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The purpose of Part I of this research was to assess the relationship between household food insecurity and infant feeding practices, including initiation and duration of breastfeeding and introduction to solids and beverages among U.S. infants and toddlers ages 0 to 24 months. Data from 3 cycles of the National Health and Nutrition Examination Surveys (2009 – 2014) was used for this study. 2,069 infants and toddlers were included in Phase I analyses.

Survey-weighted analyses revealed that the breastfeeding initiation rate was 74.4% among this population, lower than the estimated breastfeeding initiation rate by the CDC. 43.5% were introduced to other foods prior to 4 months of age. Stratified analyses revealed that lowest initiation and duration rates of breastfeeding occurred among non-Hispanic Blacks. Overall, no significant differences were observed by household food security status after controlling for covariates in multiple regression analysis.

The purpose of Part II of this research was to assess the nutrient intakes of U.S. infants and toddlers ages 6 to 24 months, compare their adequacy to the Dietary Reference Intakes (DRIs), and assess differences by race/ethnicity. 1,160 infants and toddlers were included in Phase II analyses. About 1/3 of infants ages 6 to 11.9 months did not meet the daily carbohydrate or total fat requirement, and about a quarter did not meet the vitamin A or iron requirements. 55.4% of infants exceeded the UL for vitamin

A. Among toddlers ages 12 to 24 months, 96.6% did not meet the requirement for dietary fiber, most exceeded sodium and vitamin A, but 40.5% did not meet iron. By race/ethnicity, Hispanics were at higher risk of not meeting requirements.

EXAMINATION OF BREASTFEEDING RATES AND OTHER FEEDING PRACTICES AMONG US INFANTS AND TODDLERS: RESULTS FROM THE NHANES 2009-2014

by

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CHAPTER I

INTRODUCTION

Obesity has risen dramatically in the US within the past two decades. Not only has the epidemic affected adults, but it is also seen in higher proportions among children and adolescents and is a public health concern thus far[1]. Obesity has long-term effects in both children and adults, and research has shown that even children are experiencing a higher burden of adult-onset chronic diseases[2–4] as a result of excess body weight. There has been a call for research elucidating the risk factors associated with childhood obesity, as well as the potential mechanisms by which the epidemic can be combatted or prevented.

Especially, it is noted that the first 1,000 days of life – starting from the first day of pregnancy to infancy - is a critical period in establishing a healthy weight trajectory for a lifetime[5]. Certain practices such as early cessation of breastfeeding and early introduction of solid foods and beverages have been associated with the development of childhood obesity[6–9]. It has been observed that particularly low-income and racial/ethnic minority caretakers, who are more likely to experience food insecurity, are at higher risk of performing poor feeding practices than their counterparts[10–12].

According to the USDA, in 2017, food insecurity affected about 15 million US households, characterized by inconsistent access to safe and nutritious foods[13,14]. Especially, the food insecurity-obesity paradox is seen among caretakers in the US. The

causes of this paradox are associated to the limited time, knowledge and resources of these households to pursue suitable dietary and lifestyle habits[15–17]. In particular, to satisfy the energy needs of the family, use of convenient and cheap foods, which are generally high in calories, is commonly seen among food insecure households[18–20].

Current literature from small-scale, convenient sampling studies indicates that socio-economic status, including household income, food insecurity and maternal education are strong predictors of low-initiation of breastfeeding, early introduction of solids, and feeding sugary drinks to infants and toddlers[21–24]. However, there is lack of evidence at the national level on current feeding practices, including breastfeeding rates and socio-demographic differences, and to how food insecurity plays a role in predicting feeding practices and nutrient intakes among infants and toddlers[21,23,25].

In order to examine feeding practices at the national level, a secondary analysis of the National Health and Nutrition Examination Surveys (NHANES) will be conducted. NHANES uses a cross-sectional, multi-stratified sampling method to interview 5,000 children and adults every year to assess their health and nutritional status[26]. NHANES data from 2009 to 2014 will be used to test the following specific aims:

1) Determine the associations between household food insecurity and initiation and duration of breastfeeding among infants and toddlers ages 0 to 24 months,
2) Determine the associations between household food insecurity and feeding choices of introduction of solids and beverages among infants and toddlers ages 0 to 24 months, and;

3) Determine the associations between household food insecurity and daily nutrient intakes among infants and toddlers ages 6 to 24 months.

CHAPTER II

HOUSEHOLD FOOD INSECURITY, BREASTFEEDING AND RELATED FEEDING PRACTICES IN US INFANTS AND TODDLERS: RESULTS FROM NHANES 2009-2014

Note: The manuscript below is formatted based on the author's guidelines of a peer-reviewed journal titled "*Journal of Nutrition Education and Behavior*," to which this paper has been submitted and accepted for publication.

Introduction

Breastfeeding provides multiple health benefits to women and children[27]. Breastfeeding promotion has become a national public health priority for countries worldwide[28]. Further, to ensure optimal nutrition and development in early stages of life, breastfeeding policies encouraging women to exclusively breastfeed for the first 6 months has become a significant public health goal[29]. According to the Centers for Disease Control and Prevention (CDC), low rates of breastfeeding adds more than $3 billion yearly in maternal and pediatric healthcare costs[30]. Breastfeeding is considered a healthcare saving investment since it is associated with reduced risk for asthma, obesity, and ear and respiratory infections among infants[7,9,30–32]. Even among mothers, breastfeeding has been associated with lower risk for high blood pressure, obesity, and ovarian and breast cancer[27,30].

In the United States (U.S.), although most infants are breastfed, the majority are not breastfed for the duration recommended by the American Academy of Pediatrics (AAP)[33]. Further, substantial disparities exist by race/ethnicity. Fewer non-Hispanic

Black infants are ever breastfed (69.4%) in comparison to non-Hispanic White and Hispanic infants (86% vs 85%, respectively)[34]. In a study by Marseglia et al, it was fond that poor maternal health (i.e., high post-partum weight retention) and childhood obesity among minority group of non-Hispanic Blacks were in part due to low levels of breastfeeding in the group[35]. Similarly, in a systematic review, Dixon et al documented that early-life risk factors for childhood obesity, such as lower likelihood to breastfeed, premature introduction of complementary foods, and maternal restrictive feeding styles were more prevalent among minority children[36]. Additionally results of the Early Childhood Longitudinal Study indicated that by affecting parenting practices, household food insecurity was associated with overweight among toddlers[24]. These findings are critical, since minority households are more prone to food insecurity. In a study with low-income urban (Haitian and African-American) mother-and-infant dyads, it was found that after adjusting for maternal socio-demographics, low to very low food secure mothers were *2-3 times* more likely than their counterparts to feed their infants sugar-sweetened drinks[23]. Another cross-sectional study of pediatric clinics in low-income areas found that 27% of food-insecure mothers, compared to 9% of food-secure mothers, reported infant formula shortages[21]. Also qualitative studies have shown that through different socio-behavioral pathways, low to very low food security negatively affects breastfeeding practices[16,17]. In these in-depth investigations, the specific factors attributed to low breastfeeding were stress, job instability, financial vulnerability, housing issues and low self-efficacy[25,37].

The present study sought to characterize the relationship between race/ethnicity, food security status and early infant feeding practices using national recommendations on initiation of breastfeeding, duration of breastfeeding and age of introduction to foods/ other drinks, by racial/ethnic groups using cross-sectional data from the National Health and Nutrition Examination Surveys (NHANES). We hypothesized that higher food insecurity would be associated with lower breastfeeding and early introduction to foods/other drinks across all the racial/ethnic groups. The study findings have implications for breastfeeding programs and policies and can inform the 2020 Dietary Guidelines Committee in the development of nutritional recommendations for infants and toddlers.

