EXAMINING ENERGY INTAKE AND SELECT MACRONUTRIENTS AND
MICRONUTRIENTS OF FORMULA FED WIC INFANTS AS PER
RECOMMENDATIONS OF THE DIETARY GUIDELINES

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ABSTRACT OF THE THESIS

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The Special Supplemental Nutrition Program for Women Infants and Children (WIC) is designed to help offer nutrition education, nutrient dense foods, and improve access to regular health care to low and moderate-income pregnant, postpartum and breastfeeding women, and children under the age of 5. However, studies have shown that infants who are participants of the WIC program may be susceptible to rapid weight gain. Research also shows that a possible excess in macronutrients over time may lead to weight gain. The objective of this thesis was to examine and compare the total energy intake, and intake of macronutrients and micronutrients (vitamin A, vitamin D, calcium and iron) to the Dietary Guidelines for infants, to determine whether this sample was receiving an adequate amount of nutrients. Participants (n=96) were recruited through the Rutgers Infant and Nutrition and Growth (RING) Project in 2003 and consisted of African American (n=23) and Hispanic (n=73) mother–infant dyad. Dietary recalls for the infant were taken over the course of two days at 3, 6, and 12 months. The results showed that the infants had an adequate intake in most of the macronutrients, micronutrients and total caloric intake;
however, they showed that they were below the adequate intake of vitamin D. Since infancy is an important stage for nutrients needed for proper growth and development, further research should be done to make sure that formula fed infants who are a part of WIC are being provided with proper and adequate amounts of total calories, macronutrients, and micronutrients to improve their overall growth throughout infancy and early childhood.
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They say it takes a village, and I have never found this statement to be truer.

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CHAPTER ONE: INTRODUCTION

Exclusive breastfeeding is recommended by the Centers for Disease Control and Prevention (CDC), which urges mothers to exclusively breastfeed for the first six months, and the World Health Organization (WHO), which advises that infants be breastfed for the first 2 years along with the appropriate complementary foods (CDC, 2018). Many healthcare providers and researchers believe that “breast is best” for infants because breastfeeding is associated with decreased incidences of infectious morbidities, childhood obesity, type 1 diabetes, leukemia and sudden infant death syndrome (Oddy, 2002; Stuebe, 2009). Breastfeeding has also been noted to be beneficial for mothers by increasing chances of returning to pre-pregnancy weight, and is also associated with decreased risk of certain cancers and osteoporosis (Ogbuanu et al., 2009).

Although exclusive breastfeeding is widely recommended, many mothers choose to cease breastfeeding or supplement with formula prior to the six months of age (Walker, 2015). For example, the CDC has found that only 1 in 4 infants are exclusively breastfeeding when they are six months of age (CDC, 2018). Also, breastfeeding disparities are particularly prevalent among minorities, especially African American and Hispanic mothers (Afeiche, Villalpando-Carrión, Reidy, Fries, & Eldridge, 2018; Dauphin et al., 2020; DeVane-Johnson, Giscombe, Williams, Fogel, & Thoyre, 2018). African American mothers tend to have a lower prevalence of breastfeeding in comparison to non-Hispanic White mothers. The CDC analyzed the National Immunization Survey-Child (NIS-Child) data for infants born in 2015 to compare the breastfeeding duration and exclusivity at ages 3 and 6 months among all African American and non-Hispanic White infants. The data indicated that at 3 months 58.0% of African American infants were breastfeeding versus
72.7% of non–Hispanic White infants; at age 6 months, the data revealed that 44.7% of African American infants were breastfed and 62.0% of Non–Hispanic White infants were breastfed (Beauregard et al., 2019). However, it should be noted that although infant formula is not considered the preferred source of nutrition like breastmilk, it is considered an adequate source of nutrition for infants (Green Corkins & Shurley, 2016). In the United States, formula must go through vigorous testing and meet federal nutrient requirements to ensure adequate growth among infants (Ventura, Inamdar, & Mennella, 2015).

There are many reasons as to why women decide to formula-feed their infants. They include returning to work (Kimbro, 2006), low level of education (Acharya & Khanal, 2015; Whipps, 2017), cultural beliefs (e.g., breastfeeding related to being a wet nurse, seeing formula as a step up, breastfeeding being seen as immodest) (DeVane-Johnson et al., 2018), anxiety, prenatal depression (Fairlie, Gillman, & Rich-Edwards, 2009), postpartum depression, (Slomian, Honvo, Emonts, Reginster, & Bruyère, 2019), and lack of support ( Radzyminski & Callister, 2016).

Formula feeding does have certain benefits, such as allowing mothers to track the infant’s milk consumption by noting the ounces remaining in the bottle after the feed, as well as ease when returning to work. However, studies have found that it is associated with excess intake (Mennella, Papas, Reiter, Stallings, & Trabulsi, 2019). This may be due to the caregiver’s lack of knowledge regarding the appropriate measurement and ratios of formula and water (Cartagena et al., 2014), or a poor ability to read infant satiety signals (Worobey, Lopez, & Hoffman, 2009). When infant formulas are not mixed properly and are either diluted or concentrated this can lead to health concerns for the infant. For example, if there is an excess of water added to the formula the infant could experience
hyponatremic seizures, a lack of calories for proper growth, and diarrhea; whereas if too little water is provided, the infant could experience hypernatremia dehydration. The latter could cause the infant to experience hospitalization, a permanent disability, and in extreme cases death (Fein & Falci, 1999; St. Jude Children's Research Hospital, 2021).

Observations have shown that infants who are formula fed are more likely to experience rapid weight gain (RWG) in the first three months in comparison to infants who are breastfed (Dewey, 1998; Kramer et al., 2004). Given the two milks have a different chemical composition, there may be a possibility that formula-fed infants have an increased chance of receiving excess caloric intake as well as being over nourished on certain nutrients but undernourished on others.

It is imperative that during the first two years of life an infant obtain adequate amounts of essential nutrients by consuming a variety of foods that include adequate intake of macronutrients and micronutrients (United States Department of Agriculture, 2019). Macronutrients are nutrients that provide energy to the body which help to maintain health, and includes proteins, fats, and carbohydrates (Carreiro et al., 2016). Macronutrients that make up an infant’s diet are primary building blocks that can influence childhood growth patterns and the subsequent risk of non-communicable diseases (Lim et al., 2018). Micronutrients, which include vitamins and minerals, are also important for healthy development and disease prevention (CDC, 2020a). For purposes of this study, the focus will be on vitamins A and D, iron, and calcium, as these micronutrients are key components for growth and development of infants (Fiscaletti, Stewart, & Munns, 2017; Kinabo et al., 2019).
As a result of the aforementioned research and to contribute to preexisting literature on infant nutrition, the following research questions have been created for this study:

**Research Question 1:** Will formula-fed infants who are clients of a WIC Program have an increased caloric intake in comparison to the recommendations put forth by the Dietary Guidelines (DG), thus placing them on the higher percentile on the growth chart? Based on data from the Rutgers Infant Nutrition and Growth (RING) Project, which was comprised of minority infants (African American and Hispanic) and assessed weight gain and diet at 3-, 6- and 12-months, it is hypothesized that infants receiving a higher energy intake will be of a higher percentile on the growth chart.

**Research Question 2:** Will formula-fed infants who are clients of a WIC Program meet the infant DG for macronutrients and micronutrients? It is also hypothesized that when the nutrient intake of this sample is compared to the DG for infants, it will show that this sample of infants will meet their requirements in macronutrients (protein, carbohydrates, and fats) and in vitamin D, calcium, and iron. However, it is also hypothesized that the infants will not meet the recommended intake requirement for vitamin A.
CHAPTER TWO: LITERATURE REVIEW

This review of literature is divided into the following sections: energy balance during infancy, macronutrient needs during infancy, micronutrient needs during infancy, breastfeeding in infancy, formula feeding in infancy, choosing a method of feeding, special considerations when using formula, formula preparation, and adequacy of infant formula.

ENERGY BALANCE DURING INFANCY

It is important that infants be provided with all the nutrients needed for proper growth and development. The World Health Organization (WHO) defines undernutrition as wasting (i.e., low weight-for-height) (Richard, Black, & Checkley, 2012), stunting (i.e., low height-for-age) (WHO, 2021a), underweight (i.e., as low weight-for-age) (Richard et al., 2012), and deficiencies in vitamins and minerals (WHO, 2021a, 2021b). Undernutrition makes children in particular extremely vulnerable to disease and death (WHO, 2020), whereas over-nutrition, which is categorized as a type of malnutrition, can be described as an occurrence due to excessive intake of calories, leading to accumulation of body fat, which can lend to obesity (Mathur & Pillai, 2019).

Statistics have shown a prevalence of 8% of infants and toddlers being overweight, with rates higher in racial/ethnic minority children (Thomson, Goodman, Tussing-Humphreys, & Landry, 2018). When assessing the growth of infants aged 0-2 years, infant growth charts established by the WHO should be used. The WHO growth charts are preferred over the CDC growth charts because of the special precautions taken in designing studies that would provide the best portrayal of physiological growth throughout infancy (CDC, 2010). To create the WHO growth charts, primary studies used growth of infants who were primarily breastfed for the first 4 months and continued breastfeeding at 12...
months (CDC, 2010). The CDC’s growth chart, however, started their primary studies at 3 months, and had a smaller sample size for 6 months old compared to the WHO growth charts (CDC, 2010). Thus, the CDC growth chart is considered to not be appropriate in infancy.

The WHO and the CDC growth charts are divided into percentiles to help identify if an infant is growing properly, however, the WHO growth chart considers the effects of infant feeding on growth by using breastfeeding infants as the norm (CDC, 2010, 2020b).

When energy balances are disturbed this can impact body mass. (Hill, Wyatt, & Peters, 2013) For example, negative energy balance occurs when energy expenditure exceeds intake, and results in wasting. Whereas positive energy balance occurs when energy intake exceeds expenditure and lends to weight gain and growth (Hill et al., 2013). However, an overabundance of energy can lead to excess weight gain (Hill et al., 2013). Due to the latter, the maintenance of a positive energy balance is crucial in sustaining the health and development within children (Birch, Johnson, Andresen, Peters, & Schulte, 1991).

An infant’s energy intake relies on many determinants such as physical activity, size at birth, age, sex, genetic factors, medical conditions, ambient temperature, and growth rate (United States Department of Agriculture, 2019). The USDA has estimated energy requirements (in calories per day) for infants, which depends on their age, sex, and size. For example, for males at 1 to 3 months: 472 to 572 calories per day, 4 to 6 months: 548 to 645 calories per day, 7 to 9 months: 668 to 746 calories per day, and at 10 to 12 months: 793 to 844 calories per day. Additionally, although female infants also have a recommended adequate intake level their intake is slightly less in comparison to
male infants (i.e., 1 to 3 months: 438 to 521 calories per day, 4 to 6 months: 508 to 593 calories per day, 7 to 9 months: 608 to 678 calories per day, 10 to 12 months, and 717 to 768 calories per day) (Eunice Kennedy Shriver National Institute of Child Health and Human Development, 2021).

When considering energy requirements, it can also be useful for parents to examine an infant’s energy intake by looking at their consumption of milk in ounces. A newborn drinking formula will consume 2 to 3 ounces, which is equivalent to 60–90 mL of formula per feeding, and will eat every 3 to 4 hours on average during the beginning weeks (American Academy of Pediatrics, 2018). The formula amount should be increased by 1 ounce (30 mL) each month until the infant is consuming about 7 to 8 ounces (210–240 mL). An infant should drink no more than 32 ounces (960 mL) of formula in 24 hours (American Academy of Pediatrics, 2018). In comparison breastfed newborns will be fed on demand approximately every 2 to 3 hours, or 8 to 12 times per day. As the baby grows at 8 to 12 months, breastfeeding infants will eat approximately 3 to 4 times per day (DiMaggio, Cox, & Porto, 2017).

MACRONUTRIENT NEEDS DURING INFANCY

Proteins, carbohydrates, and fats make up the three macronutrient categories. These three nutrients are required in large amounts and provide energy for one’s body which in return helps to maintain body functions, enable the growth and repair of tissues, regulate body temperature, and allows one to complete daily life activities (Carreiro et al., 2016; Nelms & Sucher, 2019; The University of Waikato, 2011). During infancy from 0 - 6 months, infants are recommended to consume at least 60 g/day of carbohydrates, 31 g/day of fat, and 9.1 g/day of protein. From 7-12 months infants should be consuming at least 95
g/day of carbohydrates, 30 g/day of fat, and Recommended Dietary Allowance (RDA) of 11 g/day of protein (United States Department of Agriculture, 2019). Additionally, it should be noted that currently, the DG do not offer recommendations on certain macronutrients and micronutrients at all stages of infancy and therefore the WIC Infant Nutrition Feeding Guide was utilized (Committee Dietary Guidelines Advisory et al., 2020; United States Department of Agriculture, 2019).

During infancy, carbohydrates help to build new tissues, nourish the brain and nervous system, and supply the body with energy for proper growth and body functions (United States Department of Agriculture, 2019). An infant’s minimum carbohydrate intake should be 40% of total energy, and as the infant grows the carbohydrate intake will gradually increase and by 2 years of age, the infant will be at an intake of 55% energy from carbohydrates (Stephen et al., 2012). One of the leading sources of dietary energy throughout the infancy stage is the carbohydrate lactose, consumed primarily through breastmilk or formula (Stephen et al., 2012). As carbohydrates provide significant energy, they can contribute to overweight and obesity when consumed in excess (Nantel, 1999). In fact, some researchers (Reifsnider, Mobley, & Mendez, 2004) believe that the increasing prevalence in obesity has a great deal to do with the increase in carbohydrate consumption; however, more research is needed to fully understand the impact of carbohydrates on the body.

