USUAL NUTRIENT INTAKES OF INFANTS AND TODDLERS

IN SAN MARCOS, TX REFLECT REGIONAL

DIFFERENCES IN NUTRITION RISK

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INTRODUCTION

Background

Estimating the adequacy of nutrient intakes is an important method for monitoring dietary sufficiency and disease susceptibility within a population. In the United States (US), estimates of nutrient intakes are used to determine the effectiveness of nutritional support programs, monitor nutritional improvement among at risk-populations, and drive national policies regarding enrichment and fortification. Currently, two nationally representative studies provide the majority of data regarding nutrient intakes within the US population. The National Health and Nutrition Examination Survey (NHANES), administered by the National Center for Health Statistics, focuses on the health and nutritional status of children and adults in the US.[1] The Nestlé Feeding Infants and Toddlers Study (FITS), conducted through funding from industry, provides analogous data for US infants and toddlers.[2] Whereas NHANES has been collecting data since 1962, FITS has completed just two rounds of surveys, the first in 2002 and the most recent in 2008. As the only nationally representative study measuring nutrient intake among infants and toddlers in the US, FITS provides essential data to governments, agencies, and researchers.

The most recent FITS study showed that younger infants (ages 4-5.9months), older infants (ages 6-11.9months), and toddlers (ages 12-23.9months) consumed diets providing at least the recommended amounts of most nutrients; however, certain nutrients were consumed in inadequate or excessive amounts.[3] According to this study, approximately 12% of 6-11.9month (m) infants had an intake of iron that was less than the Estimated Average Requirement (EAR), and toddlers' mean intakes of potassium and fiber fell below the Adequate Intake (AI).[3] In contrast, preformed vitamin A (retinol) and sodium were consumed in excess of the Upper Limit (UL) by 31% and 45% of toddlers, respectively.[3] Additionally, while mean energy intakes decreased across all age groups in the six years between the 2002 and 2008 FITS studies, in 2008 mean energy intakes still exceeded the Estimated Energy Requirement (EER) based on standard height and weight for younger infants, older infants, and toddlers.[3]

While the national FITS studies provide useful information about nutrient intake among the US population as a whole, it is important to investigate nutrition risk on a smaller scale. Race, ethnicity, geographic location, regional and cultural feeding practices, and socioeconomic status can influence dietary preferences and access to healthy foods, and thereby, impact the nutritional status of infants and toddlers. [4-7] Moreover, studies focused on regional populations have demonstrated that large, national studies can sometimes overlook potentially detrimental levels of nutrient deficiency present in specific segments of the population. Studies in Atlanta, GA and Minneapolis, MN show higher rates of iron, zinc, and vitamin D deficiencies among low-income minority populations than would be expected based on national averages.[8-10] A study specifically comparing Hispanic infants and toddlers to non-Hispanic infants and toddlers within the FITS 2002 dataset demonstrated that Hispanics had significantly lower intakes of calcium, fiber, and vitamin E and significantly higher intakes of sodium and vitamin A than non-Hispanics.[7] While the incidence of overweight among children is increasing world-wide, [11] data from Texas show that Hispanic children are twice as likely to be overweight as non-Hispanic children, and that this difference may be driven, in part, by cultural perceptions of body composition.[12] Some authors even suggest that obesity among Hispanic children is masking stunting, which is occurring as a result of greater nutritional deficiencies.[13] Given the essential role played by many nutrients in cognitive development and the increased risk for chronic disease associated with obesity, failing to accurately measure nutrient intakes among at-risk populations ties these populations to a vicious cycle of disadvantage.

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a nutrition assistance program administered through the US Department of Agriculture and funded through the Child Nutrition and WIC Reauthorization Act, most recently reauthorized in 2009. WIC provides supplemental foods, nutrition education, and healthcare referrals to low-income women, infants, and children at nutritional risk, annually serving approximately nine million throughout the US, and 971,000 in the state of Texas.[14, 15] In 1972, when the program was founded, the WIC food benefits package was created to provide adequate levels of five key nutrients: calcium, vitamin A, protein, iron, and vitamin C. Although minor changes subsequently added a few nutrient-dense foods to the package, no major adjustment was made between 1972 and the early 2000's, despite data demonstrating changing nutritional status among children in the US.[16] A 2005 report by the Institute of Medicine (IOM) recommended changes to realign the WIC food package with current dietary guidelines, and in 2007 an interim rule mandating changes to the package was published in the Federal Register.[16, 17] Changes in the packages aimed to more effectively promote breastfeeding and age-appropriate introduction of cow's milk, reduce consumption of juice, reduce overall caloric consumption, reduce iron deficiency, promote fruit and vegetable consumption, and balance program costs.[18] Changes to the WIC food benefits package are summarized in Tables 1 and 2. These changes were implemented in October 2009 by the CTX-WIC regional office.

Given that WIC serves an inherently high-risk population, studies of nutrient intakes among regional WIC populations provide useful assessments of regional nutritional risk. Additionally, studies of nutritional status among WIC participants can provide useful feedback regarding program effectiveness.[19] For example, a study of feeding practices among families participating in WIC in Chicago, IL revealed racially disparate dietary patterns that contributed to differences in nutrient intake. A study of 12-36m toddlers participating in two California WIC programs demonstrated reduced risk for iron deficiency among children who were participating in WIC, and among children whose mothers participated in WIC while they were pregnant.[20] A study of food providers in Connecticut showed improved access to healthy foods in low-income neighborhoods after the WIC package change.[21]

Measuring Nutrient Intakes

The 24-hour dietary recall (24HR) is the accepted method for surveying the dietary intake of a population, and for comparing that intake to a reference standard.[22] The 24HR offers a number of advantages over other dietary assessment methods (e.g. food frequency questionnaires). Benefits include increased accuracy because the participant is asked to recall food intake over a recent, discrete period of time, increased flexibility because the foods included in the recall are not limited to those selected for use on a questionnaire, and increased reliability because the tool is administered retroactively and does not influence a participant's diet.[22-24]

The 24HR is also subject to certain types of error, including systematic error, which cannot be corrected through statistical modeling alone, and random error, which can be corrected through statistical modeling (as described below).[25] Systematic error is inherent to the 24HR and results from, for example, participants incorrectly estimating portion sizes and over- or underreporting problem foods. Previous studies have shown that this type of error exists in 24HR data even when participants are trained and are given reference books for use during the recall.[26] A new line of research attempts to correct for systematic error within the 24HR data through comparison to known, unbiased nutrient-specific biomarkers.[24, 27-29] For example, in 2004, Freedman and colleagues compared estimates of usual energy and protein intake in a population of healthy adults to measured levels of energy and protein biomarkers within a similar reference population.[28] The authors proposed that incorporating available biomarker data into the statistical model for estimating nutrient intakes may mitigate systematic error within the 24HR, but stipulated that this is only possible with certain nutrients for which biomarkers are available.