Methods

A secondary analysis of NHANES data was conducted to examine the relationship between food security status and early infant feeding practices. Operated by the Centers for Disease Control and Prevention (CDC), National Center for Health Statistics, NHANES is a stratified, multi-stage, cross-sectional survey targeting a nationally representative sample of seniors, adults and children, including infants, toddlers and pregnant women living in the US[26]. For the study, NHANES surveys from 2009 to 2014 were merged, which included household-level information and individual-level information on diet, nutritional behaviors and other health measures of the surveillance participants. Since NHANES represents publicly-available, de-identified data, the study was exempt from further approval from UNCG's Institutional Review Board. However, the National Center for Health Statistics Ethics Review Board approved

the NHANES protocols and all the respondents provided informed consent to participate in the survey[38].

For this study, the selection of household members was restricted to infants and toddlers from 0 to 24 months of age for the analyses of their feeding practices. To achieve a sufficiently large group of infants and toddlers by race and ethnicity, six years of NHANES data were merged i.e., from 2009 to 2014. In 2009 to 2014 NHANES, household-level information such as family income, education level and food security status were collected during the in-home interview. The household-level information is provided by an adult member who is at least 18 years old and plays a significant role in household management, and designated as the household 'reference person.' This reference person also answered questions on feeding practices in the in-home interview. Specific information on the relationship of the infant or toddler with the household reference person is not provided in the datasets, but is generally referred to as the primary caregiver or parent. Upon selection of all infants and toddlers over the study period (n = 2,082), we removed participants for whom information on their household food security status was not available, resulting in a final analytic sample of 2,069 participants.

Measures

Infant Feeding Practices. Specifically, 3 feeding practices (breastfeeding initiation, its duration, introduction to solids/other liquids) were examined as dependent variables, using the following questions: 1) Was the sample person (infant/toddler) ever breastfed or fed breastmilk? 2) How old was the sample person (infant/toddler) when (he/she) completely stopped breastfeeding or being fed breastmilk? 3) How old was the

sample person (infant/toddler) when (he/she) was first fed anything other than breast milk or formula? Please include juice, cow's milk, sugar water, baby food, water or anything else that might have been given. Initiation was classified as a binary measure (yes/no) and age at initiation of breastfeeding and introduction of solids were kept as continuous measures (in days).

Food Security. A validated USDA 18-item Food Security Survey Module was used in the NHANES 2009 to 2014 to assess household food security status over the prior 12 months. The scale consists of statements representing coping behaviors or experiences due to insufficient money to buy food, leading to a score ranging from 0 to 18. Based on the summed score, the households are divided into the following four food security categories using the standard USDA scoring guidelines[39]: 1) full food security, 2) marginal food security, 3) low food security, and 4) very low food security. However, to ensure sufficient sample size for each food security category for each racial/ethnic group and produce more stable estimates, the households in this study were divided into the following two categories: food secure (a score of 0 representing full food security, and a score of 1 to 2 representing marginal food security) vs. food insecure (a score of 3 to 7 representing low food security, or a score of 8 to 18 representing very low food security).

Socio-demographics. The following key household-level socio-demographic variables shown to affect infant feeding practices were taken into consideration: 1) household income-to-poverty ratio, 2) education status, 3) race/ethnicity, 4) participation in the Special Supplemental Program for Women, Infants and Children (WIC), and 5) maternal age[40–42]. For household income-to-poverty ratio, income cut-off levels for

eligibility into the Supplemental Nutrition Assistance Program (SNAP) were used[43]. Accordingly, the households were divided into two groups of income, i.e. below 130% of the federal poverty line vs at or more than 130 % of the federal poverty line. The infant/toddlers' race/ethnicity responses were grouped as follows: Non-Hispanic White, Hispanic, Non-Hispanic Black and Other. The Other group was comprised of American Indian, Pacific Islanders and Asian Americans, including multi-racial families. Due to its small size (n=220) and heterogeneity, though this group was included in the statistical analyses, results were not included for the presentation in the paper. Education was classified as less than high school, high school graduate, some college and college graduate or more. Further, participation of an infant in WIC was also included as a covariate.

Data Analysis

For all analyses, the appropriate complex survey design sample weights were considered to account for the probabilities of selection for the participants, oversampling and missing information in the NHANES survey. Refused responses to questions that parents did not want to answer, or answered 'don't know' to, were treated as missing cases. The descriptive analyses were conducted to report survey-weighted means and standard deviations for continuous variables, and as frequencies and percentages for categorical variables. Rao-Scott's weighted Chi-square test was used to detect the statistical difference in food insecurity prevalence by socio-demographics for categorical variables, while for continuous variables (i.e., mother's age), weighted *t* tests were used. Descriptive and bi-variate analysis of infant feeding practices was carried out to estimate

prevalence ratios overall and by race/ethnicity. The differences in feeding practices between food secure and insecure groups were tested in survey-weighted models, using multiple linear regression for continuous variables and multiple logistic regression for categorical variables. To test for interaction, a cross-product term between food security status and race/ethnicity was entered and stratified analyses for the three racial-ethnic groups were conducted. A sensitivity analysis was also conducted to determine the gender of the reference person who answered for the infants and toddlers. Statistical analyses were conducted using the statistical software package SAS (version 9.4; SAS Institute, Cary, NC, 2019). A *P* value of <.05 was considered statistically significant.

Results

In examining socio-demographic characteristics of our study population of infants and toddlers (Table 1), 58.8% were less than 12 months of age while the remaining were toddlers, with nearly equal distribution by gender. By race/ethnicity, 38.2% of the infants and toddlers were Hispanic, followed by 30.9% non-Hispanic White and 20.2% non-Hispanic Black. Among those who responded, 87.4% reported infant participation in the WIC program at the time of survey. By income, half of the study sample was living at or below 130% of the federal poverty line. The prevalence of food insecurity was 25% in the study population. In examining differences by food security status, significant differences were found by race/ethnicity, income and education levels. Specifically, food insecurity was higher among Hispanics, those who had less than a high school education and those whose household income at 130% or below the poverty line. Current participation in WIC was also associated with food insecurity. Further, food insecure

mothers were younger than their counterparts i.e., the average age of food insecure mothers was about 26 years compared to 29 years among the food secure group.

The overall breastfeeding prevalence in the study sample was 74.4%. Specific information on exclusive breastfeeding vs. predominant vs. partial breastfeeding was not available; however, average duration of breastfeeding in our study sample was found to be about 4 months of infant's age (Table 2). Results indicated that on average, other foods/drinks were introduced at 5 months of infant's age. Using age markers of 4 and 6 months, 43.5% of infants and toddlers were fed other drinks and solids such as juice, sugar water and baby food, before they were 4 months old. Using the upper-age limit marker, 85% our study sample had received other solids/beverages before they were 6 months old.

Significant differences were found for breastfeeding rates by race/ethnicity. Non-Hispanic Whites initiated breastfeeding at a rate of 80.0%, followed by Hispanics at 77.5% and non-Hispanic Blacks at 57.4% ($P<.001$). When examining the introduction to something other than breastmilk/formula, no significant differences were seen by race/ethnicity when 4 months was used as the cutoff point. However, at the 6-month cut-off, significant differences were observed by race/ethnicity, with a higher proportion of non-Hispanic Whites introducing other foods/beverages prior to 6 months.

Unadjusted models examining the association between food insecurity and breastfeeding initiation showed that food insecure non-Hispanic White women were less likely to initiate breastfeeding (unadjusted results not shown). However, after adjusting for covariates, such as household income and education, no significant differences were

found by food security status among non-Hispanic Whites. For the other two racial/ethnic groups, food insecurity was not a significant predictor for breastfeeding initiation in adjusted (Table 3) and even unadjusted models. Similarly, as shown in table 3, across all the three racial/ethnic groups, food insecurity was not associated with the practice of feeding something other than breast milk or formula prior to 4 months or 6 months of age. Lastly, multiple linear regression was conducted to examine the relationship between food insecurity and the duration of breastfeeding (Table 4). Like the previous results, for all three racial/ethnic groups, the differences in duration of breastfeeding between food secure and insecure households were not significant after adjusting for sociodemographic covariates.