The second macronutrient, proteins, is equally important as they provide the building blocks of life, by providing essential amino acids that are needed for growth and development (United States Department of Agriculture, 2019). Protein is provided to the infant through breastmilk or formula feeding. In infancy, adequate intake of protein is
defined as 9.1g/day from age 0-6 months and 11g/day from age 7-12 months (United States Department of Agriculture, 2019). It is important to note that formula has a higher protein composition compared to breastmilk and can, thus, lead to increased protein intake (about 55-80% higher per kg body weight) (Koletzko et al., 2005). Although protein is needed to help with growth, too much protein in infancy has been linked to negative side effects, such as being predictive of an early occurrence of adiposity rebound and a high basal metabolic rate throughout childhood (Koletzko et al., 2009). Due to the repercussion of excess protein intake, breastfeeding is recommended over formula feeding (Koletzko et al., 2005).

Dietary lipids are a key source of energy in the growth and development of infants, on average, supplying approximately 50% of the energy consumed through breastmilk and infant formula (United States Department of Agriculture, 2019). This macronutrient contains the essential lipid-soluble vitamins (A, D, E, K) as well as omega-6 and omega-3 polyunsaturated fatty acids (PUFAs), which are important for lipoprotein metabolism, membrane composition and function, and regulate gastrointestinal functions (Delplanque, Gibson, Koletzko, Lapillonne, & Strandvik, 2015; Koletzko, Agostoni, Bergmann, Ritzenthaler, & Shamir, 2011). With regard to intake, health care professionals recommend that fat not be restricted for children under two years of age (Nantel, 1999). It should also be noted that deficiencies in fatty acids, particularly long chain fatty acids like arachidonic acid and docosahexaenoic acid, can impact the central nervous system, as well as vision, and brain development (Hardy & Kleinman, 1994).

Some studies suggest that increased consumption of macronutrients can lead to excess weight gain in infancy (Mann et al., 2007; San-Cristobal, Navas-Carretero, Martínez-González, Ordovas, & Martínez, 2020). However, when managed properly,
macronutrient composition of the diet has been found to not significantly impact body weight (Mann et al., 2007). Therefore, it is important to ensure that macronutrient needs are being accurately met.

**MICRONUTRIENT NEEDS DURING INFANCY**

Micronutrients are a vital dietary component as they are needed to produce enzymes and hormones that are required for proper growth, development and function (WHO, 2020b). The major micronutrients that are of particular importance during infancy include iron, calcium, vitamin D, and vitamin A.

**Importance of Iron in Infancy**

Iron is a micronutrient that is a key component of hemoglobin in red blood cells and of myoglobin in muscles, which holds about 60% of total body iron (Clinic, 2020). Iron is necessary for helping to develop cognitive and motor skills (CDC, 2020a). At birth, there is a high amount of iron within the body, about 94 mg/kg fat-free mass (Ziol-Guest & Hernandez, 2010); due to this iron endowment, it is not necessary for an infant to have iron within their diet shortly after birth; however, most newborns have enough iron stored within their body for only the first four months of life (CDC, 2020c). As the infant grows their iron stores will begin to deplete (Singhal, 2017), and so they must be provided with iron through iron fortified foods, such as iron fortified infant cereals and iron fortified formula, or through iron supplements (Finn et al., 2017; Saarinen, 1978).

Although most infants have an initial store of iron during their first four months, iron deficiency is not uncommon in infancy (CDC, 2020c) nor is iron deficiency anemia (Domellöf et al., 2014; Killip, Bennett, & Chambers, 2007). This is due to a combination of a low iron intake during a time of accelerated growth rate, such as during infancy.
In order to identify an iron deficiency in infants, a blood test is ordered; iron deficiency anemia is defined as Hb <110 g/L and serum ferritin <10–12 g/L for infants age 6 to 12 months (Domellöf, Dewey, Lönnerdal, Cohen, & Hernell, 2002). Infants who are at an especially high risk of being iron deficient are premature infants, infants who are exclusively breastfed after 6 months (Sanyaolu, Okorie, Qi, Locke, & Rehman, 2019), and infants who drink cow’s milk before the age of 1 (McFadden & Toole, 2006). There is also an increased prevalence of iron deficiency in African Americans (Beutler & West, 2005), those of Mexican descent (Rossen, Simon, & Herrick, 2016), lower income individuals (Bodnar, Cogswell, & Scanlon, 2002), and obese or overweight children (Pons, Bargalló, Folgoso, & Sabater, 2000), making them a target of nutrition education to ensure adequate iron intake. However, as mentioned previously supplementation can be provided to the infants and iron fortification has been shown to help infants achieve adequate iron levels (Domellöf et al., 2014). Iron levels have been shown to also be higher in some formula-fed infants in comparison to breastfed (Domellöf et al., 2014).

**Importance of Calcium in Infancy**

Calcium is the most abundant mineral in the human body and makes up about 1.5–2% of the total body weight; 99% of this mineral can be found in an individual’s bones and teeth (Chan, 1991). Thus, calcium is imperative for bone formation and when an infant has insufficient calcium in their body, linear growth will be impeded and peak bone mass may not be achieved, which can contribute to rickets (Sahay & Sahay, 2012). Rickets is a bone disease commonly diagnosed in children and is due to improper levels of calcium which can lend to short stature and joint deformities (Chanchlani et al., 2020; United States
Department of Agriculture, 2019). Adequate intake for infants 0-6 months is 200mg/day with an upper limit of 1000 mg/day; 7-12month old infants should have an adequate intake of about 260mg/day with an upper limit of about 1500mg/day (United States Department of Agriculture, 2019). It has been observed that some non-Hispanic Blacks who are participants within the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) have lower calcium and vitamin D intake (Zimmer, Rubio, Kintziger, & Barroso, 2019). It is important to be aware of racial/ethnic disparities in nutrients such as calcium for those participating within the WIC program to know what nutrition education information should be provided to families and for future packaged revisions (Zimmer et al., 2019). In contrast, it was also observed in a study that compared the intake of calcium in WIC infants to higher-income non WIC participants that the WIC clients had a higher compliance of calcium intake (Jun et al., 2018). However, more research is needed to confirm if WIC infants are obtaining adequate intakes of calcium due to conflicting results.

**Importance of Vitamin D in Infancy**

There are few foods that naturally contain vitamin D, including fish liver oils, oily fish, egg yolk, and, milk, yogurt, wild mushrooms; however, most individuals cannot meet their vitamin D intake through diet alone (O’Mahony, Stepien, Gibney, Nugent, & Brennan, 2011). Vitamin D may also be synthesized through Ultraviolet (UV) exposure, where the inactive form of vitamin D, vitamin D₃ cholecalciferol, is converted to the active form, Calcitriol by 7-dehydrocholesterol with type B UV radiation, present in sunlight with an UV index of 3 or more (Nair & Maseeh, 2012); however, this is limited to a small time frame in the year depending on the geographic region (Holick & Chen, 2008; Nair & Maseeh, 2012). Vitamin D is a fat soluble vitamin that helps with metabolizing bones and
calcium homeostasis, and therefore is highly important throughout infancy and childhood (Choi, Kim, & Jeong, 2013). A deficiency in vitamin D can lead to bone diseases such as osteoporosis (Bendik, Friedel, Roos, Weber, & Eggersdorfer, 2014) and rickets (Nozza & Rodda, 2001), as well as a deficiency in calcium (Pfotenhauer & Shubrook, 2017). Vitamin D deficiency is highly prevalent among children and, if severe, can lead to hypocalcemic seizures, fractures, lower-limb deformities, abnormal dentition and delayed developmental milestones (Ward, Gaboury, Ladhani, & Zlotkin, 2007). In order to prevent vitamin D deficiencies in infancy, exclusively breastfed children should be supplemented with 400 IU/day, as breastmilk does not provide adequate vitamin D (Kim, 2013). Studies have also shown that infants who consume formula tend to have higher vitamin D levels in comparison to those who did not consume formula (Almeida et al., 2018). Due to the conflicting data more research is needed.

Similar to calcium it is important that to be aware of racial/ethnic disparities that one may experience with vitamin D. For those who have darker skin they need more exposure to sunlight to absorb vitamin D in comparison to those of a fairer complexion. The reason for the latter is because, larger amounts of the pigment melanin in the epidermal layer result in darker skin and reduces the skin’s ability to produce vitamin D from sunlight (Nair & Maseeh, 2012).

**Importance of Vitamin A in Infancy**

Vitamin A is another fat soluble vitamin which is critical to the development of the retina and the lungs (Darlow, Graham, & Rojas-Reyes, 2016), protection of the epithelium and mucus integrity in the body, and development of the immune system (Huang, Liu, Qi, Brand, & Zheng, 2018). Typically infants are born with low vitamin A stores due to the
fact that little amounts of vitamin A are transferred during utero (Miller et al., 2002; WHO, 2011). Vitamin A stores within infants are about 6 μmol total stores, or 0.04 μmol/g, which is equivalent to less than a 2-week supply (Miller et al., 2002). It has been estimated that on average vitamin A deficiency impacts about 190 million preschool-aged children (West, 2003; WHO, 2011). It has been suggested that as an infant grows that they achieve an adult concentration of about 0.07 μmol/g (or about 20 μmol total stores) by 6 months of age so that they do not experience a deficiency (Miller et al., 2002). Vitamin A deficiency can lead to xerophthalmia, which is a syndrome where one experiences continuous dryness of the conjunctiva and cornea (Sherwin, Reacher, Dean, & Ngondi, 2012; Stoltzfus & Underwood, 1995). In order to provide adequate vitamin A to infants, mothers should breastfeed their infants; breastmilk provides vitamin A in varying amounts at its different stages (e.g., 151 ug/100 ml in colostrum, 88 ug/100 ml in transitional milk, 75 ug/100 ml in mature milk) (Ross & Harvey, 2003). The RDA for vitamin A is given as retinol activity equivalents (RAE) due to the various bioactivities of retinol and provitamin A carotenoids. It is recommended that infants 0-6 months have 400mcg RAE and infants 7-12 months have 500 mcg RAE (National Institutes of Health Office of Dietary Supplements, 2020).

**BREASTFEEDING IN INFANCY**

Breastmilk is described to be the best source of nutrition in infancy. Although there are supplemental milks that are designed to simulate human milk, breastmilk contains beneficial components that cannot be found within formula. Breastmilk is broken into three main phases as the infant grows—colostrum, transitional milk, and mature milk—where each phase changes per the infant’s changing needs.
Breastmilk Composition

The first milk from the breast that an infant will receive is a thick yellow substance called colostrum that is high in proteins, vitamins, and immunoglobulins (Bravi et al., 2016). For example, this fluid contains beta carotene, a precursor of vitamin A, which helps with eye health and the production of white blood cells (Bravi et al., 2016). It is also has high levels of an immunoglobulin called SIgA which helps protect the infant’s immune system by fighting against foreign substances like bacteria and viruses (Andreas, Kampmann, & Le-Doare, 2015; National Research Council, 1989), giving the infant an advantage over illness. The colostrum begins being produced during mid pregnancy (12 - 18 weeks) and then the body will exclusively produce colostrum 2 -5 days after birth before turning to transitional milk (American Pregnancy Association, 2021a)

The next phase of milk an infant will receive is called transitional milk (WIC Breastfeeding Support, 2021). This fluid is rich in fat, lactose, and water-soluble vitamins; however, it does not have as many immunoglobulins as the colostrum (National Research Council, 1989). This milk gets its name because it is the turning point of the breastmilk going from colostrum to mature milk and has a composition similar both milks. Transitional milk begins around 2-5 days after birth and ends two weeks later (WIC Breastfeeding Support, 2021).

The last phase of milk is called the mature milk (WIC Breastfeeding Support, 2021). Mature milk has two forms: the foremilk and hindmilk. When the infant first begins the suckling process the mother produces foremilk, which is a watery liquid that is lower in calories than hindmilk (American Pregnancy Association, 2021b). Foremilk is about 90% water which helps with the hydration of the infant. During the same breastfeeding
session, as the baby continues to feed, the mother will begin to produce hind milk; hind milk has a higher fat and calorie content which continues to help the infant receive the necessary nutrients (American Pregnancy Association, 2021b; Radzyminski & Callister, 2016). Both foremilk and hind milk are advantageous to infant development and growth.

**Advantages of Breastfeeding**

Breastfeeding has been associated with improved overall health, both in infancy and in later life stages. For example, breastfeeding has been associated with a decreased risk of chronic diseases, such as type 1 diabetes, ischemic heart disease, and atherosclerosis, as well as a healthier lipoprotein profile later in life (Allen & Hector, 2005; Gartner et al., 2005). However, one of the leading reasons why health professionals increasingly advocate for breastfeeding is to decrease the odds of obesity in later stages in life (Vandewark, 2014; Yan, Liu, Zhu, Huang, & Wang, 2014).

Possible reasons as to why breastmilk may protect against diseases includes: the makeup of the milk, suckling experience (Li, Scanlon, May, Rose, & Birch, 2014) and the metabolic response due to the consumption of human milk (Andreas et al., 2015; Butte, 2001). Many studies have concluded that breastfed infants consume less energy in the form of calories than formula-fed infants (Coven, 2010). Lastly, breastfeeding not only has benefits for the infant but the mother as well, as mothers that breastfeed have a reduced risk of postpartum bleeding and osteoporosis, (Ambike, Ambike, Raje, & Chincholikar, 2017) and a decreased risk of getting ovarian and breast cancers (Gartner et al., 2005).

**FORMULA FEEDING IN INFANCY**

Infant formula is an alternative way to provide infants with proper nutrition (United States Department of Agriculture, 2019). The Federal Food, Drug, and Cosmetic Act
(FDCA) classifies infant formula as “a food which purports to be or is represented for special dietary use solely as a food for infants by reason of its simulation of human milk or its suitability as a complete or partial substitute for human milk.” (Green Corkins & Shurley, 2016). This means that, although not exactly like human milk, formula has been designed to replicate that produced by the breast for the infant to achieve growth similar to infants consuming breastmilk (Green Corkins & Shurley, 2016; United States Department of Agriculture, 2019).

