information.

Data for this study was self-reported, therefore there was potential for a number of biases, including recall, information and social desirability bias, to be present. Additionally, our sample mainly consisted of women of higher socioeconomic status, which may limit the generalizability to the general women of childbearing age across the United States. Although this study was intended to be a nationwide survey, respondents were skewed more toward southern United States suggesting selection bias.

Future research should target a more diverse and representative sample of the population to assess whether the trends observed in this study are the same for a different population. Conducting longitudinal studies could better capture changes in infant feeding knowledge over time. Additionally, interviews with parents could provide more in-depth, qualitative reasoning as to why certain groups have lower awareness of infant feeding recommendations and breastfeeding legislation. Public health initiatives should focus on improving awareness of breastfeeding rights in the workplace and within communities and enhancing education on safe infant feeding practices. Lastly, targeted interventions for young, single mothers and those with lower incomes may help fill the knowledge gap and improve breastfeeding awareness among women of childbearing age in the United States. This could be done by incorporating breastfeeding rights and laws into prenatal education offered by WIC, obstetricians, Cooperative Extension, and other community-based programs/resources. Implementing comprehensive breastfeeding education in existing community resources can increase access to accurate breastfeeding information among women of childbearing age. WIC clinics could expand existing prenatal and postnatal nutrition education to include breastfeeding recommendations and legal rights. Obstetricians who implement breastfeeding education into their care could reach additional women who may not receive these other resources. Additionally, Cooperative Extension could spread breastfeeding education to women in rural and underserved areas that may not be able to access this education any other way. By reaching these women through various existing avenues will help inform a broader range and more diverse group of women about their breastfeeding rights and safe infant feeding practices.

3.5 Conclusion

This study highlights disparities in infant feeding knowledge and awareness of breastfeeding legislation among women of childbearing age in the U.S. Participant income, employment, and marital status were associated with knowledge of breastfeeding recommendations and awareness of breastfeeding legislation. Lower-income and single women of childbearing age showed less awareness of breastfeeding recommendations and laws, which may explain the lower breastfeeding rates among these women reported in the literature. Women from households with more members and those who have children were more likely to be aware of recommendations for use of animal milk as alternatives in infant feeding. This may highlight the prevalence of misinformation about the appropriateness of animal milk in infant feeding. These findings underscore the need for targeted interventions, through healthcare, community, and federal programs. Increasing employer knowledge and strengthening workplace policies would help create a supportive environment for new mothers, guaranteeing them proper space and time to pump at work.

References

1.Meek JY, Noble L. Policy Statement: Breastfeeding and the Use of Human Milk. *Pediatrics*. 2022;150(1). doi:https://doi.org/10.1542/peds.2022-057988

2.World Health Organization. Breastfeeding. World Health Organization. Published 2021. https://www.who.int/health-topics/breastfeeding#tab=tab_2

3.Centers for Disease Control and Prevention. Results: Breastfeeding Rates . cdc.gov. Published 2019. https://www.cdc.gov/breastfeeding/data/nis_data/results.html

4.Pietrzak-Fiećko R, Kamelska-Sadowska AM. The Comparison of Nutritional Value of Human Milk with Other Mammals' Milk. *Nutrients*. 2020;12(5):1404. doi:https://doi.org/10.3390/nu12051404

5.Victora CG, Bahl R, Barros AJD, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and Lifelong Effect. *The Lancet*. 2016;387(10017):475-490. doi:https://doi.org/10.1016/s0140-6736(15)01024-7

6.Bachrach VRG, Schwarz E, Bachrach LR. Breastfeeding and the Risk of Hospitalization for Respiratory Disease in Infancy. *Archives of Pediatrics & Adolescent Medicine*. 2003;157(3):237. doi:https://doi.org/10.1001/archpedi.157.3.237

7.McCarthy C. Breastfeeding Benefits Your Baby's Immune System. HealthyChildren.org. Published 2020. https://www.healthychildren.org/English/ages-stages/baby/breastfeeding/Pages/Breastfeeding-Benefits-Your-Babys-Immune-System.aspx