Discussion

This study provides the most current estimates on initiation and duration of breastfeeding among a nationally representative sample of infants and toddlers. This study updates and extends the current limited literature on the national trend in duration of breastfeeding and timing of introduction of solids and other drinks among infants in the U.S. Only two other large-scale surveys have examined feeding practice for U.S. infants: 1) the Nestlé Feeding Infant and Toddlers Study (FITS),[12,44,45] a cross-sectional survey assessing nutrient intakes of infants, toddlers and preschoolers in the U.S. on a regular basis; and 2) the Infant Feeding Practices Study II (IFPS II)[46]. The IFPS II, sponsored by the CDC, was a longitudinal survey that followed women from the third trimester of pregnancy until their infants were 1 year old. The IFPS II provides key information on dietary trends in the U.S. for the first 1,000 days of life and is a valuable

source of information for the upcoming dietary guidelines for infants and toddlers. The present study adds to this literature by highlighting the relationship between socio-economic status, food insecurity and infant feeding practices among three major racial/ethnic groups in the U.S.

According to the 2018 CDC Breastfeeding Report Card[47], in general, breastfeeding is initiated in 4 out of 5 (83.2%) U.S. infants. In the FITS 2016, the breastfeeding rate was estimated at 83%[12]. We found that 74% of mothers initiated breastfeeding between 2009 and 2014. This rate is very similar to the CDC IFPS II breastfeeding rate of 72%[48]. Since specific details on the exclusivity of breastfeeding was not collected in the 2009 – 2014 NHANES, we were not able to distinguish between exclusive versus mixed breastfeeding. However, in this study, the average duration of breastfeeding was 4 months, indicating that although most infants received breastmilk, they did not continue breastfeeding as long as recommended. Further, results of this study indicate that, irrespective of food security status, breastfeeding duration is significantly lower among household living below the poverty line. When investigating barriers to breastfeeding, in the CDC IFPS II survey it was found that more than 50% of mothers stopped breastfeeding earlier than desired due to difficulties in lactation, including efforts associated with pumping milk[49]. In other studies, unsupportive hospital practices, lack of parental leave at work, including lack of family support, have also been identified as predictors for duration of breastfeeding[50,51].

Comparisons by racial/ethnic group associations, study results indicated that the lowest breastfeeding prevalence was among non-Hispanic Blacks, in both initiation and

duration of breastfeeding. A recent review on racial and ethnic disparities in breastfeeding also highlighted that non-Hispanic Blacks had the lowest breastfeeding rates of all groups[52]. The study suggested that non-Hispanic Black women experience barriers at various socio-ecological levels. Specifically, it indicated that non-Hispanic Black women were more likely to suffer from chronic illness and stress, poor living environments and work in jobs with minimal breastfeeding support, all contributing to systemic barriers[53–56]. Additionally, previous studies have found that historical issues such as slavery, negatively affect breastfeeding among Black women[57–60]. Promotion of breastfeeding is critical among non-Hispanic Blacks, because it could play a significant role in reducing the disproportional burden of obesity and related chronic diseases experienced by this population.

In the present study, 25% of the participants were experiencing moderate-to-severe levels of food insecurity, a higher rate than the national average during the survey period, including the highest rate of 14.9% that was observed in 2011[61]. This difference in food insecurity rates might be due to our restriction of the study population to infants and toddlers, and thus may have resulted in the over-representation of racial/ethnic minority households, who generally exhibit higher birth rates[62] and higher food insecurity[63].

In estimating the association between food insecurity and breastfeeding, no significant difference was found for all three ethnic groups after adjusting for household income and education. Similarly, in the national level study in Canada, Orr et al found that after adjusting for socio-demographics, initiation of breastfeeding was not

significantly different between food secure and insecure women[25]. In another similar study in Canada, an association between food insecurity and duration of breastfeeding was investigated. Similar to this study, no significant relationship was found between food security status and duration of breastfeeding after controlling for household socioeconomic status[64].

It is also important to recognize that breastfeeding practices are strongly influenced by social and ethnocultural factors. For instance, among Hispanics, especially among the Mexican origin group, breastfeeding is a highly expected behavior, hence, less likely to be affected by food security status. Results of an epidemiological study indicated that the significant difference in breastfeeding rates persists between non-Hispanic Black and non-Hispanic White infants even after controlling for sociodemographic characteristics. In explaining differences, low breastfeeding rates among non-Hispanic Blacks were attributed to socio-cultural preferences including poor access to breastfeeding programs and support provided to minority mothers[65].

According to the AAP recommendation[66], anything other than breastmilk and formula should not be introduced before 4 months of infant's age. Specifically, early introduction of complementary foods is found to be associated with gastrointestinal problems, respiratory tract infections and an increased risk of allergy and atopy[67]. In this study, the average age of introduction to anything other than breastmilk or formula was 5 months. In comparison by race/ethnicity, early introduction to solids or other liquids was significantly earlier for non-Hispanic White infants. In case of food insecurity, it was not a significant predictor for early introduction of solids or other liquids after adjusting for

covariates. In that case, the early introduction of solids and food insecurity might be related indirectly, as research indicates that food insecure mothers are more likely to use food for soothing[68]. Previous studies have also shown that food insecure caregivers were more likely to run out of formula at the end of the month increasing risk of using other foods and beverages for feeding infants[24,69,70].

The current secondary analysis of pooled NHANES data has some limitations: half of the respondents in the survey were male, for whom recall error was more likely to occur for questions such as duration of breastfeeding and when the first time anything other than formula or breastmilk was fed to the infant. To maximize the sample of infants and toddlers, 6 years of NHANES data were pooled from 2009-2014. Although this is a recommended approach for analyzing NHANES data, the study period may have captured some secular changes in breastfeeding practices. For example, the World Health Organization first issued its recommendation of exclusive breastfeeding in 2001 and this campaign intensified over the years with major reaffirmation at the national and global levels occurring in 2012. Similarly, during that time, revisions in the WIC program, with a specific focus on expanding breastfeeding support and promotion occurred, which might have led to varying patterns of breastfeeding adoption across the study period. Hence, the study findings may mask year-to-year variation in breastfeeding initiation and duration rates.

Implications for Research and Practice

The current study highlights the need to significantly improve efforts in promoting breastfeeding, specifically among minority women in order to reduce the gap

in health disparities. Infants from low socioeconomic households faced food insecurity and are at risk of not being breastfed and ceasing breastfeeding early. Thus, further strengthening food assistance programs such as WIC, including breastfeeding support programs, and promoting work policies that support breastfeeding among working mothers should be a public health priority. Meeting daily nutrient requirements is critical in infancy for optimal growth and development, and breastfeeding helps in meeting that goal.

CHAPTER III

EXAMINATION OF NUTRIENT INTAKES FROM FOODS AND BEVERAGES AMONG US INFANTS AND TODDLERS: RESULTS FROM NHANES 2009-2014

Note: The manuscript below is formatted based on the author's guidelines of a peer-reviewed journal titled "*PLoS ONE*," where this paper will be submitted.