Infant formula is made to contain the proper quantity of water, carbohydrates, fats, vitamins, and minerals to ensure that an infant is properly growing (Guo, 2020). Although, regulatory agencies want formula to replicate breastmilk, it is not intended to be identical in composition to human milk (Guo, 2020; Kleinman & Greer, 2013). The infant act of 1980 helped to establish the minimum levels of 29 nutrients and the maximum levels of 9 nutrients within infant formula. If one were to examine 19 nutrients of the 29 they would see that the minimum amount of these nutrients required in infant formula is above the average level found in human milk (Guo, 2020). Many components that are found within human milk can be obtained in infant formula as well.

When comparing the fat of breastmilk to formula, it is important to note that mature human milk consists of 3.8% fat and provides approximately 50% of the gross energy of milk. The fat content within cow milk-based formula provides about 40-50% of energy and comes from vegetable and animal fats helping to provide appropriate amounts of essential fatty acids (Kleinman & Greer, 2013). Additionally, when constructing the makeup of infant formula, the fat blends are chosen to provide a balance of saturated, polyunsaturated, and monounsaturated fats (Kleinman & Greer, 2013).
The protein content within breastmilk is about 0.8-0.9% and 70% comes from whey proteins. In comparison, cow milk-based formulas that are sold within the United States contain protein at concentrations ranging from 1.45 – 1.6g/dL almost 50% more than human milk (0.9 -1.0g/dL) (Kleinman & Greer, 2013). The primary types of proteins in cow milk are whey and casein; the distribution of these proteins can vary depending on the brand of formula; for example, some companies may have a ratio of 18:82. However, there are some formulas that add cow milk whey protein to try and achieve a similar whey to casein ratio of 48:53 and 60:40 (Kleinman & Greer, 2013). The reason why some formulas have higher amounts of whey in them than others is because it is more beneficial for infants who have a cow’s milk casein sensitivity. The whey protein is more likely to digest in the infant’s stomach like breast milk and increase an infant’s chances of having softer stools (Guo, 2020). Additionally, whey protein empties quicker than casein because whey protein is soluble, whereas casein clots within the stomach causing it to take longer for the amino acids to be absorbed (Gan, Bornhorst, Henrick, & German, 2018).

The primary carbohydrate in breastmilk is lactose. Lactose makes up about 6.9-7.2% of breastmilk (Jenness, 1979). Similar to breastmilk, the main carbohydrate in most infant formulas is lactose as well.

**Regulations of Infant Formula in the United States**

It is important to note that in order for formula products to be sold within the United States, they must first pass rigorous testing by The Food and Drug Administration (FDA). As a part of regulation procedures, all manufacturers of infant formula have to register their company with the FDA and make them aware of any new products before marketing them to the public (Ventura et al., 2015). Companies must provide the FDA with significant data
that demonstrates that their formula will support the infant in achieving adequate physical growth and that the formula contains the proper biological quality of the protein within the formula (Ventura et al., 2015). Not only must the ingredients within the formula be considered suitable for consumers, but they must be labeled clearly on the packaging as well. The labeling of infant formula is managed with the Code of Federal Regulations (Brody, 2016; Ventura et al., 2015). The guidelines within the Code of Federal Regulations were created to ensure that companies are adhering to certain label requirements (Brody, 2016). By having this structure, it helps to ensure that consumers are not ingesting dangerous substances and are not subjected to misleading health claims (Brody, 2016).

**CHOOSING A METHOD OF FEEDING**

Prior to delivering their infants, many mothers contemplate how to conduct their infant’s feedings (Spalinger et al., 2017). Four major considerations that are often studied to understand a mother’s decision to breastfeed include infant nutritional benefits, maternal benefits, knowledge about infant feeding, and the support of those around the mother, such as healthcare professional, friends and family (Rahman & Akter, 2019). Additionally, there are varying degrees of breastfeeding, where some women may choose to supplement with formula or opt out of breastfeeding entirely. Prior research has shown that 74% of babies start out breastfeeding, however, 67% of three month old infants are switched to formula or other supplements (Coven, 2010).

A mother’s knowledge regarding infant feeding influences her decision on the type of feeding her child will receive. However, many mothers have never been exposed to proper information on breastfeeding, like its benefits, or education on proper latching techniques for more successful lactation results (McFadden & Toole, 2006). For example,
if a mother has a negative experience, such as breastfeeding being painful (Office of the Surgeon General, 2011), confusing (Office of the Surgeon General, 2011), or if the mother has heard of other mothers having a bad breastfeeding experience (Office of the Surgeon General, 2011), she may forgo breastfeeding and choose formula (Haroon, Das, Salam, Imdad, & Bhutta, 2013). Additionally, although mothers may know that breastfeeding is considered the best option for growth, they may see it as embarrassing due to societal norms (Bernie, 2014; Brown, Raynor, & Lee, 2011b). However, if these mothers were guided in the breastfeeding process they might be more likely to breastfeed for the recommended amount of time (Mohd Shukri, Wells, & Fewtrell, 2018).

Additionally, mothers may lack time (Brown et al., 2011b), experience discomfort in breastfeeding (Mohd Shukri et al., 2018), lack support in a partner (Jones, 1987; Ogden, 2010), be less educated (Brown et al., 2011b; Ramakrishnan, Frith-Terhune, Cogswell, & Kettel Khan, 2002). Also, a lack of community support (Grossman, Fitzsimmons, Larsen-Alexander, Sachs, & Harter, 1990; Pinhas-Hamiel et al., 2003) cultural beliefs (Choudhry & Wallace, 2012; Milligan, Pugh, Bronner, Spatz, & Brown, 2000) and a lack of confidence (Avery, Zimmermann, Underwood, & Magnus, 2009; Taveras et al., 2003) can lead them to choose to formula feed over breastfeed.

Nevertheless, there are benefits a mother may gain from formula feeding her infant. Approximately 2% of mothers are physically unable to breastfeed due to breast engorgement and insufficient milk supply (Huggins, Petok, & Mireles, 2000; Office of the Surgeon General, 2011). Breastfeeding is seen by some mothers as a time-consuming process and demanding lifestyle (Brown, Raynor, & Lee, 2011; Brown et al., 2011b). Also, when mothers have to return back to work they need to be able to share the responsibility
of the feedings (Brown et al., 2011, 2011b). Although pumping is an alternative to formula feeding, it is time consuming and, although workplaces are required to offer pumping rooms, per the Affordable Care Act, the mother may not have adequate support through her work to continue to pump breastmilk.

**SPECIAL CONSIDERATIONS WHEN USING FORMULA**

When an infant is born early, their nutritional needs are different than that of a regular term infant, where they need to be provided with higher protein and calories (Cooke, Embleton, Griffin, Wells, & McCormick, 2001). It is important to note that during the third trimester minerals, such as calcium, magnesium, and phosphorus, are normally delivered through the placenta and therefore need to be provided through supplementation in preterm infants (Institute of Medicine (US) Committee on Nutritional Status During Pregnancy and Lactation, 1990). Therefore, if the baby was delivered early, supplementation through infant formula may be necessary, as breastmilk alone may lead to slow growth and nutritional deficiencies (Arslanoglu et al., 2019; Dror & Allen, 2018) which may lead to poor neurocognitive issues and other health impairments such as retinopathy, bronchopulmonary dysplasia (Arslanoglu et al., 2019) developmental delays, necrotizing enterocolitis, and late-onset sepsis increasing with decreasing gestational age and birth weight (Underwood, 2013). Formulas such as Enfacare® and Neosure® have been shown to help preterm infants reach their nutritional needs (Rossen et al., 2016).

Another reason that infants may consume formula is due to allergies. Infants whose body creates antibodies against large protein molecules in cow's milk are provided with hypoallergenic or non-allergenic formulas, like extensively and partially hydrolyzed formula. (Martin, Ling, & Blackburn, 2016) Possible symptom of a milk protein
intolerance may be blood in the stools of the infant (O'Connor, 2009). However, hypoallergenic formulas contain extensively hydrolyzed proteins that help to reduce the stimulation of antibody production (O'Connor, 2009).

**Societal Factors Influencing a Mother’s Choice of Formula Feeding**

Additionally, a mother’s support system can play a vital role in determining if she will formula feed. For example, supportive healthcare providers can be a key determinant in how an infant will be fed. Prior to the birth of the child, healthcare providers should discuss how the mother will feed her baby and help support her over the course of her hospital stay. However, it has been observed that mothers who felt as though staff members within the hospital had a neutral attitude towards each feeding played into their ceasing to breastfeed (Radzyminski & Callister, 2016). Women have reported that they are getting mixed messages from healthcare providers (Office of the Surgeon General, 2011; U.S. Department of Health and Human Services, 2011). Although their healthcare team may mention the benefits of breastfeeding, they might also provide them with a formula gift pack which may be due to certain policies the hospital has set in place (Hong, Callister, & Schwartz, 2003). As a result, of these mixed messages studies have shown women cease breastfeeding within weeks of delivering the infant (Hong et al., 2003; Radzyminski & Callister, 2016).

Whereas, mothers who deliver in Baby Friendly® hospitals are more likely to breastfeed for longer because these hospitals have strict guidelines such as not marketing formula feeding and encouraging and education mothers through the process(Pérez-Escamilla, Martinez, & Segura-Pérez, 2016). Baby friendly hospitals also have a concept called rooming in. During this process mothers who are postnatal stay with their newborn
for a minimum of 23 hours; this is to encourage early breastfeeding and mother–infant bonding (Theo, 2017). One other important implementation that Baby Friendly hospitals offer mother-infant dyads is The Golden Hour. The Golden Hour is based upon evidence-based practices that help contribute to the physiologic stabilization of both the mother and the infant (Neczypor & Holley, 2017). Cord clamping, skin-to-skin contact, the performance of newborn assessments on the maternal abdomen, delaying non-urgent tasks such as bathing the newborn for 60 minutes, and the early initiation of breastfeeding occur at this time (Neczypor & Holley, 2017).

Friends of the mother can also impact how the mother feels about feeding her infant. For instance, if the mother only hears negative outcomes about breastfeeding from friends, she may choose to use formula (Office of the Surgeon General, 2011). Another influential person within this process could be the husband or spouse (Jones, 1987; Mannion, Hobbs, McDonald, & Tough, 2013). Mannion et al. 2013 conducted a study and concluded that mothers were more likely to continue breastfeeding when they felt as though their spouse was being supportive. Whereas those who got negative feedback from their spouse about breastfeeding felt more ambivalent (Mannion et al., 2013). Family members may also play a role in how the infant is fed; one study found that 2 out of 3 mothers received information on infant feeding from a family member (Eckhardt et al., 2014). This demonstrates the importance of building support throughout the community to ensure mothers are able to make the best decision regarding breastfeeding for their family.

**The Impact of Poverty on Infant Feeding**

In 2019, the Census Bureau found that 34 million individuals living within the United States were living in poverty; out of those 34 million, about five million of those
individuals were children (United States Department of Agriculture, 2019). Research has shown that poverty can negatively impact a young child’s health and can lead to increased post-neonatal mortality rates, greater risk of injuries resulting from accidents, higher risk for asthma, and lower developmental scores on tests in later years of life (Aber, Bennett, Conley, & Li, 1997).

Unfortunately, when children grow up in lower income families their guardian may find coping strategies, such as reduced food intake to help make ends meet (Keith-Jennings, Nchako, & Llobrera, 2021). Consequently, the health of the family can be placed in jeopardy (Gupta, de Wit, & McKeown, 2007). One example may be guardians who try to create their own formula for their infant which may contain harmful ingredients or be lacking in certain nutrients (S. A. Davis, Knol, Crowe-White, Turner, & McKinley, 2020). Another example is, caregivers who dilute formula to make it last longer, or a caregiver who allots a certain amount of formula for their infant to consume before the feeding has begun (Burkhardt, Beck, Kahn, & Klein, 2012). When an infant’s formula is diluted it can cause the infant to have hyponatremic seizures, a lack of calories for proper growth, and diarrhea (Bruce & Kliegman, 1997; Spalinger et al., 2017).

Food assistance programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) were created to help families struggling financially provide appropriate nutrients to their children. Although this program has done a good job with providing families with nutrient dense foods, many children who participate in the program are overweight or obese (Daepp, Gortmaker, Wang, Long, & Kenney, 2019; Sekhobo, Edmunds, Reynolds, Dalenius, & Sharma, 2010). For instance, in previous years malnutrition was associated with insufficient intake due to low calorie intake. However,
malnutrition is also now characterized by excessive caloric intake which is a contributing factor to the obesity epidemic within our nation (Gilmore et al., 2019). Low income minority women, which the WIC community serves, specifically African American and Hispanic women are highly prevalent to obesity (Gilmore et al., 2019). Additionally, many of the infants enrolled in WIC experience rapid weight gain (Graulau, Banna, Campos, Gibby, & Palacios, 2019), which is a concern because it increases the infant’s chances of obesity and chronic illnesses later in life (Sloan, Sneddon, Stewart, & Iwaniec, 2006). This increase in weight gain is seen at greater rates among African American and Hispanic participants (Graulau et al., 2019; Worobey, Lopez, & Hoffman, 2008). Additionally, infants participating in the WIC program are 12% more likely to be formula-fed instead of breastfed in comparison to those who are not in the program (Hedberg, 2013; Kent, 2006; Zhang, Lamichhane, Wright, McLaughlin, & Stacy, 2019).