8.CDC. About Breastfeeding. Breastfeeding. Published May 2, 2024. https://www.cdc.gov/breastfeeding/php/about/index.html

9.Garwolińska D, Namieśnik J, Kot-Wasik A, Hewelt-Belka W. Chemistry of Human Breast Milk—A Comprehensive Review of the Composition and Role of Milk Metabolites in Child Development. *Journal of Agricultural and Food Chemistry*. 2018;66(45):11881-11896. doi:https://doi.org/10.1021/acs.jafc.8b04031

10.Kim SY, Yi DY. Components of Human Breast milk: from Macronutrient to Microbiome and microRNA. *Clinical and Experimental Pediatrics*. 2020;63(8):301-309. doi:https://doi.org/10.3345/cep.2020.00059

11.American Pregnancy Association. What's In Breast Milk? American Pregnancy Association. Published April 25, 2012. https://americanpregnancy.org/healthy-pregnancy/first-year-of-life/whats-in-breastmilk/

12.Ballard O, Morrow AL. Human Milk Composition: Nutrients and Bioactive Factors. *Pediatric Clinics of North America*. 2013;60(1):49-74. doi:https://doi.org/10.1016/j.pcl.2012.10.002

13.Boersma S, Cozzella T. *How the Breast Works*. https://breastfeedingresourcesontario.ca/sites/default/files/pdf/BFI_How_the_Breast_Works_web.pdf

14.Pillay J, Davis TJ. Physiology, Lactation. PubMed. Published 2021. https://www.ncbi.nlm.nih.gov/books/NBK499981/#:~:text=Lactogenesis%20is%20the%20process%20of

15.Plamada D, Vodnar DC. Polyphenols—Gut Microbiota Interrelationship: A Transition to a New Generation of Prebiotics. *Nutrients*. 2022;14(1):137. doi:https://doi.org/10.3390/nu14010137

16.National Institutes of Health. Are there any special conditions or situations in which I should not breastfeed? http://www.nichd.nih.gov/. Published January 31, 2017. https://www.nichd.nih.gov/health/topics/breastfeeding/conditioninfo/special-conditions

17.Institute of Medicine (US) Committee on the Evaluation of the Addition of Ingredients New to Infant Formula. Comparing Infant Formulas with Human Milk. Nih.gov. Published 2004. https://www.ncbi.nlm.nih.gov/books/NBK215837/

18.Roy D, Ye A, Moughan PJ, Singh H. Composition, Structure, and Digestive Dynamics of Milk From Different Species—A Review. *Frontiers in Nutrition*. 2020;7. doi:https://doi.org/10.3389/fnut.2020.577759

19.Thakore V, Jain N. Protein and fat examination from the raw milk of different mammalian species (Cow, buffalo, goat, and human) with successive lactation days. ~ *506 ~ The Pharma Innovation Journal*. 2018;7(10):506-510. https://www.thepharmajournal.com/archives/2018/vol7issue10/PartI/7-10-57-423.pdf

20.Claeys WL, Verraes C, Cardoen S, et al. Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. *Food Control*. 2014;42:188-201. doi:https://doi.org/10.1016/j.foodcont.2014.01.045

21.FAO. Dairy production and products: Milk composition. www.fao.org. https://www.fao.org/dairy-production-products/products/milk-composition/en/

22.Lad S, Aparnathi KD, Mehta B, Velpula S. Goat Milk in Human Nutrition and Health – A Review . International Journal of Current Microbiology and Applied Sciences. Published April 17, 2017. Accessed September 23, 2024. https://www.ijcmas.com/6-5-2017/Sachin%20S.%20Lad,%20et%20al.pdf

23.Kalyankar SD, Sarode AR, Khedkar CD, Deosarkar SS, Pawshe RD. Sheep: Milk. Science Direct. Published September 22, 2015. https://www.sciencedirect.com/science/article/abs/pii/B9780123849472006218

24.Flis Z, Molik E. Importance of Bioactive Substances in Sheep's Milk in Human Health. *International Journal of Molecular Sciences*. 2021;22(9):4364. doi:https://doi.org/10.3390/ijms22094364