Abstract

The present study sought to assess macro and micronutrient intakes among U.S. infants and toddlers ages 6 to 24 months old (n = 1160) , compare their adequacy to the Dietary Reference Intakes (DRIs) and asses mean differences by racial/ethnic categories. A secondary analysis was conducting using nutrient intakes on a given day and sociodemographic data from the National Health and Nutrition Examination Surveys (NHANES) from 2009 to 2014. In the current sample, 458 infants ages 6 to 11.9 months and 702 toddlers ages 12 to 24 months were included in the analyses, comprised largely of minority populations and households below 185% of the poverty line. Results indicated that 33% of older infants in the U.S. do not meet the recommendations for carbohydrates and fats and consume high amounts of sodium and vitamin C. However, 25% of older infants did not meet the requirements for iron and half exceeded the upper limit of vitamin A. In addition, toddlers met the requirements for macronutrient intakes, did not meet the requirements for dietary fiber or iron, and exceeded vitamin A. In racial/ethnic analyses, Hispanic toddlers consumed less kilocalories, carbohydrates,

sugar, sodium and iron but consumed higher amounts of vitamin C. This study adds to the current literature on early childhood nutrition and can inform the upcoming 2020 Dietary Guidelines for infants and toddlers. Improvements can be made in the diets of all U.S. infants and toddlers, and the strengthening of public health programs that educate and provide U.S. mothers with nutrition education and other resources.

Introduction

The "First 1,000 Days of Life," the period from conception to the second year of life, is of great significance since the foundations of optimal health, growth and neurodevelopment are established during this time[71]. Specifically, nutrition during this period is critical and plays a major role in setting the stage for growth, development and health later in adulthood. A recent policy statement from the American Academy of Pediatrics (AAP) indicates that the childhood obesity epidemic is in part due to overnutrition during infancy [72]. Especially considering the significance of nutrition in early childhood, the 2020 Dietary Guidelines for Americans will now also include recommendations for infants and toddlers[5].

The Nestlé Feeding Infants and Toddlers Study (FITS), one of the largest epidemiological studies focused on dietary intake among infants, toddlers and preschoolers, indicates that feeding practices contributing to obesity are common among U.S. infants and toddlers, such as low vegetable intake[12]. Furthermore, according to the study, 20 to 30% of toddlers consume sugar-sweetened beverages on any given day. This finding is critical, since sugar-sweetened beverages such as fruit-flavored drinks and soft drinks contribute to excess intake of added sugars and calories, with little to no vitamins

and minerals. In addition to examining food consumption patterns, it is important to assess trends in nutrient intakes to inform policy, program and intervention efforts to improve the health of all infants and toddlers in the U.S.

Research evidence indicates that racial/ethnic minority children are at higher risk of obesogenic feeding and more likely to be obese by 2 years of age compared to their white counterparts[36]. In addition, it is documented that lower breastfeeding rates, premature introduction of solids/beverages and maternal restrictive feeding styles are more common among minority children[24,73,74]. Our recent study confirms that breastfeeding initiation is less likely to occur among black infants compared with white and Hispanic newborns[75]. Even food consumption studies have shown that intake of protein/sugar/fat groups are more common among minority toddlers[76,77].

NHANES collects and provides reliable nutrition and health information of the U.S. population at all ages, including infants and toddlers[26]. Using this data, the aims of this study are to 1) examine daily intake of selected priority nutrients and evaluate their adequacy in relation to the Dietary Reference Intakes (DRIs) for age group 6 to 11.9 months and 12 to 24 months, and; 2) investigate racial/ethnic differences in nutrient intakes among toddlers ages 12 to 24 months in the U.S.

Materials and Methods

*Study Design***.** A secondary analysis of NHANES was conducted to examine the relationship between race/ethnicity and selected nutrient intakes from food and beverage sources. NHANES is a nationally-representative, cross-sectional study conducted yearly to determine the health and nutritional status of the U.S. population[26]. It is a stratified,

multi-stage, cross-sectional survey targeting a nationally representative sample of all life stages, including infants and toddlers. Further, NHANES is unique in that it combines household-level information with individual-level information of nutrition behaviors and health status[26]. The household-level information is provided by an adult who is at least 18 years of age and plays a significant role in the home. This person is designated as the household 'reference person.' For the purposes of this study, participants were restricted to infants and toddlers ages 6 to 24 months for the analyses of their nutrient intakes. To achieve a sufficiently large group of infants and toddlers by each major racial/ethnic group (i.e. Non-Hispanic White, Non-Hispanic Black and Hispanic), the most recent available six years of NHANES data from 2009 to 2014 was used.

Ultimately, to fulfill the objectives of this study, the selection of household members was restricted to infants and toddlers 6 to 24 months of age with complete and reliable 24h recalls, resulting in a final analytic sample of 1,160. Since NHANES represents publicly-available, de-identified data, the study was exempt from further approval by UNCG's Institutional Review Board. However, the National Center for the Health Statistics Research Ethics Review Board approved the protocol for data collection[78]. For the study population of infants and toddlers, written parental consent was obtained, and proxies, usually the mother or primary caretaker of the child, completed the 24h recalls. Infants ages 0 to 6 months were excluded from this study since their diets were primarily based on breast milk and formula, and had a very limited daily oral intake (1 older infant and 1 toddler were breastfed on the days of the 24-h recalls,

hence, nutrient contribution by breastmilk was not imputed). Similarly, nutrient intakes from dietary supplements were not included.

*Dietary Recalls***.** In the NHANES cycles selected for the study, 24h recalls were conducted using the USDA Automated Multiple-Pass Method. In general, two 24h recalls are conducted, with the first recall completed in-person, while the second recall is completed over the telephone approximately 3 to 10 days after[79]. In reference to the study participants of infants and toddlers, dependent *t* tests showed few significant differences between the Day 1 and Day 2 nutrients of interest. In addition, there was a 17% dropout rate for the second telephone recall. Since the goal of this study was not to estimate usual intakes, only the first or Day 1 dietary recall was sought to examine the percentage of infants and toddlers meeting the DRIs and compare mean differences in nutrient intakes by race/ethnicity.

Of the total sample of 1160, 458 were 6- to 11.9-month-old infants and the remaining 702 were 12- to 24-month old toddlers. Based on the previous review on nutrition monitoring of infants and toddlers[80], the following nutrients were selected for analysis in addition to total energy intake and proportion of macronutrients: total sugars (g), sodium (mg), vitamin A, (µg), vitamin C (mg), dietary fiber (g), and iron (mg).

Statistical Analysis

Descriptive statistics on socio-demographics were conducted to describe distribution of study population by gender, race/ethnicity, food security, household income and child participation in the Special Supplemental Program for Women, Infants and Children (WIC). Consistent with the analytic guidelines[81], the appropriate sample

weights were considered in inferential analyses to account for the complex survey design, probability of selection and non-response rates.

Mean nutrient intakes of macronutrients and other selected nutrients were analyzed by the two age categories of infants 6 to 11.9 months old and toddlers 12 to 24 month old, and were compared to the Recommended Dietary Allowance (RDA) or Adequate Intake (AI) of the DRIs set by the National Academy of Medicine[82]. The analysis was conducted to estimate the percentage of older infants and toddlers not meeting (or falling below) the RDA or AI through daily intake of foods and beverages. Estimation was also conducted to examine the percentages of our population groups that exceeded the Tolerable Upper Intake Levels (UL) established for certain nutrients. Briefly, the RDA is the estimated average daily level of a nutrient needed to meet the requirements for nearly all (about 97-98%) healthy people. When the RDA cannot be determined, the AI is used and is based upon experimental and observed estimates of adequate nutrient intakes[83]. Further, the UL has been established for nutrients of which excess intakes can lead to adverse physical and cognitive effects[83].

As a first step, bivariate analysis was conducted to examine differences in nutrient intakes by race/ethnicity for each group of older infants (6 to 11.9 months) and toddlers (12 to 24 months). These were then compared to the established DRIs for each group. Then, linear regression analysis was conducted to compare the differences in mean daily nutrient intakes among toddlers by race/ethnicity; finally adjusting by household income and education. The infants/toddler's race/ethnicity responses were grouped as follows: Non-Hispanic White, Non-Hispanic Black, Hispanic and Other. Although the Other

racial/ethnic group was included in the analyses, results are not presented here due to its small sample size (n = 75) and high heterogeneity and variability of the group, including American Indian, Pacific Islanders and Asian Americans, including multi-racial families. All analyses were conducted using SAS Version 9.4 and statistical significance was set at $p<.05$.