However, programs like WIC can be extremely beneficial for lower income families. Research has shown that these programs have helped children to perform better in school which can later lend to higher earnings when the child becomes an adult (Sherman, Trisi, & Parrott, 2013). The WIC program has also helped with improved diet and diet related outcomes such as higher intakes of iron, vitamin C, thiamin, niacin and vitamin B6, without an increase in food energy intake (Food and Nutrition Service, 2013). Additionally, WIC helps to educate pregnant women and post-partum women on their health during these stages which has helped to lower fetal deaths and infant mortality, reduce low birthweight rates, and increase the duration of pregnancy (Food and Nutrition Service, 2013).
FORMULA PREPARATION

Formula comes in two main formats, ready to use, which tends to be more expensive, and a powdered form where the caregiver must add water to the formula. However, if the formula is improperly made, it may provide calories, proteins and other nutrients at insufficient levels for meeting the developmental needs for proper infant growth (Spalinger et al., 2017). Research has found that some caregivers do not accurately measure formula and water when preparing bottles (Graulau et al., 2019).

Consequences of Improper Formula Preparation

The reason that caregivers should be cognizant of infant formula feeding practices is to help with combating obesity in later years (Appleton et al., 2018). Obesity can also lead to other comorbidities such as type 2 diabetes, hypertension, and dyslipidemia (Gurnani, Birken, & Hamilton, 2015). Additionally, research has shown that bottle feeding may contribute to rapid weight gain among infants (Wood et al., 2016). Although formula provides similar nutrients to breastmilk, many formula products have an energy density of approximately 67 kcal/100 mL, which exceeds the energy content of early breastmilk and formula fed infants have been seen having a 1.2- to 9.5-fold greater energy intake (Hester et al., 2012). Dietary energy intake during infancy has led researchers to believe that high volumes of formula may impact an infant's weight trajectory (Guell, Whittle, Ong, & Lakshman, 2018; Ong, Emmett, Noble, Ness, & Dunger, 2006).

Although research has shown an association between a high volumes of energy intake which can lead to an overconsumption of kcals, some mothers do not believe this to be possible or they feel that infancy is too early to practice obesity prevention (Lakshman et al., 2012). It is recommended that as infants grow that they are not provided more than
32 ounces of formula within 24 hours as it can lead to rapid weight gain (American Academy of Pediatrics, 2018). It is suggested that some infants have a higher need for sucking and may just want a pacifier and not necessarily more to eat (American Academy of Pediatrics, 2018). Thus, there is a need for interventions to improve the preparation of bottles for caregivers who formula feed to help them be more precise of their preparation of the formula, so that rapid weight gain does not occur (Kavanagh, Cohen, Heinig, & Dewey, 2008; Wood et al., 2016).

**ADEQUACY OF INFANT FORMULA**

Infants consuming properly prepared formula, will meet the DRI of 10µg/day of vitamin D, if they consume 1000 mL of formula. This is, however, especially difficult for young infants given the fact that they cannot consume large amounts of formula, and could lead to a vitamin D deficiency (Kim, 2013). In addition, vitamin D deficiency can also lead to a calcium deficiency, as vitamin D is required for proper calcium absorption (Lips, 2012).

Vitamin A deficiency is another common nutrient deficiency seen in infancy. It is important to note that breastfeeding has been found to prevent vitamin A deficiency due to the high levels of retinol found in breastmilk (Ross & Harvey, 2003). Researchers have conducted studies to determine if both formula fed and breastfed infants are obtaining an adequate amounts of vitamin A, and they found that supplements can aid in infants obtaining marginal intakes to help achieve adequate intake (Briefel, Hanson, Fox, Novak, & Ziegler, 2006; Leaf & RCPCH Standing Committee on Nutrition, 2007). However, as formulas are modified and new products are placed on the market, there needs to be updated
research to determine if infants are receiving an adequate amount of vitamin A from formula.

Iron deficiency is another common nutrient deficiency seen in infancy. During the 1950s, many infants were becoming iron deficient; to help reduce the prevalence of iron deficiency, it was added to infant formulas in 1969 (Committee on Nutrition, 1999). Today, infant formulas are available in both “low iron” and “iron fortified” versions (Gahagan, Delker, Blanco, Burrows, & Lozoff, 2019). If a formula has an iron concentration ≥6.7mg/L it considered iron fortified and must display that on the packaging (Committee on Nutrition, 1999). Many WIC infants are formula fed (Hedberg, 2013; Kent, 2006; Zhang et al., 2019), and WIC food packages were revised in 2009 to make sure that they were offering food options that coincided with the 2005 DG (Chaparro, Crespi, Anderson, Wang, & Whaley, 2019). When reviewing the formulas within the packages the WIC committee checked to see that the formulas were iron fortified and followed FDA regulations (National Academies of Sciences & Medicine, 2017; Neuberger, 2010). In 2016, it was reported that 87% of WIC infants met the estimated average requirement, compared with 69% of non-WIC infants (Guthrie et al., 2020). The iron prevalence is most likely due to WIC programs requiring the use of iron fortified formula.

**SUMMARY**

During the beginning stages of life, an infant must depend on their caregiver to provide both proper and adequate nutrients. It should be noted that nutrient requirements per pound of body weight are proportionally higher throughout infancy than at any other stage within the life cycle (United States Department of Agriculture, 2019). When an infant is properly nourished, they are more likely to have optimal growth and development.
However, when infants have excess energy intake, negative health impacts have been identified that track through childhood and adulthood (Hardwick, 2014; Hill, 2013). For example, children who are in higher weight-for-age percentile on the WHO and CDC growth charts have an increased risk of being overweight or obese in later stages of their life (CDC, 2010, 2020b; Khadilkar & Khadilkar, 2011).

This is an even greater risk for African American and Hispanic families, who face health disparities, even from infancy (Hartline-Grafton, 2015; Thomson, 2018). Due to the biological, social, and economic backgrounds of minorities, many are more susceptible to diseases such as obesity (Kumanyika, 1993) and its comorbidities (e.g., hypertension and diabetes)(CDC, 2020a, 2020d). This may be due to the fact that lower income families may not be surrounded by nutrient dense foods, and they may opt for foods that are lower in price and higher in sugar, fat and sodium which can result in negative health outcomes (Neuberger, 2010; Paul, 2009). WIC plays an important role in the lower income communities because they are allotted with the resources to help educate mothers and provide their children with nutrient dense food to help prevent comorbidities in the future (Neuberger, 2010).

There is limited research comparing key nutrients and DG amongst infant minorities who are formula-fed participants of food assistance programs such as the Special Nutritional Program for Women, Infants, and Children, as well as whether these infants may be at risk for excess energy intake. Therefore, this thesis will address this gap in the literature.
CHAPTER THREE: METHODS

A secondary data analysis from a longitudinal study, the Rutgers Infant and Nutrition and Growth (RING) Project (Worobey, 2002, 2009), was performed to examine the energy, macronutrient, and select micronutrient intake of formula fed infants participating in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) to see if they obtained an adequate amount of these nutrients in comparison to the DG for infants. The Institutional Review Board at Rutgers University and the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) Center in New Brunswick, New Jersey, approved this study. Additionally, funding for this study was obtained through the National Institutes of Child Health and Human Development Grant #R03 HD39697, 2002-2005 (Worobey, 2002).

PARTICIPANTS

Participants were recruited through the RING Project beginning in 2003. To be eligible to participate, a client of the WIC program had to be a mother of a newborn child and have a gross family income of less than or equal to 185% of the family's poverty guideline amount (Ver Ploeg, Betson, & National Research Council, 2003). Those who participated were either African American or Hispanic. Participants were called to schedule home visits when their infant turned 3 months, 6 months, 12 months, and once a year thereafter until the child turned 5 years old.

PROCEDURES

The recruitment process for this study began by mothers being screened for eligibility and obtaining their written consent to participate. When the mothers arrived at
the WIC center for their initial postpartum visit, they were asked by the WIC receptionist demographic questions and how they planned on administering feedings to their infant. If the mother stated that she would be solely formula feeding, a research assistant from the RING project was signaled and made a note to approach the mother once she completed her WIC consultation. When the women were later approached, they were told about the nature of the study including that it would be a longitudinal study that focused on maternal feeding, infant development, and involved home visits. The mothers were also informed that if they participated in the study, they would be compensated. If a mother confirmed her participation within the study with the research assistant, she was immediately compensated with a $10 dollar gift certificate to a local grocery store.

If the mother decided to participate, she signed a written informed consent form, before proceeding any further with the study. Depending on the mother’s background, she had the choice of completing the form in English or Spanish (Appendix A). A demographic form (Appendix B) was then provided to the mother. This sheet included questions pertaining to age, race/ethnicity, language preference, number of years residing, etc. If a mother needed help filling out her form, there was a bilingual research assistant who could help instruct her through the questions in either English or Spanish.

Anthropometric information was obtained by the WIC staff from both the mother and her infant and shared with the research assistants, with the permission of the mother. First, the mother’s pre-pregnancy measurements of weight, height, and body mass index (BMI) and her infant’s birth weight were obtained through the WIC client database. It should be noted that the mother’s weight and height were only taken at baseline by a WIC staff member who was trained in anthropometric measurement by personnel from the state...
Department of Health and Senior Services. After the anthropometrics was completed for the mother, the weight and length were obtained for the infant by a trained WIC staff member.

The mothers were then informed about the process for scheduling appointments. Mothers were told that a month prior to when the researchers were supposed to collect their data, a postcard would be sent to their house reminding them of their upcoming visit from the researchers. Approximately two weeks after receiving the postcard, the participants received a phone call from the researchers to schedule an at home visit. While scheduling the appointment, the participant had to provide consent that she was still willing to be a participant in the study.

**DATA COLLECTION**

The collection of data was divided over two days. To ensure that all the information was properly communicated, mothers who primarily spoke Spanish had their paperwork written in Spanish. Also, there were two research assistants at each visit that spoke either English or Spanish, to ensure accurate recording of the information.

**Home Visit: Day 1.** During the first visit, the weight, height, and arm circumference of the infant was taken and recorded by researchers. To increase the likelihood of the measurement being as accurate as possible, the weight and length were measured twice. The mothers also had to confirm they were exclusively formula feeding. Next, each mother was asked about what her infant was fed over the previous 24 hours. To help the mother in the recall process, she could start from the last item, and indicate the amount the child consumed, and continue backwards. During this time, mothers told the researchers the timing of feeds, number of feeds, and how many ounces of formula were administered to
the infant (Appendix C). Also, the mother was asked about her child’s behavior over the last 24 hours. This was done to make sure that the infant was not exhibiting any behavior that was not atypical. Lastly, before the research assistants left the home of the mothers, they explained to the mothers that they needed to keep a food diary for the next 24 hours, and that they would be returning the next day to gather the results.

The weight of the infant was measured in kilograms and the length of the infant was measure in centimeters. The length was assessed following proper procedures, where length of an infant was determined by measuring from the top of the head to the heel of the infant’s foot (Gibson, 1993). The information was later noted on a gender specific infant growth chart to help determine the trajectory of the infant’s growth and illustrate what percentile the infant fell within.

**Home Visit: Day 2.** On day two, the research assistants returned to the home of the mothers to collect their infant’s food diary. Similar to the first home visit, the mothers were asked if their child displayed any abnormal behaviors during the last 24 hours. If the mother said that her infant exhibited typical behavior the research assistants would continue with collecting the 24-hour diet recall of the infant. If the mother needed further assistance stating how much or what her child consumed, food models and visual aids were provided. At the end of the second day of the home visit, the participants were given $30 gift card for their participation. These procedures were repeated at 3, 6, and 12 months.

**DATA ANALYSIS**

To analyze each infant’s dietary intake, the information was taken from either the mother’s 24-hour recall or both the 24-hour recall and the next day diary, depending on if the information was properly reported. By gathering this information those working on this
study were able to examine the calories consumed through the energy intake. Researchers decided to exclude anyone who had incomplete anthropometrics or if an infant was experiencing an atypical eating style. This information was then inputted into a program called Nutrition Pro Diet Analysis (Axyya Systems). This program provides a breakdown of the total nutrients from the food and beverages that the infants consumed. For this study descriptive analyses were completed to compare the levels of macronutrients and micronutrients (Appendix D) to the DGs for infants, to determine whether this sample was receiving an adequate amount of nutrients. Pearson’s correlation was performed to assess whether there was a relationship between an increased consumption of kcals with increased levels of micro and macronutrients. For statistical significance, a p value of <0.05 was used a priori.
CHAPTER FOUR: RESULTS

Of the 166 mothers that initially consented to participate in the study, complete dietary and nutrient information through 12 months was available for 96 of the participants. Table 1 displays the demographics of the mother and infant dyads. The sample included 49 female infants and 47 male infants. Infants were nearly evenly split by gender (51% female). Mothers averaged about 27 years of age and having lived in the United States over 6 years. Mothers had a pre-pregnancy BMI average that was slightly above what is considered a healthy BMI, averaging just under 26. Mothers primarily identified as Hispanic (76%), with fewer identifying as African American (24%). Most mothers had some high school or less (62%), with few reporting some college or more (19%), or a high school diploma/GED (19%).
Table 1. Characteristics of the study population: full analytic sample (N=96)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean±SD or N (%)</th>
</tr>
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<tbody>
<tr>
<td><strong>Maternal Characteristics</strong></td>
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<tr>
<td>Age in years</td>
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<tr>
<td>Number of years in the US</td>
<td>6.26 ±4.49</td>
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<tr>
<td>Pre-Pregnancy BMI</td>
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<td><strong>Race/Ethnicity</strong></td>
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<tr>
<td>African American</td>
<td>23 (24%)</td>
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<td>Hispanic</td>
<td>73 (76%)</td>
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<td><strong>Education</strong></td>
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<td>Some high school or less</td>
<td>60 (62%)</td>
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<tr>
<td>High school diploma/ GED</td>
<td>18 (19%)</td>
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<tr>
<td>Some college or more</td>
<td>18 (19%)</td>
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<td><strong>Infant Characteristics</strong></td>
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</tbody>
</table>
Table 2 summarizes the comparison of calories that the USDA recommends in comparison to what the RING infants consumed. The DG’s does not have estimations for energy intake for infants during their first year of life at this time. However, the USDA does have recommendations for calorie intake for infants during the first year of life and they appear in Table 2. The USDA recommends that at 1-3 months male infants should range between 472 to 572 calories and female infants should have an intake of 438 to 521 calories. When looking at the infants from the RING project the males slightly exceeded the range by 1 calorie and the females exceeded the upper limit of the range by 90 calories during the 1–3 month age period. At 4-6 months male infants should have an estimated calorie intake between 548-645 calories while a female infant should consume approximately 508 to 593 calories. Looking at results of both male and female infants at the 4-6 month stage, both the male and female infants exceeded the USDA recommendations of 885 and 757 calories, respectively. For the final months, 10-12, the USDA recommends male infants consume 793 to 844 calories and female infants consume 717 to 768 calories. The infants of the RING Project again exceeded the recommended average intake of calories at this stage of life with the male infants consuming 902 calories making for 110% consumption and female infants consuming 910 calories which is equivalent to 122% consumption intake above the average recommended calorie intake.
Table 2. Comparison of Calories: USDA recommendations\(^1\) and RING Infants