25.Puertas-Bartolomé M, Włodarczyk-Biegun MK, Campo A del, Vázquez-Lasa B, San Román J. Development of bioactive catechol functionalized nanoparticles applicable for 3D bioprinting. Science Direct. Published October 2021. https://www.sciencedirect.com/science/article/pii/S092849312100655X

26.Lim DY, Shin SH, Lee MH, et al. A natural small molecule, catechol, induces c-Myc degradation by directly targeting ERK2 in lung cancer. *Oncotarget*. 2016;7(23):35001-35014. doi:https://doi.org/10.18632/oncotarget.9223

27.Hu J, Wang Z, Miszuk JM, et al. Vanillin-bioglass cross-linked 3D porous chitosan scaffolds with strong osteopromotive and antibacterial abilities for bone tissue engineering. *Carbohydrate Polymers*. 2021;271:118440. doi:https://doi.org/10.1016/j.carbpol.2021.118440

28.Zduńska K, Dana A, Kolodziejczak A, Rotsztejn H. Antioxidant Properties of Ferulic Acid and Its Possible Application. *Skin Pharmacology and Physiology*. 2018;31(6):332-336. doi:https://doi.org/10.1159/000491755

29.Ding Y, Fan B, Zhu C, Chen Z. Shared and Related Molecular Targets and Actions of Salicylic Acid in Plants and Humans. *Cells*. 2023;12(2):219. doi:https://doi.org/10.3390/cells12020219

30.Swelum AA, El-Saadony MT, Abdo M, et al. Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. *Saudi Journal of Biological Sciences*. Published online February 2021. doi:https://doi.org/10.1016/j.sjbs.2021.02.057

31.Zhao D, Bai Y, Niu Y. Composition and characteristics of Chinese Bactrian camel milk. Science Direct. Published April 2015. https://www.sciencedirect.com/science/article/pii/S0921448815001595?casa_token=-0Ucdel3_VkAAAAA:nTpbmdKR0peBR2DjGTL46pEFQ1SrfNAXmqnpoLQsL5J3R059SDNSpYCiFR8uEaEs1yeAEz2depE

32.AL-Ayadhi L, Halepoto DM. Chapter 30 - Camel Milk as a Potential Nutritional Therapy in Autism. ScienceDirect. Published January 1, 2017. https://www.sciencedirect.com/science/article/abs/pii/B9780128097625000309

33.Izadi A, Khedmat L, Yousef Mojtahedi S. Nutritional and therapeutic perspectives of camel milk and its protein hydrolysates: A review on versatile biofunctional properties. Science Direct. Published July 2019. https://www.sciencedirect.com/science/article/pii/S1756464619303652

34.Halima EH, Zeineb J, Imed S, Amel A, Amel N, Touhami K. Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. Research Gate. Published July 2015. https://www.researchgate.net/publication/280494239_Comparison_of_composition_and_whey_protein_fractions_of_human_camel_donkey_goat_and_cow_milk

35.American Psychological Association. Socioeconomic Status. *American Psychological Association*. https://www.apa.org/topics/socioeconomic-status. Published 2022.

36.CDC. Socioeconomic factors . Centers for Disease Control and Prevention. Published 2023. https://www.cdc.gov/dhdsp/health_equity/socioeconomic.htm

37.Vo CQ, Samuelsen PJ, Hilde Leikny Sommerseth, Torbjørn Wisløff, Wilsgaard T, Anne Elise Eggen. Comparing the sociodemographic characteristics of participants and non-participants in the population-based Tromsø Study. *BMC Public Health*. 2023;23(1). doi:https://doi.org/10.1186/s12889-023-15928-w

38.Magnano San Lio R, Maugeri A, La Rosa MC, et al. The Impact of Socio-Demographic Factors on Breastfeeding: Findings from the "Mamma & Bambino" Cohort. *Medicina*. 2021;57(2):103. doi:https://doi.org/10.3390/medicina57020103

39.Baumgartner T, Bhamidipalli SS, Guise D, et al. Psychosocial and Sociodemographic Contributors to Breastfeeding Intention in First-Time Mothers. *Maternal and Child Health Journal*. 2020;24(8):1047-1056. doi:https://doi.org/10.1007/s10995-020-02928-0