Results

In examining the socio-demographic characteristics of our study population of older infants and toddlers, 61% were 12 months of age or older while the remaining were older infants, with nearly equal distribution by gender (Table 5). By race/ethnicity, 39.9% were non-Hispanic Black, followed by 29.5% non-Hispanic White and 20.5% were Hispanic. Among those included in these analyses, 67.5% of infants and toddlers resided in a household with an income below or equal to 185% of the federal poverty line, with 25.7% living in households experiencing some level of food insecurity (i.e. low or very low food security).

The daily intakes of macronutrients and selected micronutrients for infants and toddlers are presented in Table 6. The average energy intake for older infants was 893 kcal, with a macronutrient distribution of 52.9% of calories coming from carbohydrates, 11.0% coming from protein and the remaining 36.9% of calories coming from fat. The mean intakes for all of the macronutrients were above the established RDA or AI. For instance, the AI for carbohydrate for infants is 95 g, while the mean intake was estimated at 118 g. However, approximately 1 in every 3 older infants did not meet the established recommendations for carbohydrate and fat intakes (Table 6). Among the selected

micronutrients, the daily sodium AI recommendation is established for infants at 370 mg. In comparison, the mean daily intake of sodium among older infants in the study was almost double, at 605 mg. In comparison, 49% of older infants did not meet the daily requirements for sodium. About one-fourth of infants were not meeting the daily requirements for vitamin A or iron, while only 4% surpassed the UL for iron. However, for vitamin A, it was noted that 55.4% of the infants consumed higher than the UL set for vitamin A at 600 ug.

In examining trends among toddlers ages 12 to 24-months age, mean energy intake was 1,251 kcal, with the average macronutrient distribution of calories at 52.4% coming from carbohydrates, 15.3% from protein and 33.5% from fats (Table 6). The average distribution of macronutrients was within the recommended range of Acceptable Macronutrient Distribution Range for this age group; however, 29% of toddlers did not meet the recommendation set for carbohydrates. Further, the AI for dietary fiber among is set at 19 g per day, where almost 97% of toddlers did not meet the daily requirement. Among the other selected micronutrients, the mean intake was estimated at 1,679.3 mgs, more than double the AI. For vitamin A, the average intake was 580 ug per day in comparison to the recommended RDA of 300 ug. It was estimated that 17% of toddlers fell below the recommended RDA, while about 42% exceeded the UL of 600 ug. Similarly, mean vitamin C intake among toddlers was nearly 5 times greater than the recommended guideline, for which most did not surpass the UL. Finally, the average intake of iron was estimated at 9.5 mg, with 40.5% of the toddlers consuming less than the recommended daily requirement.

In estimating the mean differences in nutrient intakes by race/ethnicity, no significant relationships were found for older infants 6 to 11.9 months of age in bivariate and multivariate unadjusted and adjusted analyses (results not presented). However, among toddlers ages 12 to 24 months, significant differences were observed among non-Hispanic blacks for saturated fat and vitamin C intakes (Table 7). Particularly, non-Hispanic Blacks consumed significantly less saturated fats at 16.9 g, compared to the 19.8 g consumed by non-Hispanic Whites. In addition, non-Hispanic Blacks consumed significantly higher amounts of vitamin C at 103.3 mg, compared to the 69.9 mg consumed by non-Hispanic Whites. No significant differences were observed for the other selected macronutrients or micronutrients by race/ethnicity.

Further, when controlling for household income and education levels, the significance differences among these relationships persisted. For example, non-Hispanic Black consumed 3 g less of saturated fat compared to non-Hispanic Whites, even after adjusting for income and education levels (Table 8a). Yet, no other significant differences were observed in the other selected macronutrients. When examining differences in micronutrient status, non-Hispanic Blacks consumed 27.9 mg more of Vitamin C when compared to non-Hispanic Whites (Table 8b). Among the other micronutrients, after controlling for education and income, Hispanics were found to consume 1 mg less of iron that their non-Hispanic White counterparts ($p<0.05$). In explaining the lack of significance between race/ethnicity and other nutrients of interest, household education seemed to affect the relationships for dietary fiber and iron. Specifically, toddlers living in less educated households consumed significantly less dietary fiber (-1.9 ± 0.9 for some

college, and -2.7 ± 0.9 for high school-educated households) and iron (-1.9 ± 0.8 for high school-educated).

Discussion

NHANES is unique in that it oversamples minority populations, including non-Hispanic Blacks, low-income non-Hispanic Whites and Hispanics, in order to achieve a representative sample of US Americans at all ages[81]. Our current knowledge of dietary composition and nutrient intakes of US infants and toddlers comes from two of the largest infant feeding studies, the Feeding Infants and Toddlers Study (FITS) 2016[84]. Yet, the study participants come from a commercial list of infants and toddlers who generally come from higher income, non-Hispanic White households.

In this current study, 25% of the sample population were identified as being food insecure; food insecurity is known to disproportionately affect households with children under 6 years of age, those with low-income and minority populations[63]. In general, research literature indicates that food insecurity is a significant predictor of poor diet quality and overweight/obesity among both adults and children[24]; therefore, the most significant predictors of food insecurity (race/ethnicity, income and education) were selected as the independent variables and covariates of this study, in which food insecurity was not found be a significant predictor of nutrient intakes in preliminary analyses.

Primarily, results of this study indicated that 33% of older infants did not meet the requirements for carbohydrates and fats, while a similar proportion of toddlers did not meet the recommendation for carbohydrate intake among their age group. This is

concerning as macronutrient insufficiency can adversely affect the development of the brain, leading to behavioral dysregulation and poor academic performance in school[85,86]. The general trend shows that protein intakes are higher among our study participants of infants and toddlers, which may displace the intake of the other macronutrients. Although we did not find significant differences in macronutrient intakes by race/ethnicity, Davis et al found that Mexican Americans in particular consumed less energy, carbohydrates and fats compared to non-Hispanic Blacks and Whites[74]. Lack of significant differences in our study could be due to small sample sizes and that we did not separate out Mexican Americans in our Hispanic group.

In addition, both infants and toddlers had high mean intakes of sodium similar to the findings in the FITS 2016 study, although almost half of infants did not meet the established DRI for sodium[84]. It is important to note that although ULs have not been set for children and adults greater than 2 years of age, recommendations to reduce sodium intakes above a certain level have been set in order to reduce the risks of chronic disease, such as high blood pressure and cardiovascular events[87].

There is also concern that both infants and toddlers, and especially Hispanic toddlers, do not meet the recommendations set for iron and surpass the UL set for vitamin A. The FITS 2016 study[88] found that 18% of infants did not meet the recommendations for iron, whereas our study showed that 26% of infants and 41% of toddlers did not meet the RDA for iron. The IFPS II study also found that most infants were not introduced to meats until around 8 months of age, which is of concern since fetal iron stores are

depleted by around 6 months of age; iron found in infant cereals has low bioavailability, potentially accounting for the lack of iron from dietary sources[10].

Iron deficiency during these early stages of life are associated with deficits in neurocognition that may be impossible to reverse, leading to poorer brain function in adulthood[89]. Both infants and toddlers were found to consume excessive intakes of vitamin A. ULs have been established for Vitamin A due to its potential toxic effects as a fat-soluble vitamin, including liver damage and intracranial and skeletal abnormalities[90]. In a secondary analysis, Davis et al found that vitamin A and C intakes were higher among low-income populations ($p < 0.02$ and $p < .0001$, respectively) and among non-Hispanic blacks ($p < 0.06$ and $p < .0001$, respectively). In addition, a staggering 97% of all toddlers do not meet the recommended intake for dietary fiber, which reflects the similar findings observed among older Americans[91]. Fiber is critical for adequate gastrointestinal function and is associated with reduced risks of cardiovascular disease, hypertension, obesity and diabetes[92].