The random error associated with the 24HR reflects intra-individual variability in dietary intake. The diet of any individual, and therefore that individual's nutrient intake, fluctuates from day to day, and this variability cannot be captured within one 24HR. As a result, while population estimates of nutrient intake based on a single 24HR may reasonably estimate mean intake, such methods overestimate the proportion of the population with excessive or deficient intakes.[22, 30] That is, a simple average of individual 24HRs across a population will produce a distribution of nutrient intakes with an accurate mean, but an artificially high kurtosis.[31] This can be corrected by completing many non-consecutive 24HRs, but completing a high number of 24HRs per study participant increases the cost of research and places an undue burden on participants.[32]

Various statistical methods have been developed and tested in order to account for the random error associated with 24HR data. These methods are reviewed in Table 3. Each of these methods requires the completion of at least two 24HRs for a subset of the study population, and estimates the "usual intake" of nutrients. This usual intake distribution approximates the distribution of the long-term average intake of a given nutrient for the population. In general, each of the methods follows the same basic mathematical steps, including: 1) preliminary adjustments to the data, 2) transformation of the data to approximate normality, 3) estimation of the usual intake distribution, and 4) transformation of the estimated usual intake distribution back to the original scale.

While each method has specific strengths and weaknesses,[23] the IOM has identified two statistical methods, the Iowa State University (ISU) method and the National Resource Council (NRC) method, as particularly effective in the estimation of usual nutrient intakes from recall data.[31-33] Indeed, the ISU method is the method of choice within nutrition research, and has been used repeatedly to estimate nutrient intakes for large groups within the United States.[3, 7, 26] As stated by the IOM in 2003, the ISU method requires a sample size of over 100 individuals, whereas the NRC method more effectively estimates the usual intake distribution for smaller samples.[32] Dodd addresses this same issue in his 2006 review paper, but advocates the Best Power method (a derivation of the ISU method) for use with smaller samples. Dodd points out that the Best Power method includes a transformation of the usual intake distribution back to the original scale, allowing comparison of usual intake percentiles with published dietary reference standards.[23]

The most recently published method for the estimation of usual nutrient intakes, the National Cancer Institute (NCI) method, not only addresses the issue of smaller sample sizes, but also offers a strategy for dealing with episodically consumed foods.[34] Many foods that deliver important nutrients are consumed on less than a daily basis (i.e. episodically). For example, fish is consumed only occasionally by many adults in the US, and therefore food-based intake of docosahexaenoic acid (DHA) is irregular.[30] When measured via 24HR, DHA presents a high number of zero intakes and an intake distribution that is severely skewed to the right. Usual intakes of nutrients like DHA may not be accurately estimated by statistical methods that fail to account for this skewness.[35] The NCI method accounts for episodic consumption and so may more accurately estimate the usual intake distribution of many nutrients.[35]

Objectives and Hypotheses

This study used the NCI method to assess the usual nutrient intakes of children ages 4-24m enrolled in a Central Texas WIC program (CTX-WIC) before and after the change to the WIC food benefits package. This study addressed two primary questions: 1) How do the usual intake distributions for select nutrients compare within the CTX-WIC population before and after the WIC package change? 2) How do usual nutrient intake distributions for select nutrients compare between the study population (CTX-WIC) and infants and toddlers nationally?

With regard to the first question, infants and toddlers enrolled in CTX-WIC were expected to have lower usual intakes of kilocalories and carbohydrates and higher usual intakes of iron, zinc, and potassium after the package change, because the package change was intended to promote consumption of foods rich in iron, zinc, and potassium instead of calorie-dense, sugary foods. With regard to the second question, infants and toddlers enrolled in CTX-WIC were expected to have higher usual intakes of kilocalories and carbohydrates compared to the national average because of the increased risk for obesity in this population relative to the national average. CTX-WIC infants and toddlers were expected to have lower usual intakes of iron, zinc, and vitamin D, because consumption of these foods is typically lacking in low-income populations.

METHODS

Recruitment

Cross-sectional survey data was used to examine usual nutrient intakes of infants and toddlers enrolled in the CTX-WIC program. Following a convenience sampling strategy, participants were recruited during regular visits to the CTX-WIC clinic from June to September of 2009 (before the package change) and July to November of 2011 (after the package change). To recruit, researchers gave standardized presentations during WIC-mandated nutrition education classes, met with interested caregivers to determine eligibility, obtained informed consent, explained details of study participation, and provided the *Food Amounts Booklet*, an illustrated guide to portion sizing used by FITS.[26, 36] To incent participation, interested caregivers were promised a $10 gift card to a local grocery store upon completion of data collection. English and Spanish-speaking researchers were present throughout recruitment. Recruitment goals were set at approximately 25% of the total CTX-WIC enrollment.[37] Caregivers with a child aged 4-24m were eligible to participate. Only one child from each household was included in the study. All study protocols were pre-approved by state and university Institutional Review Boards, and informed consent was received from all study participants prior to data collection.

Data Collection

Within 10 days of recruitment, researchers contacted study participants by phone and administered demographic, health history, and feeding practice questionnaires modeled after questionnaires used in the FITS study.[36] At least 10 attempts were made to contact caregivers before they were considered unreachable and excluded from the study. Following completion of the questionnaires, researchers asked caregivers to provide information regarding their child's diet over the last 24 hours, using the multi-pass 24 hour recall (24HR) method administered through the Nutrition Data System for Research (NDSR).[38] The 2008 version of the software was used in 2009 and the 2011 version was used in 2011. The two versions differ only in their treatment of Vitamin D. In the 2008 version, ergocalciferol (vitamin D2) and cholecalciferol (D3) are reported in combination as "calciferol", whereas in the 2011 version, ergocalciferol and cholecalciferol are reported separately.[38] Interviews were conducted in English or Spanish depending on the desire of the participant.

Second Dietary Recalls

In order to estimate the usual nutrient intake of a population, it is necessary to have at least two nonconsecutive days of dietary recall data from at least some individuals in the population.[22] Researchers in both years attempted to collect a second dietary recall for approximately 50% of the sample. After collecting the initial 24HR, researchers asked participants if they were interested in completing a second 24HR for an additional $10 gift card. Those who expressed interest were called and, if they answered within the first 10 attempts, dietary intake data were collected. If, after ten phone calls, a participant could not be reached, she was replaced with another previously interviewed participant.

Data Analysis

Usual Nutrient Intakes

Estimation of usual intake distributions was completed in SAS (SAS Institute, Cary, NC, Version 9.1) using the procedures developed by researchers at the National Cancer Institute (the NCI Method).[30, 35] By this method, a usual intake distribution is estimated for a single nutrient by means of two SAS macros, MIXTRAN and DISTRIB. The MIXTRAN macro uses the SAS procedure NLMIXED to fit a nonlinear, mixed effects model to data from the first and second dietary recalls. The DISTRIB macro uses Monte Carlo simulation to produce the usual intake distribution based on parameter estimates produced by MIXTRAN.