<table>
<thead>
<tr>
<th>Months</th>
<th>Male USDA</th>
<th>Male RING</th>
<th>Female USDA</th>
<th>Female RING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 months</td>
<td>472 - 572</td>
<td>573.03</td>
<td>438-521</td>
<td>611.31</td>
</tr>
<tr>
<td>4-6 months</td>
<td>548-645</td>
<td>885.29</td>
<td>508-593</td>
<td>757.92</td>
</tr>
<tr>
<td>10-12 months</td>
<td>793-844</td>
<td>902.64</td>
<td>717-768</td>
<td>910.18</td>
</tr>
</tbody>
</table>

\(^1\) The USDA Infant Nutrition and Feeding Guide has been designed for the Special Supplemental Nutrition Program for Women Infant and Children (WIC) as reference for how to feed and what to look for when feeding infants (United States Department of Agriculture, 2019).
Table 3 summarizes the caloric intake and weight related – variables in relation to Pearson’s Correlation Coefficients. Having established the energy intake of the infants’ exceeded recommendations at each of the three points of measurements (3, 6, 12 months), tests were completed to see how their high caloric intake correlated to anthropometric measurements of the infants. Although at 3 months the infants were found to be in the 55th percentile. There was no significant correlation between calorie intake at 3 months for weight for length, weight for age, or for weight gain. At 6 months the infants were found to be in the 57th percentile with their calorie intake. Yet there was no significant correlation between calorie intake at 6 months for weight for length, weight for age, or for weight gain. Finally, the data also showed the infants were in the 67th percentile at 12 months however there was no significant correlation between calorie intake at 6 months for weight for length, weight for age, or for weight gain.
Table 3. Pearson Correlation Coefficients between Caloric Intake and Weight-related Variables

<table>
<thead>
<tr>
<th>Kilocalories at 3 months</th>
<th>Weight/Length At 3 months</th>
<th>Weight/Age At 3 months</th>
<th>Weight Gain from 0-3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.089</td>
<td>0.163</td>
<td>0.131</td>
</tr>
<tr>
<td>Kilocalories at 6 months</td>
<td>Weight/Length At 6 months</td>
<td>Weight/Age At 6 months</td>
<td>Weight Gain from 3-6 months</td>
</tr>
<tr>
<td></td>
<td>0.103</td>
<td>0.038</td>
<td>0.036</td>
</tr>
<tr>
<td>Kilocalories at 12 months</td>
<td>Weight/Length At 12 months</td>
<td>Weight/Age At 12 months</td>
<td>Weight Gain from 6-12 months</td>
</tr>
<tr>
<td></td>
<td>0.082</td>
<td>0.118</td>
<td>0.076</td>
</tr>
</tbody>
</table>

*Significance for the Pearson Correlation set at p<0.05

* The USDA Infant Nutrition and Feeding Guide has been designed for the Special Supplemental Nutrition Program for Women Infant and Children (WIC) as reference for how to feed and what to look for when feeding infants (United States Department of Agriculture, 2019)
During the 0 to 3-month period, the DG do not offer recommendations for macronutrient consumption for infants. However, WIC does have current recommendations for an infant’s macronutrient intake of proteins, carbohydrates, and fats during this age period and these values appear in Table 4 for reference (United States Department of Agriculture, 2019). Recognize that although these values are being used as references for comparison purposes, there is not enough information about micro- and macronutrients for this age period to set a Recommended Dietary Allowance.

Table 4 summarizes the macronutrient intake of the infants in this study in comparison to the DG. Again, because the DG do not offer recommendations for protein intake at 3 months, the WIC infant guidelines which was created by the USDA are used as a reference for infant nutrition intake. The data indicates that at 3 months the RING infants exceeded the adequate intake recommendation for protein. The DG do however have protein intake recommendations at 6 and 12 months of 11 grams and 13 grams, respectively. As depicted in Table 4, the infants of this study again exceeded the recommendations at 6 months and nearly exceeded their intake by triple the amount at 12-months for protein.

At the 3-month period the intake for carbohydrates was compared to the WIC guidelines and the infants had a higher intake than recommended. The DG carbohydrate intake recommendations at 6 and 12 months are 95 grams and 130 grams, respectively. As shown in Table 4, however, the data displays the infants exceeding their recommended intakes at 3- and 6- months, but not reaching their recommended intake for carbohydrates at 12-months. Finally, the DG also does not currently have recommendations for fat intake.
for infant ages 0-12 months. However, the WIC guidelines uses 31 g/day as an adequate intake during the 0-to-6-month age period for infants. At the 3-months and 6-months the infants were relatively close to this recommendation. At 12-months the fat intake recommendations are only 30 g/day, which the infants slightly exceeded.
Table 4. Comparison of macronutrient intake: Dietary Guidelines and RING Infants (N=96)\textsuperscript{ab}

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Dietary Guidelines* 3 months</th>
<th>RING infants 3 months Mean±SD</th>
<th>Dietary Guidelines* 6 months</th>
<th>RING infants 6 months Mean±SD</th>
<th>Dietary Guidelines* 12 months</th>
<th>RING infants 12 months Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)\textsuperscript{1}</td>
<td>9.1**</td>
<td>13.82±7.94</td>
<td>11</td>
<td>19.20±16.42</td>
<td>13</td>
<td>36.09±19.15</td>
</tr>
<tr>
<td>Carbohydrate (g)\textsuperscript{2}</td>
<td>60**</td>
<td>69.58±30.55</td>
<td>95</td>
<td>111.21±87.64</td>
<td>130</td>
<td>112.95±50.64</td>
</tr>
<tr>
<td>Fat (g)\textsuperscript{3}</td>
<td>31**</td>
<td>28.34±11.89</td>
<td>31**</td>
<td>32.06±14.10</td>
<td>30**</td>
<td>34.98±17.55</td>
</tr>
</tbody>
</table>

DG: Dietary Guidelines: The Dietary Guidelines 2020-2025 has been created to offer evidenced based food and beverage recommendations for Americans at each stage of life (Committee Dietary Guidelines Advisory et al., 2020)

\textsuperscript{**} WIC Guidelines for Infant Feeding: The USDA Infant Nutrition and Feeding Guide has been designed for the Special Supplemental Nutrition Program for Women Infant and Children (WIC) as reference for how to feed and what to look for when feeding infants (United States Department of Agriculture, 2019)

\textsuperscript{1} The WIC Infant Feeding Guidelines for protein at 3 months are based on AI while the Dietary Guidelines for protein is based upon the RDA at 6 and 12 months

\textsuperscript{2} The WIC Infant Feeding Guidelines for carbohydrates at 3 months are based on AI while the Dietary Guidelines for carbohydrates are based on AI at 6 months and RDA at 12 months

\textsuperscript{3} The WIC Infant Feeding Guidelines for fat at 3, 6, and 12 months are based on adequate intake
Table 5 summarizes the micronutrient intake of infants enrolled in this study in comparison to the DG. Currently, the DG has not published micronutrient guidelines for infant’s ages 0 – to -3 months. However, to make up for this missing information the WIC infant nutrition guidelines were used for Vitamin A, vitamin D, calcium, and iron at that time of age.

At 3 months although infants consumed about 65% of the upper limit recommendation, they did not exceed it and were below the adequate intake level recommendation at this age which is 400mcg/RAE. Whereas, at 6 and 12 months there is a recommendation of 500mcg/RAE and 300 mcg/ RAE, respectively. As shown in Table 5, at 6 months the infants of this study slightly exceeded the dietary intake for vitamin A and greatly exceeded the recommended intake at 12 months. The WIC guidelines recommends that infants between the ages of 0-6 months not exceed 25mcg while 10mcg of vitamin A is seen as an adequate intake; and the infants did not exceed the limit.

When looking at the vitamin D nutrient recommendations for infants at 3 months the WIC Infant Feeding Guidelines were referenced. It was stated that infants should have an adequate intake of 10ug at 3 months, which the infants did not reach. Additionally, the DG currently have vitamin D intake recommendations at 6 and 12 months. At 6 months it recommends adequate intake of 10ug. Whereas at 12 months there is a recommended RDA of 15 µg. The participants fell short of the recommended intake at both age points as seen in Table 5.

At the 3-month mark for calcium WIC recommends that infants consume an adequate intake of 200mg per day. Yet, the infants consumed more than double the amount adequate intake. However, it was also a recommended that infants do not exceed the upper
limit for calcium of 1000 mg which the infants did not. The DG currently have calcium intake recommendations at 6 and 12 months of 260 mg and 700 mg, respectively. The infants of this study greatly exceeded the recommended intake of calcium at 6 months, but to a lesser degree at 12-months.

Finally, to conclude the micronutrient table, at 3-months of age infants are recommended a low adequate intake of iron in comparison to other months, of only 0.27mg. Additionally, it is recommended that infants at 3-months do not exceed 40mg of iron per the WIC guidelines. When looking at the data the infants did exceed the adequate intake amount for iron but not the 3-month upper limit recommendation. Finally, the DG currently have iron recommendations at 6 and 12 months of 11 mg and 7mg, respectively. At 6 months the infants exceeded their intake recommendation, but at 12 months the infants met the recommended intake for iron precisely.
Table 5. Comparison of micronutrient intake: Dietary Guidelines and RING Infants\textsuperscript{ab}

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Dietary Guidelines 3 months</th>
<th>RING infants 3 months</th>
<th>Mean±SD</th>
<th>Dietary Guidelines 6 months</th>
<th>RING infants 6 months</th>
<th>Mean±SD</th>
<th>Dietary Guidelines 12 months</th>
<th>RING infants 12 months</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (mcg RAE)\textsuperscript{1}</td>
<td>400* 600\textsuperscript{2}</td>
<td>385.11±351.15</td>
<td>500</td>
<td>532.92±410.10</td>
<td>300</td>
<td>536.74±560.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D (µg)\textsuperscript{3}</td>
<td>10*</td>
<td>8.49±3.49</td>
<td>10</td>
<td>9.26±4.10</td>
<td>15</td>
<td>8.81±5.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (mg)\textsuperscript{4}</td>
<td>200* 1000\textsuperscript{2}</td>
<td>483.26±245.31</td>
<td>260</td>
<td>751.58±844.31</td>
<td>700</td>
<td>858.08±512.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (mg)\textsuperscript{5}</td>
<td>0.27*</td>
<td>9.72±4.47</td>
<td>11</td>
<td>23.73±59.02</td>
<td>7</td>
<td>7.03±5.03</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DG: Dietary Guidelines: The Dietary Guidelines 2020-2025 has been created to offer evidenced based food and beverage recommendations for Americans at each stage of life (Committee Dietary Guidelines Advisory et al., 2020)

** WIC Guidelines for Infant Feeding: The USDA Infant Nutrition and Feeding Guide has been designed for the Special Supplemental Nutrition Program for Women Infant and Children (WIC) as reference for how to feed and what to look for when feeding infants (United States Department of Agriculture, 2019)

\textsuperscript{1} The WIC Infant Feeding Guidelines for vitamin A at 3 months are based on AI while the Dietary Guidelines for vitamin A is based upon AI at 6 months and RDA at 12 months

\textsuperscript{2} Upper Limit

\textsuperscript{3} The WIC Infant Feeding Guidelines for vitamin D at 3 months are based on AI while the Dietary Guidelines for vitamin D is based upon AI at 6 months and RDA at 12 months

\textsuperscript{4} The WIC Infant Feeding Guidelines for calcium at 3 months are based on AI while the Dietary Guidelines for calcium is based upon AI at 6 months and RDA at 12 months