Upon examining racial/ethnic disparities among US toddlers, non-Hispanic Black toddlers had significantly lower intakes of saturated fats and higher intakes of vitamin C. A previous study found similar results, in that non-Hispanic Black children consumed less saturated fats compared to non-Hispanic Whites[93]. Diet-related disparities have been observed among non-Hispanic Blacks and African Americans such as the consumption of diets high in fats, particularly processed foods that are rich in saturated fats and low in fruits and vegetables[94]. In explaining this trend, a previous research paper found that non-Hispanic Black children were more likely to be fed 1% or skim milk, compared to non-

Hispanic Whites and Hispanics[95]. In explaining increased intakes of vitamin C among non-Hispanic Blacks, a previous NHANES study utilizing similar data cycles found that non-Hispanic Black children were more likely to consume the most sugar-sweetened beverages, including 100% juices[96].

This study primarily focused on the contribution of food and beverages to nutrient intakes on any given day among older infants and toddlers in the US. While dietary supplement use is common among younger children, supplementation among these age groups would likely contribute to higher nutrient intakes, or excessive intakes, not represented here. We also did not associate specific nutrient intakes to food groups, which we recognize would inform the type of foods infants and toddlers are consuming. In addition, smaller sample sizes could explain the lack of significant differences observed among most of the selected nutrients. Previous studies have generally reported that nutrient intakes of infants and toddlers generally meet or exceed the recommended dietary guidelines[77,97,98]. The variability observed among mean nutrient intakes and not meeting the RDA/AI or exceeding the UL within the same age group may reflect the variety of cultures and eating practices in the US. Unlike the IFPS II and FITS studies, this study draws from a representative sample of US infants and toddlers, further outlining the dietary shortfalls among children ages 6 to 24 months.

Conclusion

This study is critical and timely in that it adds to the current literature of nutrient intakes and their adequacy among US infants and toddlers, which can inform the 2020 Dietary Guidelines Committee in the development of nutritional recommendations for

infants and toddlers. This study showcases that there are still improvements to be made in the diets of all US infants and toddlers, and calls for the strengthening of public health programs, such as WIC, that educate and provide US mothers with nutritional support and education.

Specifically, providing iron supplementation or resources to mothers concerning iron-rich foods among women of child-bearing age, prior to conception, could prevent the negative effects of iron deficiency at the prenatal and early childhood periods. In addition, tackling fiber intakes among toddlers early on may increase the proportion of older Americans that meet the daily requirement in the future, and reduce the risk of certain morbidities. It may be critical that dietary fiber recommendations be included for these age groups, as this is the period when solids foods are being incorporated into the child's diet. Identifying and encouraging appropriate sources of dietary fiber in early childhood could aid in reducing the risk of chronic disease later in life. Lack of specific guidelines concerning most micro- and macronutrients, especially for the older infant age group of 6 to 11.9 months, prohibits determining the adequacy of the diet.

Overall, there is growing evidence that optimal early childhood nutrition determines future health outcomes, especially to support the rapid growth and development that occurs during this critical time period. Although we did not link these dietary intakes to specific food codes in the NHANES, we recognize that expanding on this research is necessary. Proper nutrition and education are needed to aid mothers even before conception to achieve optimal health in adulthood, acquire appropriate infant feeding practices, and break the cycle of malnutrition and chronic illness. This is

especially crucial among non-Hispanic Black mothers and children who are at higher risk of diet-related health disparities.

CHAPTER IV

OVERALL CONCLUSIONS

This research project updates and extends the current literature on infant feeding practices among US infants and toddlers ages 0 to 24 months. As of yet, research among this population group has been very limited, especially in targeting a representative sample that more closely captures current rates of breastfeeding, initiation of foods and beverages and daily nutrient intakes. Through the secondary analysis of publicly-available, recently published NHANES data, we are able to more accurately capture current dietary feeding practices across varying levels of food security and poverty, household education and race/ethnicity.

Our results indicate that by targeting a representative sample of US infants and toddlers, breastfeeding rates are closer to those estimated by the CDC and lower than those estimated by surveys that target higher-income, higher-education level households. In addition to this, most infants and toddlers are introduced to other foods and beverages by ~5 months of age, while 44% are introduced prior to 4 months of age. However, our research indicates that food security status, more specifically, food insecurity is not a significant predictor of poor feeding practices and nutrient intakes. Further research is needed on the relationship between introduction of solids and beverages in the context of food allergies, overweight/obesity and overall health in the future.

In conclusion, we found that there are improvements to be made in breastfeeding rates and other infant feeding practices among US mothers. Specifically, non-Hispanic Blacks are at a higher risk of not initiating breastfeeding, breastfeeding for shorter durations and not achieving the dietary recommendations set for certain nutrients. We propose the reinforcement of public health programs and policies, such as breastfeeding-friendly workplace policies and the strengthening of food assistance programs, that encourage and educate o optimal feeding practices. These programs not only promote population health in the US, but also provide preventative health measures that reduce health care costs and spending in the future.

Table 1. Demographic and Household Characteristics of US Infants and Toddlers, Overall and By Food Security Status: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 2,069)

	Study Sample (n = 2,069)	**Food Secure (n = 1,547)**	**Food Insecure (n = 522)**	***P*[b]**
	n [%]			
Infant's Age				.10
0 to 5.9 months	621 (30.0)	459 (29.6)	162 (31.0)	
6 to 11.9 months	595 (28.8)	439 (28.4)	156 (29.9)	
12 to 24 months	853 (41.2)	649 (42.0)	204 (39.1)	
Infant's Gender				.18
Male	1,026 (49.6)	754 (48.7)	272 (52.1)	
Female	1,043 (50.4)	793 (51.3)	250 (47.9)	
Race/Ethnicity				< .001
Non-Hispanic White	639 (30.9)	532 (34.4)	107 (20.5)	
Hispanic	791 (38.2)	523 (33.8)	268 (51.3)	
Non-Hispanic Black	417 (20.2)	309 (20.0)	108 (20.7)	
Other	222 (10.7)	183 (11.8)	39 (7.5)	
Currently receiving WIC [a] (n = 1,333)				<.001
Yes	1,165 (87.4)	762 (85.9)	403 (90.4)	
No	168 (12.6)	125 (14.1)	43 (9.6)	
Income-to-poverty ratio (n = 1,891)				<.001
Above 130%	943 (49.9)	842 (59.3)	101 (21.5)	
Below or equal to 130%	948 (50.1)	579 (40.7)	369 (78.5)	
Education (n = 2,020)[c]				<.001
College or more	434 (21.5)	407 (26.8)	27 (5.4)	
Some college	585 (29.0)	475 (31.2)	110 (22.0)	
High school	485 (24.0)	355 (23.4)	130 (26.0)	
Less than high school	516 (25.5)	283 (18.6)	233 (46.6)	
	Mean (SD)	Mean (SE)		<.001
Mother's age when the infant was born (n = 2,066)[d]	27.5 (6.2)	28.5 (.26)	26.3 (.29)	

[a]WIC refers to the Special Supplemental Nutrition Program for Women, Infants and Children. [b]Rao-Scott's weighted Chi-square test for categorical variables, and weighted *t* test for continuous variable of mother's age.

[c]Represents the educational level of the head of the household and not necessarily the infants' mother's education level.

[d]Mother's age is at the time of delivery and not at the time of survey.