The NCI Method assumes that 24HR data can be transformed to a normal scale. Prior to analysis, we reviewed the frequency distribution, skewness, and kurtosis of each nutrient in SPSS (IBM SPSS Statistics 20.0.0. 2011. Chicago: SPSS Inc.) and since no episodes of bi- or multi-modality or excessive skewness were exhibited, it was assumed that all data could be transformed to a normal scale.

The NCI method allows for the incorporation of covariates, and thereby enables subgroup analysis within samples of at least 100 individuals. Usual intake distributions were estimated for nutrients of interest based on intake data from 2009 and 2011 separately, using child's age category (4-5.9m, 6-11.9m, 12-23.9m) as a subgroup within each year. As appropriate to each nutrient, the AMDR, AI, EAR, and UL were included as cut-points for the assessment of nutrient intakes. Because the study was conducted according to a convenience sampling strategy, survey weights were not incorporated into usual intake analysis.

The NCI method addresses a key point that is not addressed by other methods for estimating usual intake distribution: it differentiates between nutrients consumed on a daily basis (regularly consumed), and nutrients consumed on a periodic basis (episodically consumed).[39] Therefore, prior to analysis, each nutrient was examined to determine the frequency of consumption. As per standards established by Dodd, *et al*, nutrients that were absent from the diet in more than 10% of participants were classified as episodically consumed, while nutrients that were absent from the diet in less than 5% of participants were classified as regularly consumed.[25] Usual intake distributions were estimated for episodically and regularly consumed nutrients using the CORR and AMOUNT models of the MIXTRAN macro, respectively. For nutrients that were absent from the diet in 5-10% of participants, usual intake distribution was estimated using both the CORR and AMOUNT models, and the model with the best fit was chosen on the basis of the following fit statistics: -2 Log Likelihood (-2LL) and the Akaike Information Criterion (AIC).[25]

Incorporation of Covariates

Prior to data analysis, 21 variables were selected as possible covariates from the demographic, health history, and feeding practices datasets. The selected possible covariates included: day of intake, caregiver’s relationship status, language spoken at home, caregiver’s country of origin, years caregiver has lived in the US, age of caregiver,

caregiver's education level, caregiver's employment status, caregiver's race, caregiver's body mass index (BMI), whether the caregiver or the child had health insurance, child's age group (4-5.9 m, 6-11.9 m, 12-23.9 m), child's race, and whether the child consumed certain foods or beverages on a daily basis before four months of age (vegetables, sweets, cereal, or juice). In order to obtain the model with the best fit, the usual intake distribution was estimated multiple times for each nutrient, first including the full set of potential covariates, and then excluding covariates based on lack of significance. A covariate was considered to have a significant effect on the model if the *p*-value associated with the parameter estimate produced by MIXTRAN was <0.05. Models producing comparatively lower values of the fit statistics -2 Log Likelihood (-2LL) and Akaike Information Criterion (AIC) were determined to have the best fit.

Comparison between 2009 and 2011

The NCI Method for usual intake analysis produces a usual intake distribution for the population, rather than intake data for each sampled individual. Therefore, usual intake data produced by this method cannot be used to compare population means. To determine whether nutrient intake was different in 2009 compared to 2011 (before and after the WIC package change), we compared the mean intakes of nutrients from the first day of 24HR data collection in each year using a Students T-test.[40] While this method does not incorporate the benefits of usual intake analysis, it does provide a simple way of examining changes in intakes between years. This analysis was completed in SPSS (IBM SPSS Statistics 20.0.0. 2011. Chicago: SPSS Inc.)**.** Differences between years were considered to be significant if the p-value was <0.05.

RESULTS

Sample Population

In 2009, 149 caregivers were recruited, 84 provided 24HR data for their children, and 67 completed a second 24HR. In 2011, 171 caregivers were recruited, 120 provided 24HR data for their children, and 94 completed a second 24HR (Table 4). Recruited caregivers who could not be contacted by telephone after multiple attempts were eliminated from the study. The characteristics of children and caregivers included in the 2009 and 2011 sample were compared by χ^2 and t-tests, and no differences were found between the years with respect to: child age, gender, race, breastfeeding, or insurance status, and caregiver age, race, relationship status, country of origin, years spent in the United States, language spoken at home, employment status, or education level (Table 4). Toddlers in 2009 were significantly heavier than toddlers in 2011 (mean weight in 2009 was 27.8, SE=0.97, and mean weight in 2011 was 23.2, SE =0.45. Approximately 4.8% of infants and toddlers received supplements in 2009, and 9.4% in 2011.

Nutrient Analysis

Usual nutrient intake distributions were estimated for 4-5.9m infants, 6-11.9m infants, and 12-24m toddlers using the NCI Method. The means of single day (day 1) intakes from 2009 and 2011 were compared for 6-11.9m infants and 12-24m toddlers using t-tests. The means of day 1 intakes were not compared for 4-5.9m infants because the N for this age group was less than 30 in each study year, and results of t-tests would therefore be less valid. Usual intake distributions and data from day 1 intakes are presented in Tables 5-7.

Kilocalories

Between 2009 and 2011, mean usual caloric intakes decreased among 4-5.9m infants (Table 5). Among 4-5.9m infants, usual caloric intakes exceeded the level recommended by the Dietary Reference Intakes (DRI) formula based on average weight of the sample for all infants in both years (Table 8). Additionally, prior to the package change, in 2009, 4-5.9m infants had usual caloric intakes that exceeded the level recommended by the DRI formula based on maximum weight of the sample (Table 8).

Among 6-11.9m infants, mean usual caloric intake was higher in 2009 than in 2011, although this difference in caloric intake was not significant when comparing means of day 1 intakes (Table 6). In both 2009 and 2011, all 6-11.9m infants exceeded the caloric intake level recommended by the DRI formula based on the average weight of the sample but had usual caloric intakes lower than the level recommended by the DRI formula based on maximum weight of the sample (Table 8).

Among 12-24m toddlers, usual mean caloric intake was lower in 2011 than in 2009 (Table 7); this difference was significant when comparing means of day 1 intakes ($p=0.017$). Prior to the package change, but not after the package change, 12-24m toddlers had usual caloric intakes that exceeded the level recommended by the DRI formula based on average weight of sample (Table 8). In both years, all toddlers had usual caloric intakes lower than the level recommended by the DRI formula based on maximum weight of the sample.