\textsuperscript{5} The WIC Infant Feeding Guidelines for iron at 3 months are based on AI while the Dietary Guidelines for iron is based upon RDA at both 6 and 12 months
Table 6 summarizes and compares the measurements of female infants versus male infants during the first home visit at 3 months. When looking at the data for male versus female there were no statistically significant differences. Both male and females were virtually equivalent on all measures at 3-months. The data in Table 6 shows that although the female infants were slightly higher than the males in their intake of calories, proteins, carbohydrates, fat, vitamin D, and calcium there was statistically no significant difference. Additionally, the male infants at this age had a higher weight-for-length despite the female infants having an overall slightly higher mean intake in the macronutrients. As for the intakes of vitamin A and iron, the males consumed more. However, it should be noted that there again was no significant difference in the intakes of vitamin A and iron in comparison to male and female infants.
**Table 6. Home Visit 1 Measurements (N=96)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Female (N=49) Mean±SD</th>
<th>Male (N=47) Mean±SD</th>
<th>T df=94</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurements from 1st Home Visit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant age (IN DAYS)</td>
<td>92.92±8.00</td>
<td>92.34±9.60</td>
<td>0.32</td>
<td>0.75</td>
</tr>
<tr>
<td>Weight for length</td>
<td>53.35±32.39</td>
<td>56.22±36.43</td>
<td>-0.41</td>
<td>0.68</td>
</tr>
<tr>
<td>Kilocalories (kcal) from dairy</td>
<td>611.30±268.74</td>
<td>573.03±214.73</td>
<td>0.99</td>
<td>0.32</td>
</tr>
<tr>
<td>Protein (g) from dairy</td>
<td>14.31±9.76</td>
<td>13.30±5.50</td>
<td>0.63</td>
<td>0.53</td>
</tr>
<tr>
<td>Carbohydrate (g) from dairy</td>
<td>72.58±35.12</td>
<td>66.44±24.91</td>
<td>0.99</td>
<td>0.32</td>
</tr>
<tr>
<td>Total fat (g) from dairy</td>
<td>28.84±11.97</td>
<td>27.82±11.91</td>
<td>0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>Vitamin A (RE) from dairy</td>
<td>358.84±181.19</td>
<td>412.56±468.17</td>
<td>-0.74</td>
<td>0.47</td>
</tr>
<tr>
<td>Vitamin D (ug) from dairy</td>
<td>8.63±3.63</td>
<td>8.33±3.37</td>
<td>0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>Calcium (mg) from dairy</td>
<td>484.65±268.96</td>
<td>481.81±220.97</td>
<td>0.01</td>
<td>0.96</td>
</tr>
<tr>
<td>Iron (mg) from dairy</td>
<td>9.64±4.91</td>
<td>9.81±4.01</td>
<td>-0.19</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Table 7 summarizes and compares the measurements of female infants versus male infants during the second home visit at 6 months. Whereas at the 3-month home visit (Table 6) the females had higher total means in most of the categories, the opposite occurred during the 6-month visit, as shown in Table 7. The only characteristics in which the female infants had a slightly greater mean total was in the weight-for-length category and the infant’s age at 6-months. However, there was no statistical difference. When looking at the intakes for the male infants on this table they consumed roughly 127 more calories than the female infants. Also, when looking at the calcium intake the male infants consumed roughly 138 mg more of calcium even though it is still not statistically a significant difference.
Table 7. Home Visit 2 Measurements (N=96)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Female (N=49) Mean±SD</th>
<th>Male (N=47) Mean±SD</th>
<th>T df=94</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurements from 2nd Home Visit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant age (IN DAYS)</td>
<td>183.35±8.96</td>
<td>180.98±11.68</td>
<td>1.11</td>
<td>0.27</td>
</tr>
<tr>
<td>Weight for length</td>
<td>58.38±29.01</td>
<td>55.90±38.91</td>
<td>0.35</td>
<td>0.72</td>
</tr>
<tr>
<td>Kilocalories (kcal) from dairy</td>
<td>757.92±249.18</td>
<td>885.28±706.27</td>
<td>-1.17</td>
<td>0.25</td>
</tr>
<tr>
<td>Protein (g) from dairy</td>
<td>17.12±6.03</td>
<td>21.56±23.09</td>
<td>-1.28</td>
<td>0.21</td>
</tr>
<tr>
<td>Carbohydrate (g) from dairy</td>
<td>103.60±40.79</td>
<td>119.63±120.17</td>
<td>-0.87</td>
<td>0.39</td>
</tr>
<tr>
<td>Total fat (g) from dairy</td>
<td>30.28±10.07</td>
<td>34.02±17.45</td>
<td>-1.28</td>
<td>0.21</td>
</tr>
<tr>
<td>Vitamin A (RE) from dairy</td>
<td>516.73±306.99</td>
<td>550.85±505.92</td>
<td>-0.34</td>
<td>0.69</td>
</tr>
<tr>
<td>Vitamin D (ug) from dairy</td>
<td>9.00±3.38</td>
<td>9.54±4.79</td>
<td>-0.64</td>
<td>0.53</td>
</tr>
<tr>
<td>Calcium (mg) from dairy</td>
<td>684.42±355.56</td>
<td>822.37±1158.29</td>
<td>-0.78</td>
<td>0.44</td>
</tr>
<tr>
<td>Iron (mg) from dairy</td>
<td>18.35±18.84</td>
<td>29.69±83.59</td>
<td>-0.91</td>
<td>0.37</td>
</tr>
</tbody>
</table>
Table 8 summarizes and compares the measurements of female infants versus male infants during the third home visit at 12 months. Again, both males and females were largely equivalent on all measures, including age. When looking at the weight-for-length the males had a slightly higher mean, but it was not statistically significant. Although the male infants had a higher weight-for-length the female infants consumed about 7-and-a-half calories more per day than the male infants. The female also had slightly higher mean totals for intake of total fat, vitamin A, vitamin D, and calcium. When looking at the data though there was no significant difference in mean totals for intake of total fat, vitamin A, vitamin D, and calcium between male and female infants.
Table 8. Home Visit 3 Measurements (N=96)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Female (N=49) Mean±SD</th>
<th>Male (N=47) Mean±SD</th>
<th>T df=94</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurements from 3rd Home Visit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant age (IN DAYS)</td>
<td>362.66±18.65</td>
<td>365.65±16.02</td>
<td>-0.84</td>
<td>0.40</td>
</tr>
<tr>
<td>Weight for length</td>
<td>66.12±30.60</td>
<td>67.52±29.35</td>
<td>-0.23</td>
<td>0.82</td>
</tr>
<tr>
<td>Kilocalories (kcal) from diary</td>
<td>910.17±412.13</td>
<td>902.64±338.39</td>
<td>0.10</td>
<td>0.92</td>
</tr>
<tr>
<td>Protein (g) from diary</td>
<td>36.86±21.33</td>
<td>35.24±16.64</td>
<td>0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>Carbohydrate (g) from diary</td>
<td>107.34±52.96</td>
<td>119.05±47.82</td>
<td>-1.14</td>
<td>0.26</td>
</tr>
<tr>
<td>Total fat (g) from diary</td>
<td>37.36±17.81</td>
<td>32.38±17.06</td>
<td>1.40</td>
<td>0.16</td>
</tr>
<tr>
<td>Vitamin A (RE) from diary</td>
<td>503.13±510.20</td>
<td>573.32±613.38</td>
<td>-0.61</td>
<td>0.54</td>
</tr>
<tr>
<td>Vitamin D (ug) from diary</td>
<td>9.57±6.45</td>
<td>7.98±3.55</td>
<td>1.50</td>
<td>0.14</td>
</tr>
<tr>
<td>Calcium (mg) from diary</td>
<td>900.28±581.32</td>
<td>812.12±427.16</td>
<td>0.85</td>
<td>0.40</td>
</tr>
<tr>
<td>Iron (mg) from diary</td>
<td>6.61±4.92</td>
<td>7.48±5.18</td>
<td>-0.84</td>
<td>0.40</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: DISCUSSION

During the first two years of life it is important that an infant receive adequate amounts of macronutrients and micronutrients to increase their likelihood of healthy development (Ahluwalia et al., 2016). Exclusive breastfeeding is recommended by the CDC for the first six months, and for the first two years of life by the WHO, to help infants achieve their best growth expectancy (CDC, 2020b). Yet, the CDC has found that only 25% of American infants were exclusively breastfed the first six months in 2015 (CDC, 2018, 2021). Benefits of exclusive breastfeeding may include decreased risk of diabetes, heart disease, and aiding in steady weight gain (Allen & Hector, 2005; Gartner et al., 2005; Vandewark, 2014). Data has shown that infants who are formula fed are more likely to experience rapid weight gain versus infants who are breastfed (Dewey, 1998; Kramer et al., 2004). It is important to be mindful of this rapid weight gain during infancy because it has been associated with obesity in later stages of life (Sloan et al., 2006).

Although there are many benefits to exclusive breastfeeding, time and financial constraints may make it a difficult option for many families (Brown et al., 2011, 2011b). There tends to be an evident breastfeeding disparity in participants receiving WIC benefits, with formula fed infants experiencing rapid weight gain (Graulau et al., 2019; Kent, 2006). Although research has shown that this population has an increased risk for the prevalence of obesity, there is limited research examining the macronutrient and micronutrient composition of the diet of these infants to determine if they are consuming sufficient nutrients. This thesis offers insights into the intake of macronutrients and micronutrients of formula fed WIC infants.
**Research Question 1:** Will formula-fed infants who are clients of a WIC Program have an increased caloric intake in comparison to the recommendations put forth by the DG, thus placing them on the higher percentile on the growth chart?

The first research aim of this study was to determine if the infants were exceeding the recommended caloric intake. Few studies to date have examined whether infants receiving WIC are meeting or exceeding recommended caloric intake. The first comparative study that this thesis will utilize to see how the RING infants fared incorporates results from the National Health and Nutrition Survey (NHANES). NHANES is a program of studies created to assess the health and nutritional status of adults and children in the United States. Another primary aim of NHANES is to determine the prevalence of major diseases and risk factors for diseases.

Ahluwalia and colleagues observed the caloric intake of infants, who were participants of 2009-2012 NHANES(Ahluwalia et al., 2016). Although the study looked at the energy intake of infants at different stages, for the purpose of this thesis the findings from the age range from 6-11 months will be discussed. For reference 38% or the participants were ≤130% of the poverty income ration. Next, the mean energy intake of the infants (n=381) was 836 kcal/day. However, participants who fell within the 50th percentile consumed about 809 kcal/day and infants in 90th percentile had an excess calorie intake which was 25% higher than the infant of the 50th percentile. The results showed that the infants within the 90th percentile range had a consumption of 1132 kcal/day. However, it should be noted that majority of the participants within this study were Non–Hispanic White, followed by Hispanic and then Non–Hispanic Black. Additionally, since there
were many lower income families within this study this may be supporting evidence that lower income infants may be prevalent to a higher energy intake.

Furthermore, a study conducted by Huang et al., (2018) examined how early feeding of larger volumes of formula milk during the beginning stages of life can be associated with greater body weight or overweight in later infancy (J. Huang et al., 2018). During this study there were three groups which the infants could be placed in, breastfed (BM, no formula), lower-volume formula milk feeding (LFM, <840 ml formula/d), and lastly higher-volume formula milk feeding (HFM, ≥840 ml formula/d). A comparison of weight for length was conducted for each group at 3, 6, and 12 months. The data concluded that there was a higher weight for length in infants who were in the HFM versus the infants who were in the BM group throughout the study. Similarly, when looking at the weight for lengths for the infants of RING study it also showed that the infants were in a higher weight for length group at 3, 6, and 12 months. Due to high caloric intake of the infants this placed them in the 55th, 57th, and 67th percentile meaning they were above the median at 3, 6 and 12 months, respectively.

Similar to this study, Thornton et al., (2014) also examined the differences in energy intake among WIC participants; and the infants whom he collected data on were clients of the Central Texas WIC program (Thornton, Crixell, Reat, & Von Bank, 2014). Additionally, like the RING study over half the participants in Thornton et al., were Hispanic (68%); however, the remaining participants were primarily White (17%) rather than a minority group. The Thornton et al., (2014) study first looked at infants between the ages of 4 to 5.9 months and later at 6 to 11.9 months during the years 2009 and 2011. However, the primary focus will be on the data analysis from ages 6 to 11.9 months.
Thornton et al. (2014) study included the intakes of mothers who were still breast feeding at each age point. When looking at data analyses in 2009 only 23% of the mothers were still breastfeeding whereas in 2011, 30% of mothers were still breastfeeding. The authors concluded that calorie intake of infants in 2009 were higher than that of 2011, at 920 calories versus 866 calories, respectively. It should be noted however that the infants within the Central Texas WIC study still exceeded the recommended calorie intakes based upon their mean intake in both years (Thornton et al., 2014). Similarly, infants in this study exceeded the recommended energy intake at all ages.

One reason health professionals and researchers recommend breastfeeding over formula feeding is due to the belief that infants can self-regulate more easily from the breast than from bottle feeding (Lönnerdal & Hernell, 2016). When the caregiver is less experienced and unaware of the satiety cues the infant is exhibiting, there is a greater likelihood of overfeeding that infant (Mennella, Turnbull, Ziegler, & Martinez, 2005). Although, there are studies that show an infant can experience rapid weight gain from both formula and breastmilk (Graulau et al., 2019), findings suggest that bottle feedings provide a wider range regarding how much an infant will consume (Wood et al., 2016), which may lend to more rapid infant weight gain. Additionally, the concept of a “chubby” baby as being healthy is held by many parents, caregivers, and even health care providers, where they interpret rapid weight gain as the baby having a good appetite or is thriving in terms of health (Johnson, Clark, Goree, O’Connor, & Zimmer, 2008; Persad & Mensinger, 2008).

Observational studies have shown that when infants experience excessive energy intake, and rapidly gain weight as a consequence, they have an increased likelihood of obesity and chronic illness in later stages of life (Sloan et al., 2006). This is of concern as
obesity in childhood is associated with chronic health problems, such as type 2 diabetes (T2DM), dyslipidemia, hypertension, sleep-disordered breathing, nonalcoholic fatty liver disease, and polycystic ovarian syndrome (PCOS) (Gurnani, Birken, & Hamilton, 2015). Obesity has been a growing problem in the United States and worldwide. Especially concerning is the increase in rapid weight gain during infancy that has been observed in the United States (Graulau et al., 2019; Monteiro & Victora, 2005). To overcome this, in 2004 the WHO reduced their recommended energy requirements for infants by 15 to 20% (Guell, Whittle, Ong, & Lakshman, 2018). However, even with these changes in recommendations, infants have continued to experience rapid weight gain with an increased prevalence among formula fed infants (Appleton et al., 2018; Horodynski, Silk, Hsieh, Hoffman, & Robson, 2015; Mennella et al., 2019).