Table 2. Prevalence and Mean Days of Breastfeeding and Other Feeding Practices in US, Overall and by Race/Ethnicity: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 2,069)

Infant Feeding Practices	Total	Non-Hispanic White (n = 639)	Hispanic (n = 791)	Non-Hispanic Black (n = 417)	*P*[a]
Initiated breastfeeding (n = 2,065)	1,536 (74.4)	495 (80.0)	618 (77.5)	241 (57.4)	< .001
Fed anything other than breastmilk or formula before 4 months (n = 1,679)[b]	731 (43.5)	250 (44.7)	262 (38.5)	153 (44.4)	0.18
Fed anything other than breastmilk or formula before 6 months (n = 1,679)[b]	1,424 (84.8)	458 (87.3)	541 (81.6)	274 (80.0)	.02
Duration of Breastfeeding (in days) (n = 2,064)[c]	105 (135)	137 (8)	111 (8)	72 (6)	< .001
Infant's age when anything other than breast milk or formula was first fed (in days) (n = 1,679)[b]	154 (77)	151 (4)	163 (3)	156 (5)	< .001

[a]Rao-Scott's weighted Chi-square tests for categorical variables, weighted ANOVA for continuous variables; the other category of race/ethnicity not shown (n = 222).[b]390 cases were missing because they responded 'never' to the question: "How old was the infant/toddler when he/she was first fed anything other than breast milk or formula (juice, cow's milk, sugar water, baby food, or even water)?"; most of those who responded 'never' were in the younger age categories of 3 months or less. [c]Includes those who never initiated breastfeeding (duration was zero); 459 cases were 'still breastfeeding' and were assigned a value of their age at the time of survey.

Table 3. Odds of Practicing Poor Infant Feeding Behaviors Among Food Insecure Households by Race/Ethnicity: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 2,069)

Non-Hispanic White (n = 639)	**Hispanic (n = 791)**	**Non-Hispanic Black (n = 417)**
Adjusted OR (95% CI)[a]		
Not initiating breastfeeding[b,c]		
1.45 (0.83, 2.54) *P* = .19	1.10 (0.55, 2.20) *P* = .79	0.82 (0.50, 1.33) *P* = .41
Introducing other solids/beverages prior to 4 months of infant's age[b,c]		
1.43 (0.83, 2.47) *P* = .19	1.03 (0.66, 1.62) *P* = .90	0.68 (0.33, 1.40) *P* = .29
Introducing other solids/beverages prior to 6 months of infant's age[b,c]		
2.01 (0.77, 5.29) *P* = .15	1.17 (0.74, 1.83) *P* = .49	0.85 (0.37, 1.97) *P* = .69

[a]OR: Odds Ratio; CI: Confidence Intervals. Stratified multiple logistic regression was used in order to generate the odds ratios by each race/ethnic category, with food secure group as the reference category; hence, the odds ratios and confidence intervals represent the likelihood of the feeding behavior among food insecure households. Because of heterogeneity and small sample size, the "other" race/ethnic group is not reported (n = 222).

[b]Represents the fully-adjusted model including household food security status, infant's gender (male vs. female), household reference person's education level (college or more vs. some college vs. high school vs. less than high school), income-to-poverty ratio (above 130% vs. at or below 130%), current participation in the WIC program (yes vs. no), mother's age at the time of delivery (continuous).

[c]For the Hispanic group, to account for acculturation, nativity status (born in the US vs. born outside of the US) was also included in the final model. Also, since few cases fell into the college or more category, educational level for the Hispanic group was categorized as high school or more vs. less than high school.

Table 4. Estimated Differences in Duration of Breastfeeding Among Food Insecure Households by Race/Ethnicity: National Health and Nutrition Examination Surveys 2009 - 2014 (n = 2,069)

Non-Hispanic White (n = 639)	**Hispanic (n = 791)**	**Non-Hispanic Black (n = 417)**
Adjusted Differences (SE)[a]		
Duration of Breastfeeding in Days[b,c]		
-29 (17) *P* =.10	-2 (11) *P* = .83	+11 (15) *P* =.46

[a]SE: standard errors. Stratified, weighted multiple linear regression was used in order to generate means and standard errors by each racial/ethnic category, with food secure group as the reference group; hence, the beta estimates represent the difference in days of breastfeeding among food insecure households compared to food secure households. Because of heterogeneity and small sample size, the "other" group of race/ethnicity is not reported (n = 222). Results include those who never initiated breastfeeding (duration of zero) and the 459 cases who were still breastfeeding were assigned a value of their age at the time of survey.

[b]Represents the fully-adjusted model including household food security status, infant's gender (male vs female), household reference person's education level (college or more vs. some college vs. high school vs. less than high school), income-to-poverty ratio (above 130% vs. at or below 130%), current participation in the WIC program (yes vs. no), mother's age at the time of delivery (continuous).

[c]For the Hispanic group, to account for acculturation, nativity status (born in the US vs. born outside of the US) was included in the final model. Also, since few cases fell into the college or more category, educational level for the Hispanic group was categorized as high school or more vs. less than high school.

Table 5. Sociodemographic and Household Characteristics of Infants and Toddlers Ages 6 to 24 Months: National Health and Nutrition Examination Surveys 2009 – 2014

	6–11.9 mo	12-24 mo	6-24 mo
n[a]	458	702	1,160
		(%)	
Infant's gender			
Male	49.1	49.7	49.5
Female	50.9	50.3	50.5
Race/ethnicity			
Non-Hispanic White	31.0	28.5	29.5
Hispanic	40.0	39.9	39.9
Non-Hispanic Black	19.9	20.9	20.5
Other	9.1	10.7	10.1
Income-to-poverty ratio			
>185%	29.7	34.3	32.5
≤185%	70.3	65.7	67.5
Household food security status (n = 1,153)			
Food secure	72.1	75.8	74.3
Food insecure	27.9	24.2	25.7
Currently receiving WIC[c] (n = 811)			
Yes	95.5	75.2	83.5
No	4.5	24.8	16.5
Education[d] (n = 1,130)			
College or more	18.0	19.4	18.8
Some college	26.4	30.6	28.9
High school	28.8	23.6	25.7
Less than high school	26.8	26.4	26.6
Mother's age[e] (n = 1,158)	26.9 ± 6.2	27.3 ± 6.2	27.2 ± 6.2

[a]Unweighted sample sizes

[b]Values are weighted percentages

[c]Represents infant or toddler participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) in the previous 12 months from the time of survey.

[d]Represents the highest educational level completed by the head of the household and not necessarily the childs' mother's education.

[e]Mother's age at the time of delivery and not at the time of survey, values presented as mean ± SD.

Table 6. Mean Intake of Macronutrients and Selected Micronutrients Among US Infants and Toddlers, and its Comparison to the DRIs: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 1,160)

	6-11.9 mo	DRIs[b]		%[c]		12-24 mo	DRIs[b]		%[c]	
Nutrients	**Mean ± SD**[a]	RDA/AI	UL	< RDA/AI	>UL	**Mean ± SD**[a]	RDA/AI	UL	< RDA/AI	>UL
Energy, kcals	893 ± 19.9					1251 ± 29.1				
Carbohydrate, g	118.2 ± 2.7	95*	ND	34.6	----	164.0 ± 4.5	**130**	ND	28.9	----
Carbohydrate, % kcal	52.9	ND	ND	----	----	52.4	45 – 65%	ND	100	----
Protein, g	24.5 ± 0.8	**11.0**	ND	5.4	----	47.9 ± 0.9	**13**	ND	< 1	----
Protein, % kcal	11.0	ND	ND	----	----	15.3%	5 – 20%	ND	100	----
Total Fat, g	36.6 ± 0.9	30*	ND	35.5	----	46.5 ± 1.1	ND	ND	----	----
Fat, % kcal	36.9	ND	ND	----	----	33.5%	30 – 40%	ND	100	----
Total Saturated Fat, g	15.0 ± 0.4	ND	ND	----	----	18.8 ± 0.5	ND	ND	----	----
Total Sugars, g	78.8 ± 1.8	ND	ND	----	----	92.0 ± 2.8	ND	ND	----	----
Dietary Fiber, g	5.5 ± 0.3	ND	ND	----	----	9.0 ± 0.3	19*	ND	96.6	----
Sodium, mg	605.0 ± 30.9	370*	ND	48.8	----	1679.3 ± 45.9	800*	ND	7.9	----
Vitamin A (Retinol Activity Equivalents), µg	697.1 ± 20.1	500*	600	26.8	55.4	580.2 ± 20.1	**300**	600	17.0	41.6
Vitamin C, mg	100.4 ± 3.9	50*	ND	11.0	----	77.1 ± 3.5	**15**	400	10.6	< 1
Iron, mg	17.6 ± 0.6	**11**	40	25.9	3.8	9.5 ± 0.3	**7**	40	40.5	< 1

[a]Survey-weighted means of Day 1 total nutrient intakes.