Carbohydrate

Usual mean carbohydrate intakes were lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.012; Table 7). In both years, all 4-5.9m infants had usual carbohydrate intakes that met the AI. In 2009, almost all 6-11.9m infants had usual carbohydrate intakes that met the AI, whereas in 2011, 87% had usual intakes that met the AI. In 2009, all 12-24m toddlers had usual carbohydrate intakes that met the EAR and 79.4% had usual carbohydrate intakes that met the Recommended Dietary Allowance (RDA), whereas in 2011, 70% and 7.5% had usual intakes that met the EAR and RDA, respectively.

Protein

Usual mean protein intake was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.006; Table 7). Additionally, percent of calories from protein was lower among 12-24m toddlers in 2011 compared to 2009 (p=0.03; Table 7). In both 2009 and 2011, all children met the DRI for protein.

Fat

Usual mean intakes of total fat were lower in all age groups in 2011 compared to 2009 (Tables 5-7). When comparing means of day 1 intakes, the difference in total fat intake was not significant; however, there was a significant difference in percent of calories from fat among 12-24m between 2009 and 2011 (p=0.04; Table 7).

Zinc

Usual mean zinc intake was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.004; Table 7). In 2009 and 2011, all 4-5.9m infants had usual zinc intakes that exceeded the UL (Table 5). Among 6-11.9m infants, almost all infants in both years had usual zinc intakes exceeding the UL (Table 6). Among 12-24m toddlers, the percentage with usual zinc intakes exceeding the UL changed from 91.2% in 2009 to 0% in 2011 (Table 7).

Iron

Usual mean iron intake was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.045; Table 7). In 2009 and 2011, all 4-5.9m and 6-11.9m infants had usual iron intakes sufficient to meet the AI and the EAR, respectively. However, all 6-11.9m infants in both years had usual iron intakes that fell below the RDA (Table 6). All 12-24m toddlers in both years had usual iron intakes that met the EAR and RDA (Table 7).

Vitamin A (RAE)

Among 4-5.9m infants and 12-24m toddlers, mean usual vitamin A intakes (expressed as Retinol Activity Equivalents) were lower in 2011 than in 2009. Among 6-11.9m infants, mean usual vitamin A intakes were higher in 2011 compared to 2009. None of these changes were significant when comparing means of day 1 intakes (Tables

6-7). In 2011, almost all 4-5.9m infants had usual vitamin A intakes that met the AI. All 6-11.9m infants in both years had usual intakes that met the AI, and 60% in 2009 and 66% in 2011 had usual intakes exceeding the UL (Table 6). All 12-24m toddlers in both years had usual vitamin A intakes sufficient to meet the EAR and the RDA. In 2009, 96% of 12-24m toddlers had usual intakes exceeding the UL, compared to 53% in 2011 (Table 7).

Vitamin D

Usual mean vitamin D intake was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was not significant for either the 6-11.9m or the 12-24m age group; however, there was a trend toward significance for the 12-24m age group (p=0.07; Table 6). Among 4-5.9m infants, 94% had usual vitamin D intakes that fell below the AI in 2009, compared to all infants in 2011. All 6-11.9m infants in both years had usual intakes that fell below the AI (Table 6). Among 12-24m toddlers, usual vitamin D intakes fell below the EAR for 88% in 2009 and 97.5% in 2011. All 12-24m toddlers in both years had usual intakes of vitamin D that fell below the RDA (Table 7).

Calcium

Usual mean calcium intakes were lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.039; Table 7). All 4-5.9m and 6-11.9m infants in both years had usual calcium intakes that met the AI and EAR/RDA, respectively (Tables 5 and 6). All 12-24m toddlers in both years had usual intakes that met the EAR; however, after the package change, no 12-24m toddlers had intake levels sufficient to meet the RDA (Table 7).

Folate (DFE)

Usual mean folate intake (expressed as Dietary Folate Equivalents) was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.011; Table 7). All 12-24m toddlers in both years had usual folate intakes that met the EAR and RDA. Prior to the package change, 82% of 12-24m toddlers had usual folate intakes that exceeded the UL; however, after the package change all toddlers had usual folate intakes that fell within DRI recommendations. All 4-5.9m and 6-11.9m infants in both years had usual intakes that fell within the DRI recommendations (Table 6).

Vitamin B12

Usual mean intake of vitamin B12 was lower in all age groups in 2011 compared to 2009. When comparing means of day 1 intakes, this difference was only significant for the 12-24m age group (p=0.008; Table 7). All infants and toddlers in both years had usual intakes that fell within the DRI recommendations.

Vitamin E

Mean usual vitamin E intake was lower among 4-5.9m infants and 12-24m toddlers in 2011 compared to 2009 (Tables 5 and 7). Mean usual vitamin E intake was higher among 6-11.9m infants in 2011 compared to 2009 (Table 6). When comparing means of day 1 intakes, none of these differences were significant (Tables 5-7). In 2009, all 4-5.9m infants had usual vitamin E intakes that met the AI, whereas, in 2011 88.5% of 4-5.9m infants met the AI (Table 5). Among 6-11.9m infants, 63% in 2009 and 59% in 2011 had usual vitamin E intakes that fell below the AI (Table 6). Among 12-24m toddlers, 17.4% had usual intakes falling below the EAR in 2009 and 55.1% had usual intakes falling below the EAR in 2011. In this same age group, the percentage with intakes falling below the RDA was 43.9% in 2009 and 85% in 2011 (Table 7).

Vitamin C

Mean usual vitamin C intake was lower in 2011 in 4-5.9m infants and 12-24m toddlers compared to 2009 (Tables 5 and 7). Among 6-11.9m infants, mean usual vitamin C intake was higher in 2011 compared to 2009 (Table 6). None of these differences were significant. All infants and toddlers in both years had usual intakes that fell within the DRI recommendations for vitamin C (Tables 5-7).

Sodium

Usual mean sodium intake was lower in all age groups in 2011 compared to 2009 (Tables 5-7). When comparing means of day 1 intakes, this difference was not significant for either the 6-11.9m or 12-24m age groups; however, there was a trend toward significance for the 12-24m age group (p=0.08; Table 7). All infants and toddlers in both years had usual intakes that fell within the DRI recommendations.

Potassium

Usual mean intake of potassium was lower in age groups in 2011 compared to 2009 (5-7). When comparing means of day 1 intakes, this difference was significant only for the 12-24m age group (p=0.01; Table 7). All 4-5.9m and 6-11.9m infants in both years had usual intakes sufficient to meet the AI; however, none of the 12-24m toddlers in either year had usual potassium intakes sufficient to meet the AI.

DISCUSSION

Nutrients

This study addressed two primary questions: 1) How do the usual intake distributions for select nutrients compare within the SM-WIC population before and after the WIC package change? 2) How do usual nutrient intake distributions for select nutrients compare between the study population (CTX-WIC) and those reported nationally for infants and toddlers?