As mentioned previously in this thesis lower income families such as those who are participants within WIC tend to be prevalent to lower levels of education. Based off of the demographic form that the mothers filled out for this study the majority (60%) reported having some high school or less. In the Thornton et al., (2014) study depicted that the highest level of education that a majority of the mothers (64%) had was high school. Additionally, a study that was done by Davis and colleagues found a trend of those who participated in the NHANES survey displaying that infants who were of lower income families tended to have higher means of energy intake versus infants who were in a higher income bracket (K. E. Davis, Li, Adams-Huet, & Sandon, 2018). To help protect infants against rapid weight gain WIC specialist should continue to find new ways to educate on proper infant feeding techniques. As well as help mothers and provide them with the
resources needed to make sure their child is receiving adequate nutrition such as proper bottle sizes and formulas.

**Research Question 2:** Will formula-fed infants who are clients of a WIC Program meet the infant DG for macronutrients and select micronutrients?

Bovine milk makes up a large portion of infant formula, but is considered to be adequate replica to breastmilk (Ahern, Hennessy, Ryan, Ross, & Stanton, 2019). However, bovine milk tends to have high amounts of protein within it and as a result must go through a series of modifications to better replicate the composition of human milk (Ahern et al., 2019). In this thesis, the data showed that within this sample of infants, at 3, 6, and 12 months the infants consumed more than the recommended intake of protein. As the infants grew the protein intake of infants also increased. For example, at 3 months the infants slightly exceeded their recommendation. At 6 months the infants almost doubled the amount of the recommended intake. While at 12 months of age the infants did consume double the amount of the recommended intake of protein. Due to the fact that the 2020 DG for infants was just recently published there is little data providing specific numbers for how much an infant has over consumed on protein in many studies. However, this research concluded that formula fed infants may be more prevalent to consuming high amounts of protein.

To compare how the WIC infants of this study compared to infants on national spectrum, this thesis will incorporate Demmer and colleagues study which utilized two NHANES reports that ranged between the years of 2011- 2014 (Demmer, Cifelli, Houchins, & Fulgoni, 2018). Although participants of the analysis ranged from 0-5 years of age, the data from 0-11 months will only be used to compare to the data of RING infants.
Also, it was stated in the study that participants consuming breast milk (n = 260); were excluded from the study to not overestimate those with nutrient inadequacy given that the researchers did not have data on the amount of breastmilk consumed. When looking at the data from the Demmer et al. study it shows that both Black and Hispanic infants had a high protein intake, 19.8 grams and 20.2 grams, respectively. Additionally, when comparing the protein mean intake of infants of the NHANES, they too exceeded the DG recommendations for protein at 6-11 months.

The DG recommends that infants consume an adequate intake of 95 grams of carbohydrates at 6 months and an RDA of 130 grams of carbohydrates at 12 months. As mentioned in the results section the infants averaged about 111.21 grams at 6 months and about 112.95 grams at 12 months. There was another study that had similar results. This study was conducted by researcher Ahluwalia et al., (2016). The research examined the nutrient intakes of US children aged 6–23 months who participated in the NHANES. For this study multiple surveys were utilized which were conducted and based off data between the time frame of 2009–2012. This study examined how the dietary intakes of the infants compare to the age specific DRIs which was set by the Institute of Medicine. Additionally, this study did incorporate a few infants that did formula feed which was about 13% of the participants. It was concluded that the infants exceeded the intake level of 95 grams between the 6 and 11 month time frame. Additionally, the results showed that the infants consumed an average intake of about 111 grams of carbohydrates (Ahluwalia et al., 2016). Also, like the DG this study did not include the intake of carbohydrates for infants who were younger than 6 months of age. However, based off the recommendations from the USDA the infants of the RING study exceeded the adequate intake levels at 3 months.
The DG do not have recommendations for fat intake during an infant’s first year of life. However, the USDA Food and Nutrition Service department developed an infant and nutrition feeding guide which was developed as a resource for the WIC staff who provide nutrition education and counseling to the parents and caregivers of infants. This infant nutrition feeding guide was used to see how the intake of the infants compared to recommendations of the USDA. At 3 months the infants did not exceed the fat intake. But, when looking at the intake of the infants at 6 and 12 months of age infants should be consuming 31 grams and 30 grams of fat, respectively. The results showed that the infants had a slightly increased intake of the baseline intake at both the 6 month and 12-month age.

In comparison to study conducted by Ahluwalia et al., (2016) they did not have data for the infants prior to 6 months of age, but average mean intake of total fat for the infants was 34.9 grams making it slightly above the adequate intake levels between the ages of 6-11 months(Ahluwalia et al., 2016). Demmer et al., (2018) explored the intake of fat consumption among different ethnicities from 6-11 months. The results showed that average mean intake for Hispanics was 35.7 grams and for Blacks it was 38.4 grams meaning each group exceeded the USDA adequate intake recommendations. This may mean that infants who are formula fed may be prevalent to higher fat intake. However, discrepancies with the Demmer et al., (2018) study would be too that the infants are recommended to start adding in complementary foods which may have also had an impact on the infants’ fat intake.

At 3 months of age, the RING infant’s intake of vitamin A was compared to the USDA recommendations, since the DG does not offer recommendations. The infants did not exceed recommendations for vitamin A at their first home visit. The DGs says that an
adequate intake of vitamin A is 500 mcg and 300 mcg for infants at 6 and 12 months, respectively. When looking at the results for the infants from RING study at each mark the infants had an over consumption of vitamin A. Researcher López-Sobaler et al. (2016) conducted a National Dietary Survey on the Child and Adolescent Population in Spain (ENALIA) which assessed the usual micronutrient intake among Spanish infants, children, and adolescents (López-Sobaler et al., 2017).

The Lopez–Sobaler et al., (2016) study utilized European Food Safety Authority (EFSA) for guidance and recommendations on the general principles for the collection of national food consumption data in the view of a pan-European dietary survey (Marcos Suarez, Rubio Mañas, Sanchidrián Fernández, & Robledo de Dios, 2015). Additionally, the study observed the intake of Spanish infants (both breastfed and formula fed) from 6-12 months however, they utilized the estimated average reference as a guide which is also the same reference point that the DGs utilizes, 500 mcg for vitamin A. The results from the ENALIA study showed that the infants also exceeded the 500 mcg with male infants consuming over 900 mcg (903 mcg) and females over 800 mcg (850 mcg). However, it should be noted that participants of the ENALIA project only consisted of Spanish participants whereas the RING project consisted of both African American and Hispanic infants. Additionally, if one looks at the data from Ahluwalia et al., 2016 study it also observed that infants between 6 -11 months had a mean intake of 669 mcg which is also over that 500 mcg intake. The study also incorporated an upper limit amount which was 600 mcg which also means the infants of this study exceeded their intake as well (Ahluwalia et al., 2016).
The USDA consider 10 µg of vitamin D to be an adequate intake at 3 months. Additionally, the DGs considers 10 µg of vitamin D to be an adequate intake at 6 months and an adequate intake for infants and at 12 months 15 µg to be an adequate intake. When looking at the RING study the infants failed to meet recommended intake at 3, 6, and 12 months and consumed an intake of 8.49 µg, 9.26 µg, and 8.81 µg, respectively. Ahluwalia et al., (2016) observed the vitamin D intake of infants between 6-11 months and found that the infants had a mean intake of 7.0 µg. When comparing the infants of Ahluwalia et al., 2016 study to the infants within the RING project the results from Ahluwalia et al., (2016) showed that infants between 6 -11 months consumed a mean intake of 7.0 µg which is also less than the 10-µg adequate intake that the DG recommends.

A study conducted by Thornton et al., (2014) it looked at infants who were participants of the Central Texas WIC facility. Although the study did not look at the intake at 3 months it did examine the intake at 4-5.9 and 6-11 months, which concluded that the infants did not meet the recommended intake of vitamin D. Furthermore, the data showed that at the 4-5.9 stage that once the WIC package changed, there was further decrease showing that the infants in 2011 consumed 6.19µg whereas in 2009 the infants had a mean consumption of 7.37µg (Thornton et al., 2014). There was also a decrease at the 6-11.9 months with infants having a greater in take in 2009 in comparison to 2011, 7.57µg and 5.66µg respectively (Thornton et al., 2014).

The infants of the RING project had their calcium levels observed to see how their intake compares to that of the DG and USDA. Once the data was collected and reviewed it was found that the intake of the infants exceeded the recommendations at 3, 6 and 12 months, 483.26mg, 751.58mg, and 858.08mg respectively. When comparing the intake to
that of the infants from the Ahluwalia et al., (2016) study it was observed that at 6-11 months the infants had an average mean intake of 664mg of calcium which was over the adequate intake of 260mg. However, this study also observed UL which is 1500mg and the infants did not exceed that amount.

The final micronutrient that was observed within the RING project was iron. At 3 months the adequate intake and upper limit is 0.27mg and 40mg, respectively. The infants of the RING project exceeded the adequate intake but not the upper limit upon the 3-month age. At 6 months the infants consumed over two times the recommended amount of iron. When looking at the DG it recommends 11mg be consumed at 6 months and the infants of this study had an average intake of about 23.73 mg. When looking at how much iron was consumed in the Ahluwalia et al., (2016) study it was observed the infants who ranged between the age of 6-11 months had a mean intake of about 16.4mg. This shows that infants of each study exceeded the DGs amount. Thornton et al., (2014) looked at iron consumption of WIC infants in 2009 and 2011 at 6-11.9 months and found that the intakes were 11.2mg and 10.7mg respectively.

At the beginning of this thesis, it was hypothesized that this sample of infants would meet their requirements in macronutrients (protein, carbohydrates, and fats) and in vitamin D, calcium, and iron and not meet the recommended intake requirement for vitamin A. However, this was partially incorrect because the infants did not meet the recommendations of vitamin D and did meet the recommendations for vitamin A. It has been observed that infants who are breastfeeding are more susceptible to needing a supplementation for vitamin D (Day, Krishnarao, Sahota, & Christian, 2019). One possible contributing factor as to why the infants may not have reached their vitamin D intake is that although formula
is fortified with vitamin D about 1 L (33.8fl oz) is needed to be consumed to reach the recommended intake (Casey, Slawson, & Neal, 2010; CDC, 2018; Day et al., 2019). In the beginning stages of infancy this may be a difficult given the size of an infant’s stomach.

Also, as mentioned earlier in this thesis vitamin D can also be absorbed through UV exposure. However, again those who have darker skin they need more exposure to sunlight to absorb vitamin D in comparison to those of a fairer complexion (Nair & Maseeh, 2012). Additional education should be provided to minority mothers about how to obtain adequate amounts of vitamin D. Potentially, some mothers may be under the impression that if they just provide their infant with formula and the child plays while the sun is shining that their child is obtaining an adequate amount vitamin D, which may not be the case (Day et al., 2019; Nair & Maseeh, 2012). Researcher Day et al., (2019) also concurs with the notion that parents should receive more education to not only understand the importance of vitamin D, but to better grasp the dietary requirements including supplementation and the availability of vitamin D fortified foods (Day et al., 2019).

The hypothesis of this study had also included that infants would not meet the recommendations for vitamin A. In the beginning of thesis it was said that when infants are first born they only have enough vitamin A within them for about 2 weeks; however, as they grow and become about 6 months of age their vitamin A concentration may be equivalent to that of an adult(Miller et al., 2002). This may be the reason as to why at 3 months of age the infants were short of their intake at 3 months by 14.89 mcg/RAE. Whereas at 6 and 12 months the infants not only met the DG reference but exceeded the recommendation.
STRENGTHS

Currently, there are limited studies that focus on dietary intake of formula fed minority infants, who are participants of the WIC program; therefore, this study is an additional resource to this area of research. Other studies, such as the NHANES, looked at variety of infants who are from different socioeconomic classes. However, as research has shown, low-income dietary patterns of the minority population can be heavily impacted due to their social economic status. Since WIC is a program that assists lower income families it is important to know that the clients of this program are being properly nourished to increase their likelihood of proper growth and development. Another strength of this research study is that it was conducted over an extended period. This is beneficial to research because due to the fact that this research contains multiple data points it allows researchers to detect developments or changes in the characteristics of this population at both the group and the individual level. Additionally, the intake of the infant was also collected over the period of two days at each home which further allowed researchers to see trends amongst this population. Finally, the anthropometrics were taken twice at each home visit, by trained researchers which increases the validity of measurements associated with them.

LIMITATIONS

This study is also not without its limitation. One major limitation of this study is its small sample size. Although, longitudinal studies can be beneficial they can also add limitations to a study which did occur. Due to the fact that this study was done over an extended period of time, it made it harder to retain participants. Another limitation to this study is that the dietary recalls from the mothers were self-reported, as self-reported
information is not always accurate; for instances, mothers may have forgotten to report certain information or falsified certain answers. Also, during this study research assistants did not always obtain a two day 24-hour diet recalls from the mothers; this may have limited the variation of the results from the infants. However, one day of diet recalls was considered adequate from the mothers. In addition, the infant feeding recommendations that were used in comparison to the RING primarily referenced the DG. However, since the DG does not offer recommendations for caloric intake and macronutrients and micronutrients consumption at all stages of infancy the USDA’s WIC Infant Feeding Guidelines was used at a reference.

Since more information is needed for the recommended intake of infants within the DG, this may have skewed the information and the infants may not have technically been over their estimated adequate intake for age. Finally, although there were studies that had similar findings, the age range in terms of months of the infants sometimes varied. It would be more beneficial to track the trends of calorie, macronutrient, and micronutrient intake while the infants are at the same stage of life to better analyze the data. Also, some of the studies that were referenced and compared to the RING infant study utilized mixed feeding methods. Consequently, due to the various feedings methods it is hard to compare the data to know if the information is truly comparable.