[b]*DRIs or Dietary Reference Intakes* are reference values that are quantitative estimates of nutrient intakes for healthy people. They include both recommended intakes and the highest level that is likely to pose no risk of adverse health effects. The DRIs are set by the National Academy of Medicine and include: RDA or Recommended Dietary Allowance - the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a group; AI or Adequate Intake - a value based on observed or experimentally-determined approximations of nutrient intakes by a group of healthy people, used when an RDA cannot be established; UL or Tolerable Upper Intake Level - the highest level of a nutrient that can be consumed without any likely risk of adverse effects.
RDA is presented in the **bold** type, while AI is displayed in ordinary type followed by an asterisk (*).
AMDR or Acceptable Macronutrient Distribution Ranges - the recommended percentage of calories from carbohydrates, proteins and fats. ND: Not Determined for RDA/AI, or for ULs due to lack of data of adverse effects among these age groups.
[c]These columns represent the estimated proportions of infants and toddlers with a) intakes lower than the RDA or AI, and b) those exceeding the UL.

Table 7. Racial/Ethnic Differences in Mean Nutrient Intakes Among US Toddlers: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 702)[a]

	Non-Hispanic Black (n = 147)	**Hispanic** (n = 280)	**Non-Hispanic White** (n = 200)
Nutrients			
Energy, kcals	1318.3 ± 33.0	1181.8 ± 23.5	1281.7 ± 54.3
Carbohydrate, g	181.6 ± 4.2	152.8 ± 3.9	166.4 ± 7.6
Protein, g	46.5 ± 1.7	46.9 ± 1.0	49.1 ± 2.0
Total Fat, g	46.7 ± 2.0	44.0 ± 1.3	48.4 ± 2.2
Total Saturated Fat, g	16.9 ± 0.8*	18.1 ± 0.5	19.8 ± 1.0
Total Sugars, g	99.0 ± 2.9	87.1 ± 2.0	93.2 ± 4.9
Dietary Fiber, g	9.1 ± 0.3	8.3 ± 0.4	9.4 ± 0.5
Sodium, mg	1903.2 ± 91.5	1567.6 ± 47.8	1701.8 ± 92.3
Vitamin A (Retinol Activity Equivalents), µg	556.5 ± 51.0	548.4 ± 22.3	608.2 ± 28.1
Vitamin C, mg	103.3 ± 9.3*	79.6 ± 5.0	69.9 ± 5.3
Iron, mg	10.6 ± 0.4	8.6 ± 0.5	9.5 ± 0.4

*Asterisk indicates significance of $p<0.05$.

[a]Survey-weighted linear regression (unadjusted) was used in order to generate mean nutrient intakes and standard errors for each race/ethnic category, with non-Hispanic Whites as the reference group; hence, the estimates represent the differences in mean nutrient intakes of each minority group compared to non-Hispanic Whites.

The 'other' group was included in the model; however, results are not presented here due to small sample size (n = 75) and high variability among Asian, Pacific Islander, Native American and multiracial ethnic groups.

Table 8a. Adjusted Linear Regression Model for Macronutrient Intakes by Race/Ethnicity Among US Toddlers: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 702)[a]

	Energy (kcal)	Fat (g)	Saturated Fat (g)	Protein (g)	Carbohydrate (g)	Total Sugar (g)
Race						
Non-Hispanic White	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Hispanic	-124.9 ± 69.8	-5.4 ± 3.2	-2.3 ± 1.4	-2.1 ± 2.6	-17.4 ± 9.2	-10.0 ± 7.7
Non-Hispanic Black	32.3 ± 69.5	-2.2 ± 3.4	-3.2 ± 1.4*	-2.2± 3.2	15.1 ± 9.3	3.6 ± 6.6
Education Level						
College or more	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Some college	8.9 ± 83.8	-1.4 ± 3.5	-0.3 ± 1.4	-0.9 ± 3.4	5.6 ± 12.6	11.0 ± 6.1
High school	-10.5 ± 77.2	-1.0 v 3.4	0.2± 1.7	1.3 ± 4.1	-2.6 ± 9.9	9.9 ± 6.0
Less than high school	46.1 ± 123.9	-0.1 v 5.2	1.2 ± 2.6	0.5 ± 4.2	10.9 ± 18.3	15.1 ± 11.8
Income-to-Poverty						
> 185%	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
≤ 185%	28.6 ± 59.4	2.0 ± 2.8	0.3 ± 1.2	-1.1 ± 3.3	3.1 ± 7.7	1.0 ± 5.0

*Asterisk indicates significance of $p<0.05$.

[a]Adjusted linear regression was used to in order to generate mean nutrient intakes and standard errors for each race/ethnic category. The values represent mean nutrient intakes on a given day for toddlers after adjusting for household-level income and education, with non-Hispanic White toddlers as the referent group. The 'other' group was included in the model; however, results are not presented here due to small sample size (n = 75) and high variability among Asian, Pacific Islander, Native American and multiracial ethnic groups.

Table 8b. Adjusted Linear Regression Model for Micronutrient Intakes by Race/Ethnicity Among US Toddlers: National Health and Nutrition Examination Surveys 2009 – 2014 (n = 702)[a]

	Sodium (mg)	Vitamin A (RAE), µg	Vitamin C (mg)	Dietary Fiber (g)	Iron (mg)
Race					
Non-Hispanic White	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Hispanic	-139.0 ± 115.5	-47.2 ± 34.8	3.6 ± 6.4	-0.8 ± 0.5	-1.1 ± 0.5*
Non-Hispanic Black	192.6 ± 156.1	-37.1 ± 54.5	27.9 ± 10.5*	0.4 ± 0.6	1.1 ± 0.6
Education Level					
College or more	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Some college	11.7 ± 121.7	20.7 ± 47.5	6.4 ± 8.3	-1.9 ± 0.9*	-1.1 ± 0.9
High school	-71.9 ± 113.1	23.1 ± 69.4	14.0 ± 8.4	-2.7 ± 0.9*	-1.9 ± 0.8*
Less than high school	-111.6 ± 163.3	31.0 ± 72.6	5.5 ± 13.2	-1.2 ± 1.1	-1.0 ± 1.3
Income-to-Poverty					
> 185%	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
≤ 185%	90.2 ± 109.7	-64.2 ± 39.7	10.9 ± 8.8	-0.2 ± 0.5	1.2 ± 0.7

*Asterisk indicates significance of $p<0.05$.

[a]Adjusted linear regression was used to in order to generate mean nutrient intakes and standard errors for each race/ethnic category. The values represent mean nutrient intakes on a given day for toddlers after adjusting for household-level income and education, with non-Hispanic White toddlers as the referent group. The 'other' group was included in the model; however, results are not presented here due to small sample size (n = 75) and high variability among Asian, Pacific Islander, Native American and multiracial ethnic groups.

RAE = Retinol Activity Equivalents.

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