In general, CTX-WIC infants and toddlers in all age groups consumed fewer calories in 2011, after the package change, compared to 2009. Infants 4-5.9m consumed approximately 150 fewer calories in 2011; infants 6-11.9m consumed approximately 70 fewer calories in 2011; and toddlers consumed approximately 275 fewer calories in 2011. These lower levels of consumption are most likely driving the differences in macronutrient and micronutrient intake pre- and post-package change. Indeed, the magnitude of the difference in caloric consumption among toddlers may account for the high number of significant differences in mean nutrient intakes found within this age group. Importantly, although caloric consumption was lower in 2011 compared to 2009, it must be noted that for infants 4-5.9m mean caloric intakes remained well above the level recommended by the DRI based on average weight of the sample.

The package revisions were developed to be cost neutral; however, some staple foods were sacrificed to make way for new foods. For example, among toddlers, the amount of milk provided was reduced by approximately 30% and the amounts of juice and eggs provided were reduced by approximately 50% in order to accommodate vouchers for whole fruits and vegetables and the inclusion of whole grains.[18, 41] Insofar as milk, juice, and eggs are foods readily accepted by toddlers and whole fruits and vegetables were not consumed at high levels by this population on the day studied,[42] these changes may have contributed to lower levels of caloric consumption after the package change. With respect to juice, this change may not have had adverse effects. Mean usual intake of fructose was lower among toddlers after the package change (12g in 2011 vs. 17g in 2009), while usual intakes of vitamin C remained within DRI recommendations.

Given the high rates of obesity in the community from which this sample was drawn, we expected that kilocalorie intake within the CTX-WIC population would be higher than that reported by FITS.[3] Contrary to our expectations, after the package change, 6-11.9m infants had mean usual caloric intakes that were approximately equivalent to those reported by FITS in 2008, and toddlers had mean usual caloric intakes that were lower than those reported by FITS in 2008.[3] While some studies have demonstrated a link between high caloric intake in infancy and high childhood BMI,[43] childhood obesity is a complex, multifactorial issue, and a number of factors have been identified as potential contributors to high childhood BMI, including low levels of physical activity, genetic predisposition, and food insecurity.[45] Recent research points to an association between high levels of protein intake in toddlerhood and high childhood

BMI;[44] therefore, the reduction of eggs in the toddler package may not have been detrimental, especially given that protein intakes of all toddlers met the AI. Thus, it is difficult to assess the importance of the calorie or protein intake reported herein with respect to risk for high BMI.

The lower usual intakes of iron observed among the CTX-WIC population compared to the US population, were expected because CTX-WIC is a low-income, rural, majority Hispanic population. A recent review of iron deficiency anemia in the US noted a higher prevalence of iron deficiency among children 12-35m who were low-income, Mexican-American, or enrolled in WIC.[46] Smaller, regional studies have demonstrated similar results, noting that low socioeconomic status and food insecurity increase risk for iron deficiency.[8, 47] Additionally, iron requirements increase drastically between 5-6m of age as infant iron stores are depleted, and feeding practices are rarely compensatory.[46] Not only did 6-11.9m infants in the CTX-WIC population exhibit increased risk for deficient iron intakes relative to the national population – all infants in this age group had usual iron intakes lower than the RDA, compared to approximately 25% nationally.[3]

There is a well-established link between post-natal iron deficiency (that is, iron deficiency acquired around 6m of age in full-term infants born with adequate iron stores) and impaired cognitive function later in life.[48, 49] Iron deficiency can result in immediate cognitive deficits, and at least some of these abnormalities are irreversible, even with subsequent supplementation.[48] Irreversible consequences of iron deficiency and iron deficiency anemia in infancy can include increased tendency toward anxiety and depression, reduced attention span, reduced planning ability, reduced inhibitory control, and deficits in recognition memory which may contribute to lower math, reading, and IQ scores.[48, 50] The consequences of some of these cognitive losses may be felt even into the late teens.[50]

Given that fewer than 10% of the CTX-WIC population were consuming supplements, and the fact that 100% of older infants have usual iron intakes below the RDA, it can be concluded that this population is at increased risk for development of iron deficiency. The WIC food package for this age group includes iron-fortified infant formula, iron-fortified infant cereal, and baby food meats for breastfed infants.[41] These foods were included specifically to provide sufficient dietary iron for older infants at the time of weaning.[18] Unfortunately, baby food meats are not readily adopted by caregivers, and few older infants in this sample were exposed to baby food meats.[42] The amount of potential calories delivered by the WIC food package for 6-11.9m infants is less than the mean usual caloric intake among the CTX-WIC population, so it is reasonable to assume that this population is consuming at least some calories from foods that are not iron-rich. Given the importance of iron in cognitive development and the long-term consequences of iron deficiency, agencies working with children at increased risk for iron deficiency should consider supporting daily iron supplementation among older infants, and implementing caregiver education programs to promote iron-rich complementary foods.

Calcium and vitamin D are often considered together because of their synergistic effects on bone density. Of the two, calcium has been studied the most, and has been a focus of governmental nutrition support programs since the 1970s.[51] Perhaps because of this long-term emphasis, studies have demonstrated generally adequate intakes of calcium among US infants and toddlers.[3, 52] Indeed, usual calcium intakes among all infants in the CTX-WIC population were sufficient to meet DRI recommendations.

Surprisingly, all CTX-WIC toddlers had usual calcium intakes that fell below the RDA, after the package change. Comparison to national data is difficult because the DRI recommendations for calcium were updated after the FITS data were reported.[52] However, in a study of nutrient intakes among Hispanic infants and toddlers, Briefel *et al.* noted significantly lower intakes of calcium and vitamin E among Hispanic 6-11.9m infants, compared to non-Hispanic white infants of the same age.[7]

It is important to note that, within the CTX-WIC population, the prevalence of usual calcium intakes below the RDA was higher after the package change. This elevated risk for calcium deficiency is likely a consequence of changes to cow's milk in the WIC package for toddlers. The amount of cow's milk included in the 12-36m package was decreased by approximately 30% in an effort to control cost.[18] While cost-control measures are important, especially in light of current national conversations regarding the role of government in nutrition support, it is also important to remember that nutrient-dense foods play a significant role in child health.

Like calcium, vitamin D is a crucial nutrient during early childhood development. This is evidenced by the recent global increase in the prevalence of rickets, which has largely been attributed to vitamin D deficiency.[53] Studies examining serum concentrations of $25(OH)D_3$ (the circulating form of vitamin D) demonstrate widespread vitamin D insufficiency among children in the US.[54] This insufficiency is exacerbated by dark skin color, low socioeconomic status, and living in northern latitudes or cities with high levels of air pollution.[10, 53] As expected, usual vitamin D intakes among infants and toddlers in all age groups of the CTX-WIC population were low, and all age groups demonstrated a higher percentage of inadequate intakes than the national population.[3]

After the package change, 100% of 12-24m toddlers had usual vitamin D intakes lower than the RDA, and 97.5% had usual intakes lower than the EAR. Considering that the EAR identifies a level of intake adequate for 50% of the population to meet their needs, these data indicate a high risk for vitamin D deficiency within the CTX-WIC toddler population.