40.Chiang KV, Li R, Anstey EH, Perrine CG. Racial and Ethnic Disparities in Breastfeeding Initiation ─ United States, 2019. *MMWR Morbidity and Mortality Weekly Report*. 2021;70(21):769-774. doi:https://doi.org/10.15585/mmwr.mm7021a1

41.Temple Newhook J, Newhook LA, Midodzi WK, et al. Poverty and Breastfeeding: Comparing Determinants of Early Breastfeeding Cessation Incidence in Socioeconomically Marginalized and Privileged Populations in the FiNaL Study. *Health Equity*. 2017;1(1):96-102. doi:https://doi.org/10.1089/heq.2016.0028

42.Molassiotis A, Russell W, Hughes J, et al. *Study Scales: Sociodemographic Characteristics Questionnaire*. NIHR Journals Library; 2013. https://www.ncbi.nlm.nih.gov/books/NBK260709/

43.CDC. Infant Feeding Practices Study (IFPS) II. Breastfeeding Data. Published October 29, 2024. Accessed January 15, 2025. https://www.cdc.gov/breastfeeding-data/studies/questionnaires.html

44.American Academy of Family Physicians . *Social Needs Screening Tool PROVIDER FORM (Short Version)*.; 2018. https://www.aafp.org/dam/AAFP/documents/patient_care/everyone_project/provider-short-print.pdf

45.Story M, Holt K, Sofka D. *NUTRITION QUESTIONNAIRE for INFANTS*.; 2002. https://depts.washington.edu/pwdlearn/firststeps/pdfs/6nutrquestionnaire.pdf

46.UNICEF, WHO. Questionnaire for Breastfeeding Mother. Google.com. Published 2009. Accessed January 15, 2025. https://www.google.com/url?q=https://www.ncbi.nlm.nih.gov/books/nbk153494/bin/sec4_section4.2-fm8.pdf&sa=D&source=docs&ust=1736972493555799&usg=AOvVaw0YrV-Pl28z6bZx8xovZaZy

47.USDA. Food Security in the U.S. - Survey Tools | Economic Research Service. Usda.gov. Published 2025. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools

48.US Census Bureau. Population of women 15-44 years by age: United States, 2020. March of Dimes | PeriStats. Published 2023. https://www.marchofdimes.org/peristats/data?reg=99&top=14&stop=125&slev=1&obj=3

49.Loo J. Marriage: More than a Century of Change, 1900-2022. Bowling Green State University. Published 2022. https://www.bgsu.edu/ncfmr/resources/data/family-profiles/FP-24-10.html

50.United States Census Bureau. QuickFacts: United States. Census Bureau QuickFacts. Published July 1, 2024. https://www.census.gov/quickfacts/fact/table/US/PST045224

51.Duffin E. Americans with a college degree 1940-2017, by gender | Statista. Statista. Published July 27, 2022. https://www.statista.com/statistics/184272/educational-attainment-of-college-diploma-or-higher-by-gender/

52.Korhonen V. Average size of households in the U.S. 1960-2018 | Statistic. Statista. Published 2018. https://www.statista.com/statistics/183648/average-size-of-households-in-the-us/

53.U.S. Census Bureau. U.S. homeownership rate 1990-2018 | Statista. Statista. Published 2018. https://www.statista.com/statistics/184902/homeownership-rate-in-the-us-since-2003/

54.Bureau of Labor Statistics, U.S. Department of Labor,. The share of workers who worked full time, year round rose to 71.0 percent in 2022 : The Economics Daily: U.S. Bureau of Labor Statistics. Bureau of Labor Statistics. Published 2022. https://www.bls.gov/opub/ted/2024/the-share-of-workers-who-worked-full-time-year-round-rose-to-71-0-percent-in-2022.htm

55.US Census Bureau. U.S. Household Income Distribution. Statista. Published September 16, 2024. https://www.statista.com/statistics/203183/percentage-distribution-of-household-income-in-the-us/

56.United States Department of Agriculture. Food security in the U.S. - Key statistics & graphics. USDA.gov. Published January 8, 2025. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics

57. Mukuria AG, Martin SL, Egondi T, Bingham A, Thuita FM. Role of Social Support in Improving Infant Feeding Practices in Western Kenya: A Quasi-Experimental Study. *Global Health: Science and Practice*. 2016;4(1):55-72. doi:https://doi.org/10.9745/ghsp-d-15-00197

58.U.S. Department of Labor. Understanding Attitudes on Paid Family Leave: Discussions with Parents and Caregivers in California, New Jersey and Rhode Island Final Report. DOL. Published 2016. Accessed April 6, 2025. https://www.dol.gov/resource-library/understanding-attitudes-paid-family-leave-discussions-parents-and-caregivers

59.Newhook JT, Ludlow V, Newhook LA, Bonia K, Goodridge JM, Twells L. Infant-Feeding among Low-Income Women: The Social Context that Shapes their Perspectives and Experiences. *Canadian Journal of Nursing Research*. 2013;45(3):28-49. doi:https://doi.org/10.1177/084456211304500303

CHAPTER 4

CONCLUSION

This study aimed to examine infant feeding knowledge, breastfeeding laws and legislation awareness, and perceptions of animal milk as breast milk and infant formula alternative. The results of this study show the association of sociodemographic characteristics with breastfeeding knowledge and legislation among childbearing age women in the U.S. Disparities were noticed in breastfeeding knowledge across different sociodemographic groups. While most participants knew the general recommendation to exclusively breastfeed for six months, understanding specific infant feeding recommendations, such as the necessity of water and nutrient supplements during exclusive breastfeeding, varied based on factors like age, marital status, household members, race, and number of children. Awareness of breastfeeding laws was associated with higher income and full-time employment. Lower-income individuals may have limited access to workplace accommodations and breastfeeding resources. Additionally, misinformation was prevalent surrounding the appropriateness of animal milk in infant feeding practices. Most participants reported multiple types of animal milk to be appropriate for infants under 12 months old contradicting general CDC guidelines, however, they were unsure of the rationale for doing so. These findings prove that there is a need for targeted maternal education campaigns that address lack of knowledge and misconceptions about infant feeding practices to ensure that parents receive reliable and accessible information.

Our findings show that there are gaps in knowledge of breastfeeding laws and awareness. These gaps highlight disparities in access to maternal resources, especially among lower-income and single women. Our findings suggest that these populations have a lack of awareness of recommendations and therefore may contribute to lower breastfeeding rates in the U.S. As mentioned, targeted interventions are needed for these underserved populations to increase accurate knowledge of infant feeding practices and women's rights when it comes to breastfeeding. This could take the form of implementing education programs through healthcare providers, community organizations, and federal assistance programs. This would fill the knowledge gap and promote healthier infant feeding practices. Additionally, employers play an impactful role in breastfeeding rates and success. Increasing employer knowledge and strengthening workplace policies would help create a supportive environment for new mothers, guaranteeing them proper space and time to pump at work. Increasing supportive workplace environments would ultimately improve breastfeeding rates and maternal well-being. While this study underscores disparities in knowledge of infant feeding recommendations and breastfeeding laws awareness, some limitations should be considered. These include reliance on self-reported data and higher socioeconomic status participants who are predominantly White. Future research should target a more diverse population including participants of lower socioeconomic and minority status to assess whether the trends observed in this study are the same for the general U.S. population.

The importance of addressing these knowledge gaps in infant feeding practices is to ensure that all mothers have reliable information and support needed to make healthier infant feeding decisions. Limited access to reliable infant feeding education and knowledge can lead to misconceptions, therefore lower breastfeeding rates and unhealthy infant feeding practices, especially among marginalized communities. By improving access to reliable information on infant feeding practices and increasing awareness of breastfeeding policies among employers, initiatives can effectively support mothers with the resources they need to successfully breastfeed. Maternal and infant health outcomes can improve with the implementation of targeted health initiatives and the widespread accurate, evidence-based information, whether that is through healthcare providers, community organizations, or federal assistance programs to women of childbearing age. Strengthening support systems and awareness of healthy infant feeding practices are critical steps toward increasing breastfeeding rates and reducing disparities among marginalized communities.