CONCLUSIONS

In conclusion, this study showed that formula fed WIC fed infants from the RING project tended to meet the recommendations and at times exceeded recommendations for their intake. The data showed that the infants of this study consistently exceeded their caloric intakes and their weight for lengths placed them in a higher percentile. However,
instances where RING infants did not meet the recommendations included at the 12-month phase for carbohydrate intake, 3-month phase for fat intake, 3-month phase for vitamin A intake, and all three phases for vitamin D consumption. Future WIC employees should consider the benefits that can come from educating the mothers on infant feeding guidelines to help aid in the growth and development of their infants. As well as continuously coming up with new ways to keep mothers educated and helping them to feel comfortable about providing their infant with adequate nutrition. Finally, further research is needed to see how the nutrient intake of formula fed infants of the WIC population may or may not be impacted by inadequate consumption of macronutrients and micronutrients.
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WHO. (2020b). Micronutrients. Retrieved from https://www.who.int/health-topics/micronutrients#tab=tab_1

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Informed Consent Form

Project Title: Assessing Activity and Feeding in Young Infants

Investigator: John Worobey, Ph.D., Associate Professor
Department of Nutritional Sciences, Cook College, 732/932-6517

Project Description: The purpose of this investigation is to assess activity level and feeding patterns in normal babies with the use of an actometer, that is, a tiny computer that measures leg movements by the infant. Infant activity will be measured on three occasions in the family’s home. At the same time, each mother will complete a questionnaire that asks about her baby’s temperament and feeding routine, and will be watched as she feeds her infant. Descriptions of activity and feeding made by the mothers will be compared to levels of activity as measured by the actometer and seen during feeding.

I have read and understood the above description of this study, and have been given the opportunity to ask questions regarding my infant’s and my participation.

I understand that I am free to refuse to participate in any procedure or to answer any question without prejudice to me. These rights extend to my infant, who may also refuse to cooperate.

I understand that I am free to withdraw my consent and to withdraw from the investigation at any time without prejudice to my infant or myself.

I understand that my infant’s and my identities will remain confidential in any reports of the investigation.

I understand that Dr. Worobey or his assistants will answer any of my questions relating to the research procedures at any time.

I understand that I will be paid for participating in this study: $10 for completing the questionnaire today, and $30 at the end of each home visit, for a possible total of $100.

I understand that by agreeing to participate in this research, signing this form, and accepting payment, I do not waive any of my legal rights, and I will be given a copy of this form for my own records.

If I have any questions regarding my infant’s or my rights as a research subject I may contact the Office of Research and Sponsored Programs at 732/932-2104.

Name (printed) ___________________________ Name (signature) ___________________________

Staff witness ___________________________ Date _________

This informed consent form was approved by the Rutgers Institutional Review Board for the Protection of Human Subjects on July 10, 2002; approval of this form expires on July 9, 2003.
Forma de Consentimiento Informado

Nombre del Proyecto: Evaluación de la Actividad y la Alimentación en Infantes en Edad Temprana

Investigador: John Worobey, Ph.D. Profesor Asociado
Departamento de Ciencias de la Nutrición, Cook College, 732/932-6517

Descripción del Proyecto: El propósito de esta investigación es evaluar el nivel de actividad y los patrones de alimentación en bebés promedio con el uso de un actómetro, una computadora pequeña que mide el movimiento de las piernas del bebé. La actividad del bebé será medida tres veces en la casa de la familia. Al mismo tiempo, cada mamá completará un cuestionario que incluye preguntas sobre la personalidad del bebé y su rutina de alimentación, y será observada mientras alimenta a su bebé. La descripción de la actividad y la alimentación realizada por la mamá será comparada con los niveles de actividad medidas por el actómetro y los observados mientras la mamá alimentaba al bebé.

He leído y entendido la descripción del estudio que aquí se presenta, y he tenido la oportunidad de hacer preguntas en relación a mi participación y la de mi hijo (a).

Me queda claro que estoy en la libertad de rehusarme a participar en cualquier procedimiento o a contestar cualquier pregunta sin que esto me afecte. Estos derechos se extienden a mi hijo, quien también puede rehusarse a cooperar.

Me queda claro que estoy en la libertad de retirar mi consentimiento y de retirarme de la investigación en cualquier momento sin que esto afecte a mí o a mi hijo (a).

Me queda claro que la identidad de mi hijo (a) y la mía permanecen confidenciales en cualquier reporte de esta investigación.

Me queda claro que el Dr. Worobey o sus asistentes contestarán en todo momento cualquiera de mis preguntas relacionadas con los procedimientos del estudio.

Me queda claro que me pagarán por participar en este estudio: $10 en cupones por completar el cuestionario el día de hoy, y $30 cada vez que me visiten en mi casa, un posible total de $100.

Me queda claro que al acceder a participar en esta investigación, al firmar esta forma, y al aceptar el pago, no estoy suspendiendo ninguno de mis derechos legales, y que recibiré una copia de esta forma para mis archivos personales.

Si tengo alguna pregunta en relación a los derechos de mi hijo (a) y los míos como participantes de esta investigación puedo contactar la Oficina de Investigación y Programas Patrocinados (Office of Research and Sponsored Programs) al 732/932-0150 ext. 2104.

Nombre (en letra de molde) ___________________________ Firma ___________________________

Testigo ___________________________ Fecha ___________________________

Esta forma de consentimiento informado fue aprobada por el “Rutgers Institutional Review Board for the Protection of Human Subjects” el día 10 de Julio del 2002; el permiso expira el 9 de Julio del 2003.
## APPENDIX B: PARTICIPANT GENERAL INFORMATION FORM-RING

### GENERAL INFORMATION FORM-RING

#### INFANT'S INFORMATION
- First Name: 
- Last Name: _
- WIC ID #:  
- Gender: Female  
- Race/Ethnicity: Hispanic
- Date of Birth: 06/10/02  
- Birth Weight: 5 lbs  
- Birth Length: 16 inches
- Gestation Weeks: 29  
- Birth Order: 1

#### MEASUREMENT INFORMATION

<table>
<thead>
<tr>
<th>Date</th>
<th>Age at Measurement</th>
<th>Weight</th>
<th>Length</th>
<th>BMI</th>
<th>Hemoglob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/21/2002</td>
<td>1 month 11 days</td>
<td>10 lbs</td>
<td>17 weeks</td>
<td>24.22</td>
<td></td>
</tr>
</tbody>
</table>

#### MOTHER'S INFORMATION
- First Name: 
- Last Name: _
- WIC ID #:  
- Household WIC ID #: 14
- Race/Ethnicity: Hispanic/ Central/South American

#### PREGNANCY INFORMATION
- Pre-Pregnancy Weight: 120
- Weight at delivery: 153
- Weight gained during pregnancy: 33

#### Measurement DURING pregnancy

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<th>Pregnancy week</th>
<th>Weight</th>
<th>Height</th>
<th>BMI</th>
<th>Hemoglob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/06/2002</td>
<td>37</td>
<td>128 lbs</td>
<td>64 in</td>
<td>21.81%</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

#### Measurement AFTER pregnancy

<table>
<thead>
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<th>Date</th>
<th>Age at Measurement</th>
<th>Weight</th>
<th>Height</th>
<th>BMI</th>
<th>Hemoglob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/10/2002</td>
<td>24 hrs</td>
<td>13 lbs</td>
<td>64</td>
<td>25.0%</td>
<td>13.2%</td>
</tr>
</tbody>
</table>

### FEEDING INFORMATION
- Formula used: Good Start with Iron Powder
- Ever Breastfed: No
- End Date: ___
- Reason for formula feeding: ___
- Age Formula Introduced: 0 – 10 days
- Food added to the baby's formula: ___
- # of Ounces a day (as in WIC file): ___
- Date: 08/19/2002
APPENDIX C: DIARY DIET RECALL INFO—RING PROJECT

DIARY DIET RECALL INFO—RING PROJECT
To be filled by home-visitor to complement the 24 diary completed by the mother.

Date: 7/29/03
Subject #: 020666
Infant’s Name: 
Infant’s age: 2 months 24 days
Is this a typical day?: 
Is infant taking Vitamin supplements?: 
If “yes”: Since when?: Frequency?:
Types and brands?:

24 HOUR RECORD BASED ON DIARY INFO

<table>
<thead>
<tr>
<th>Time</th>
<th>Quantity</th>
<th>Details of food and drink: food item, method of preparation (fresh, frozen, baked, canned, broiled, raw), brand, flavor, main ingredients (if home-made food).</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:01 Pm</td>
<td>2oz</td>
<td>Good Start w/ Iron</td>
</tr>
<tr>
<td>8:31 Pm</td>
<td>6oz</td>
<td></td>
</tr>
<tr>
<td>11:00 PM</td>
<td>6oz</td>
<td></td>
</tr>
<tr>
<td>2:01 AM</td>
<td>5oz</td>
<td></td>
</tr>
<tr>
<td>5:01 AM</td>
<td>10oz</td>
<td></td>
</tr>
<tr>
<td>6:31 AM</td>
<td>5oz</td>
<td></td>
</tr>
<tr>
<td>8:01 AM</td>
<td>10oz</td>
<td></td>
</tr>
<tr>
<td>6:31 AM</td>
<td>3oz</td>
<td></td>
</tr>
<tr>
<td>10:31 AM</td>
<td>2oz</td>
<td></td>
</tr>
<tr>
<td>11:31 AM</td>
<td>3oz</td>
<td></td>
</tr>
</tbody>
</table>
### DIARY DIET RECALL INFO—RINK PROJECT

To be filled by home-visitor to complement the 24 diary completed by the mother.

Date: 5/4/04

Subject #: 0251510c

Infant's Name: ____________________________

Infant's age: __________

Is this a typical day?: [ ]

Is infant taking Vitamin supplements?:

If “yes”: Since when?: __________________ Frequency?: __________________

Types and brands?: __________________

### 24 HOUR RECORD BASED ON DIARY INFO

<table>
<thead>
<tr>
<th>Time</th>
<th>Quantity: Tsp, tsp, oz, cup, slice</th>
<th>Details of food and drink: food item, method of preparation (fresh, frozen, baked, canned, broiled, raw), brand, flavor, main ingredients (if home-made food).</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:31</td>
<td>8 oz Whole Milk</td>
<td></td>
</tr>
<tr>
<td>9:01</td>
<td>1 slice Whole Wheat bread</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 slice Cheese</td>
<td></td>
</tr>
<tr>
<td>9:31</td>
<td>3 1/2 oz Orange Juice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 oz</td>
<td>(100% O)</td>
</tr>
<tr>
<td>10:31</td>
<td>1/2 c Ramen Noodle Soup</td>
<td></td>
</tr>
<tr>
<td>1:31</td>
<td>1 Orange</td>
<td></td>
</tr>
<tr>
<td>5:31</td>
<td>8 oz Milk</td>
<td></td>
</tr>
<tr>
<td>5:31</td>
<td>1 oz Chicken</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 1/2 scoops of Mashed Potatoes</td>
<td>(1/4 tsp)</td>
</tr>
<tr>
<td>9:01</td>
<td>1/2 tsp Applesauce</td>
<td></td>
</tr>
<tr>
<td>10:01</td>
<td>3/4 oz Whole Milk</td>
<td></td>
</tr>
</tbody>
</table>
# APPENDIX D: CLIENT DIET RECORD NUTRIENT ANALYSIS

## Client Diet Record Nutrient Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
<th>Unit</th>
<th>Goal</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>163.00</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pottasium</td>
<td>503.33</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (RE)</td>
<td>4200.00</td>
<td>RE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (IU)</td>
<td>2000.00</td>
<td>IU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D (IU)</td>
<td>5.000</td>
<td>IU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin E (mg)</td>
<td>15.147</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin K (IU)</td>
<td>15.535</td>
<td>IU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.420</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.900</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niacin</td>
<td>5.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyridoxine (Vitamin B6)</td>
<td>0.500</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folate (Total)</td>
<td>102.00</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folic Acid (PFE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalamin (Vitamin B12)</td>
<td>1.487</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>226.687</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>240.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine</td>
<td>80.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>44.67</td>
<td>mg</td>
<td></td>
<td></td>
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<tr>
<td>Zinc</td>
<td>6.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>0.553</td>
<td>mg</td>
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<tr>
<td>Manganese</td>
<td>0.047</td>
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<tr>
<td>Selenium</td>
<td>7.733</td>
<td>mg</td>
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<tr>
<td>Fluoride</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notoberden</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary Fiber, Total</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soluble Fiber</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insoluble Fiber</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude Fiber</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar, Total</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galactose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monose</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar Alcohol</td>
<td>0.000</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Carbohydrates</td>
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<td>g</td>
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<td></td>
</tr>
<tr>
<td>Threonine</td>
<td>533.333</td>
<td>mg</td>
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</tr>
<tr>
<td>Isoleucine</td>
<td>763.333</td>
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</tr>
<tr>
<td>Leucine</td>
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<td>mg</td>
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<tr>
<td>Lyline</td>
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</tr>
<tr>
<td>Methionine</td>
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<td>mg</td>
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</tr>
<tr>
<td>Cyline</td>
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<td></td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>406.667</td>
<td>mg</td>
<td></td>
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</tr>
<tr>
<td>Tycine</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valine</td>
<td>820.000</td>
<td>mg</td>
<td></td>
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</tr>
<tr>
<td>Arginine</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Histidine</td>
<td>266.667</td>
<td>mg</td>
<td></td>
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</tr>
<tr>
<td>Alanine</td>
<td>0.000</td>
<td>mg</td>
<td></td>
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</tr>
<tr>
<td>Aspartic Acid</td>
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<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glutamic Acid</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycine</td>
<td>0.000</td>
<td>mg</td>
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<td></td>
</tr>
<tr>
<td>Proline</td>
<td>0.000</td>
<td>mg</td>
<td></td>
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</tr>
<tr>
<td>Serine</td>
<td>0.000</td>
<td>mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Nutrient Goal Template**

### (Client)

- **Protein**: 90.0% (Total)
- **Carbohydrates**: 45.0% (Total)
- **Fat, total**: 45.9% (Total)
- **Alcohol**: 0.0% (Total)

---

*Ansys Systems Nutritionist Pro™*