Vitamin D is not considered an essential nutrient because it is made in the skin in response to sun exposure (UVB radiation); however, recent studies indicate that production of endogenous vitamin D may be low as a result of air pollution, sunscreen application, and cultural practices that encourage covering skin.[53, 55] Low serum vitamin D levels reduce absorption of calcium, increase excretion of phosphorus, and contribute to the decreased bone mineralization and growth plate malformations characteristic of rickets and osteomalacia.[55] In 2011, in light of the large body of research supporting the role of vitamin D in skeletal growth and development, the IOM increased dietary intake recommendations for vitamin D among infants and toddlers.[52, 56] Although the IOM only considered evidence linking vitamin D to bone health, there is a growing body of evidence that vitamin D contributes to the maintenance of health in other ways. Additional, long-term research is needed to confirm these results; however, studies suggest that adequate serum vitamin D levels among infants and toddlers may mediate immune function, reduce susceptibility to respiratory infections, and improve insulin resistance, among other outcomes.[57-60]

Vitamin D status is important to early childhood health, and sufficient dietary intake is necessary to support adequate circulating levels of vitamin D. Some foods are fortified with vitamin D (e.g. infant formula), but fortification is not yet consistent across age groups, and foods that are typically fortified with vitamin D, may not be regularly consumed by those at greatest risk (e.g. milk).[53] The infants and toddlers enrolled in CTX-WIC represent a low-income, majority Hispanic population at increased risk for vitamin D deficiency based on low dietary intake. This issue could be addressed through provision of additional vitamin D-rich foods, encouragement of daily vitamin D supplementation, or education regarding safe, appropriate levels of sun exposure. This issue have been exacerbated by the removal from the package of foods commonly fortified with vitamin D, like milk.

Vitamin E intake from food is notably low within the US population.[7] According to the FITS data presented by Butte *et al.*, 63% of 12-23.9m toddlers had usual intakes of vitamin E that fell below the EAR.[3] In a study of nutrient intakes among Hispanic infants and toddlers, Briefel *et al.* demonstrated significantly lower intakes of vitamin E among Hispanic 6-11.9m infants, compared to non-Hispanic white infants of the same age.[7] As expected, usual intakes of vitamin E were low among all age groups of CTX-WIC infants after the package change. Approximately 11.5% of 4-5.9m infants and 59% of 6-11.9m infants had usual intakes of vitamin E that fell below the AI. Among 12-23.9m toddlers, 55% had usual intakes that fell below the EAR.

Vitamin E, circulating primarily as α-tocopherol, acts as an anti-oxidant in the body, preventing free radical oxidation of lipids. Symptoms of vitamin E deficiency, including neuropathy, impaired immune response, and hemolytic anemia, arise when levels are too low to prevent free radical damage to cellular structures.[61, 62] While in theory, vitamin E's anti-oxidant activities should prove protective against a range of inflammatory diseases, including cardiovascular disease, research has not supported a protective effected of supplemental vitamin E.[62] The DRI recommendations for vitamin E intake among 0-5.9m infants were established based on the amount of vitamin E in breast milk, and the recommendations for 6-11.9m infants were extrapolated from these values.[49] The DRI recommendation (EAR) for vitamin E intake among toddlers was extrapolated from the recommendation for adults, which was established to prevent hemolytic anemia.[49] Noting that outright symptoms of vitamin E deficiency are rare in the United States, Butte *et al* called for additional research and a re-examination of the DRI recommendations for vitamin E across all age groups.[3] Adequate vitamin E intake is certainly necessary for proper development; however, the risks associated with deficient intake seem far lower than those associated with deficient intake of vitamin D or iron. Therefore, it does not seem prudent to advocate for vitamin E fortification or supplementation targeting infants and toddlers.

Zinc is required for the proper functioning of many human transcription factors and enzymes, including DNA and RNA polymerase, and as a result deficiency of this mineral disproportionately affects systems with high cell turnover.[49] Additionally, zinc is known to directly mediate the immune system.[63] In infants and toddlers, zinc deficiency has been associated with an increased risk for diarrheal infections, anorexia, atopic dermatitis, and slow growth.[63, 64] In more severe cases, zinc deficiency results in stunting, delayed sexual maturation, and hypogonadism.[65]

Zinc deficiency occurs in approximately 4 – 73% of the global population, depending on region.[66] While zinc deficiency is most prevalent in the developing world, it also occurs within industrialized countries, particularly among children from low socioeconomic backgrounds.[9, 64] Iron deficient children are at greater risk for zinc deficiency, and although the mechanisms behind this association are unclear, deficiency could exist at least in part because iron and zinc occur in similar food sources.[9, 64] Zinc deficiency is also more common among weaning infants, due to a gradual post-partum decline in the concentration of zinc in breast milk, and low levels of naturally occurring zinc in common complementary foods.[49, 67] Despite the global prevalence of zinc deficiency, high levels of zinc intake have been noted among infants and toddlers in the US, especially those enrolled in the WIC program.[3, 68] Usual intakes of zinc were high among all age groups of the CTX-WIC population, with the exception of 12-24m toddlers after the package change. Indeed, all 4-5.9m and 6-11.9m infants had usual zinc intakes in excess of the UL, as did all toddlers before the package change. Usual zinc intakes of toddlers after the package change fell within DRI recommendations.

DRI recommendations for minimum zinc intake have been set based on age group specific research, but this has not been possible with respect to recommendations for maximum intake. The zinc EAR for 0-6m infants was set based on the average intake of zinc from breast milk.[49] The EARs for children ages 7-12m and 1-3y were set based on metabolic studies demonstrating the minimum zinc intake necessary to replace daily losses.[49] In contrast, the UL for children was extrapolated from the UL for adults, which was set based on data demonstrating the association between high zinc intake and limited copper absorption.[49] Few data exist to elucidate the association between zinc intake and copper absorption in infants and toddlers; however, a recent study demonstrated that zinc supplementation at or above the UL did not affect standard or sensitive markers of copper status in boys ages 6-18y.[69]

Mass fortification appears to have altered the discussion of zinc deficiency in the United States. Whereas in the past, breast milk and meat were the primary sources of zinc for infants and toddlers, zinc now enters the diets of young children in the form of foods more frequently consumed: fortified infant formula, fortified infant cereal, and fortified ready-to-eat adult cereal. Data from the National Health and Nutrition Examination Survey (NHANES) reveal that fortification increased the percentage of US children ages 2-18y with usual zinc intakes above the UL by 10-18% in 2003 – 2006.[70, 71] Butte *et al* reported usual zinc intakes above the UL in approximately 68% of US infants ages 6-11.9m, and 4% of US toddlers.[3] Similar data exist from other industrialized countries where voluntary food fortification with zinc is common. For example, in Australia between 1995 and 2007, approximately 79% of children ages 2-3y exceeded the UL for zinc intake.[72] Over that same time period, the contribution of cereals and cereal products to total zinc intake among this age group approximately doubled, becoming more significant than the contribution of dairy products.[72]

Given the high level of zinc intake among US infants and toddlers, examination of the effects associated with zinc intake from fortified foods is warranted. A 2009 meta-analysis of studies with healthy, full-term infants ages 6d-3.5m, demonstrated that consumption of zinc-fortified formula caused an increase in serum zinc concentration, but had no effect on growth rate.[73] Results from studies of children 6m-11y demonstrated that zinc-fortified cereal consumption had little impact on serum zinc levels or growth rate.[73] Indeed, a number of studies have noted high levels of zinc intake among children with few or no adverse effects leading a number of authors to call for the re-evaluation of the zinc UL among infants and toddlers.[3, 69, 70, 72-74]

Two additional points are relevant to the discussion of dietary zinc intake. First, the bioavailability of zinc in foods varies widely, and it is generally accepted that zinc consumed from fortified cereal grains is not as readily absorbed as zinc consumed from meats or breast milk. The absorption of dietary zinc can range from 15 – 35%.[74] A number of studies have demonstrated that zinc absorption is reduced by the consumption of phytic acid (present in high concentrations in grains such as wheat), and by the consumption of high levels of zinc.[72, 73, 75] Second, the two primary indicators of zinc status, hair zinc and serum zinc, may not be effective markers, especially in children. A meta-analysis of over 30 studies assessing the impact of zinc supplementation on plasma zinc levels revealed that plasma zinc levels do increase with supplementation; however, the relative contribution of this zinc to the body's functional pool remains unknown.[76] Additionally, because of a lack of studies with infants and toddlers, no conclusions regarding the effectiveness of plasma zinc as a marker for zinc status could be drawn for this age group.[76] Hair zinc is thought to be reflective of long-term zinc status; however, data were insufficient to support use of this marker for young children.[76]

Zinc deficiency has serious consequences and there appear to be few or no adverse effects associated with high levels of zinc intake from fortified foods. Furthermore, some researchers argue that few infants and toddlers would not meet dietary zinc requirements without the contribution of fortified foods.[67] While breast milk presents a significant source of highly bioavailable zinc, possibly providing as much as 50% of required levels even after zinc concentrations decline,[77] only about a quarter of the CTX-WIC population continued to breastfeed throughout weaning, and less than 15% continued breastfeeding after 1y of age. Baby food meats also represent an appropriate source of bioavailable zinc for weaning infants,[78] but these foods were not utilized by caregivers in the CTX-WIC population.[42] In the absence of a large-scale cultural shift regarding breastfeeding behavior and complementary feeding practices, zinc fortification of foods for infants and toddlers appears to be an effective mechanism for preventing low dietary zinc intakes in the CTX-WIC population. Additional research is needed to determine the effect of high dietary zinc intake on health outcomes, with the understanding that high dietary intake may be impacting one or more variables that are, as yet, unidentified.

Vitamin A has widespread effects within the body, including a direct role in vision (as retinaldehyde incorporated into rhodopsin), in gene expression (as *all-trans*-retinoic-acid), and in embryonic development (as *all-trans*-retinoic-acid). Symptoms of vitamin A deficiency include xeropthalmia, blindness, and an increased risk for infection, which results in the deaths of approximately 700,000 children annually worldwide.[79] Vitamin A deficiency represents a significant global nutrition issue, disproportionately affecting women and children in the developing world, where sources of natural preformed vitamin A (e.g. eggs, liver, and milk), are difficult to acquire.[80] In the United States, vitamin A intakes have long been a target of nutrition education and support programs, and the FDA has mandated minimum and maximum levels for vitamin A fortification of infant formula.[81]

Adverse effects have also been noted with high intakes of preformed vitamin A, including nausea and vomiting, birth defects, and increased intra-cranial pressure resulting in vertigo, blurred vision, reduced muscle coordination, and a bulging fontanel (in infants).[49] Children in the US consume high levels of vitamin A from fortified foods.

Butte *et al* found that intakes of synthetic preformed vitamin A from food and beverages exceeded the UL in 16% of US infants 6-11m and 31% of US toddlers 12-23m.[3] Briefel *et al* demonstrated that Hispanic toddlers in the US were at increased risk of excessive intakes of preformed vitamin A, with 46% consuming levels higher than the UL, compared to 35% of their non-Hispanic counterparts.[7] An analysis of 2007 – 2008 NHANES data revealed that children 12-36m who consumed vitamin A (as retinol) from fortified foods were at increased risk of intakes in excess of the UL.[71]

Within the CTX-WIC population, usual intakes of vitamin A (expressed as retinol equivalents) exceeded the UL among approximately half of 4-5.9m infants, two-thirds of 6-11m infants, and half of toddlers after the package change. Similac® Advance®, the most popular infant formula consumed among the CTX-WIC population, contains 300 IU of vitamin A per 100 kilocalories.[82] The ingredients list identifies vitamin A palmitate and β-carotene as sources, so it is difficult to calculate the amount of preformed vitamin A or retinol activity equivalents (RAE) delivered per serving for comparison to the UL. Applying the RAE conversion for both retinoids (1 IU = 0.3 μg RAE) and β-carotene (1 IU = 0.15 μg RAE), it is reasonable to expect that one 100 kilocalorie serving of Similac® Advance® contains 45- 90 μg RAE.[83] Assuming that 4-5.9m formula-fed infants in the CTX-WIC population were obtaining 100% of their calories from infant formula, as would be appropriate for this age group, and considering the mean usual intake after the package change of 906 kilocalories, CTX-WIC 4-5.9m infants could have been consuming 408-815 μg RAE from infant formula. The UL for this age group is 600 μg RAE. In short, infants enrolled in the CTX-WIC program are at risk for excessive intakes of vitamin A. The percentage of CTX-WIC toddlers with vitamin A intakes in excess of the UL was lower in 2011 compared to 2009, and this may have been driven by the reduction in eggs for toddlers mandated by the package change.

Some researchers have called for a re-examination and relaxation of the vitamin A UL for infants and toddlers;[84] however, there is a significant risk of adverse effects with high intakes of this nutrient during critical periods of development. Confounding this discussion are the differences that exist between the units used by regulators (IU) and the units used by scientists (primarily RAE), and the inadequacy of information provided by manufacturers regarding the source of vitamin A listed on the nutrition facts panel. Additional research is needed to refine the vitamin A UL, and regulations must be updated to standardize product information provided to consumers.

Increasing rates of cardiovascular disease within the US population have raised awareness regarding dietary intakes of sodium and potassium. High dietary intake of sodium contributes to high blood pressure, whereas high intake of potassium can help to prevent hypertension. Nationally, these minerals are consumed in inverse proportion to recommendations, with adults consuming higher levels of sodium and lower levels of potassium.[85] Among children, intakes of potassium and sodium are better matched to the recommendations, with mean intake of potassium exceeding mean intake of sodium among all age groups of infants and toddlers nationally.[3] Within the CTX-WIC population, usual intakes of sodium and potassium fell within DRI recommendations for all age groups with the exception of 12-23.9m toddlers, all of whom had usual potassium intakes below the AI.

DRI recommendations (AI) for sodium and potassium among infants and toddlers have been set based on the levels in human milk (for infants 0-6m), based on the levels in human milk and complementary foods (for infants 7-12m), or based on extrapolation from adult data (for toddlers 1-3y).[49] The establishment of an AI reflects a general paucity of data regarding intake of these nutrients among children. The potassium AI for toddlers 1-3y has been set at 3g, and all CTX-WIC toddlers had intakes below this level. National data reflect usual potassium intakes of toddlers ranging from 1175mg-2355mg – also below the AI.[3] While toddlers would certainly benefit from increased consumption of potassium rich foods, the potassium AI may be too ambitious considering a mean usual intake of 851 kilocalories among CTX-WIC toddlers. It should also be noted that, while there is no UL set for sodium for infants of any age, intakes of sodium were almost eight times higher than the AI among 4-5.9m infants and 6-11.9m infants. Additional research is warranted to investigate potential risk from high sodium intakes within these age groups.

In some national WIC populations, the revised package has increased indicators of healthy eating as well as access to healthy foods. For example, WIC participants in California reported eating more whole grains and more vegetables after the package change (although these data were not derived from 24HR and may not accurately reflect actual intake).[86] In Connecticut, healthy food composite scores for WIC and some non-WIC stores were higher after the package change, and this was especially true in low-income neighborhoods.[21] Unfortunately, the package revision has not had a similar effect on the CTX-WIC population. Reat *et al.* reported significantly *fewer* vegetables consumed by the CTX-WIC population after the package change.[42]

The NCI Method

Examining nutrient intakes can be an important method of identifying potential nutritional risks in a population.[6, 74] In populations with a high percentage of intakes outside of the recommended levels for a particular nutrient, there may be an increased risk for nutritional deficiency or toxicity. As demonstrated by the most recent FITS data, the general population of US infants and toddlers has adequate intakes for most nutrients. Notable exceptions are iron (intakes below the EAR in 12% of 6-11.9m infants), vitamin E (intakes below the EAR in 63% of toddlers), zinc (intakes from food above the UL in 68% of 6-11.9m infants and 4% of toddlers), vitamin A (intakes from food above the UL in 16% of 6-11.9m infants and 4% of toddlers), and sodium (intakes from food above the UL in 45% of 12-24.9m toddlers)[3].

Certain racial, socioeconomic, or geographic groups may exhibit different dietary patterns that produce unique differences in nutritional risk. These groups are often disproportionately impacted by cultural trends that lead to food desertification, high food costs, and lack of knowledge about healthy food. This leads to reduced access to and dietary incorporation of fruits, vegetables, lean meats, and whole grains, which may result in inadequate nutrient intake. Targeted analysis of nutrient intake within these populations can reveal potential nutrition risks that may have been overlooked in large-scale, national studies. For example, while nationally approximately 75% of infants 6-11.9m and 75% of toddlers have intakes of vitamin D that fall below the EAR[3], almost all toddlers in the CTX-WIC population have intakes of vitamin D below the EAR. Whereas 68% of infants 6-11.9m nationally have intakes of zinc above the UL[3], all infants 6-11.9m in the CTX-WIC population have intakes of zinc above the UL. These important differences in nutrient intake suggest that dietary interventions should be targeted to specific populations.

The NCI method represents an effective method for analyzing usual nutrient intake within regional populations. Compared to large, national studies, small-scale, regional analyses typically receive less funding, have fewer resources, are conducted by fewer researchers, and sample from smaller populations. It follows then, that regional studies have smaller sample sizes. By utilizing Bayesian analysis and allowing for the incorporation of subgroupings as covariates, the NCI method offers an accurate approach to the analysis of small samples.[87] The NCI method is not without drawbacks, however. The method is implemented through SAS, an expensive statistical analysis software that relies on knowledge of specific computer code. Researchers at NCI, the National Center for Health Statistics, and the USDA have made a tremendous effort to provide a “how to” tutorial for the NCI method, but the tutorial is focused on analysis of NHANES data, and significant effort and statistical knowledge are required to adapt the instructions to smaller data sets without survey weights.[88] Given that this method is so well-adapted for the study of populations at the highest risk of inadequate nutrient intakes, effort to make it more accessible would be well applied. Accessibility could be improved by the development of a simple, web-accessible user interface, much like that developed for other methods of analyzing usual intake (e.g. C-SIDE and Multiple Source Method), or by provision of SAS macros adapted for datasets without survey weights.[89, 90]

Strengths and Limitations

This study had a number of strengths. First, the population examined is of interest because socioeconomic status, geographic location, and ethnic make-up place CTX-WIC at increased risk for inadequate nutrient intakes. Second, researchers utilized 24HR, a robust, validated method, to gather extensive dietary intake data, along with data regarding feeding practices. Third, the study design incorporated a new method of usual nutrient intake analysis that is particularly appropriate for smaller samples.

It is also important to acknowledge the following limitations. First, no data were collected regarding utilization of the foods provided in the WIC package. For this reason, it is possible that the nutrient intakes reported herein reflect intake of foods not included in the WIC package. Second, sample size of the 4-5.9m infants subgroup was less than 30 in both years, and this precluded some forms of analysis within this age group.

Summary

In general, this study showed that nutrient intakes within the CTX-WIC population were different after the mandated changes to the WIC benefits packages. Some changes are likely to be beneficial for this population, for example, the lower mean usual intakes of calories and fructose, and fewer children with usual vitamin A intakes in excess of the UL. Unfortunately, some changes place this population at increased nutrition risk, for example, the lower mean usual intakes of calcium, vitamin D, and iron. It appears as though the WIC benefits package could be improved in this population by the reinstatement of the previous levels of milk in the toddler package. Further research within the CTX-WIC population should confirm the source of food consumed, taking into consideration the contribution of other nutrition support programs like the Supplemental Nutrition Assistance Program (SNAP food stamps).

The results of this study could contribute to dietary interventions within the CTX-WIC population and other low-income, Hispanic populations in Texas. Of particular interest would be interventions aimed at increasing breastfeeding among young infants, increasing iron and vitamin D supplementation among older infants, and increasing consumption of baby food meats, fruits and vegetables among older infants and toddlers. The results of this study contribute to the national conversation about fortification, and support the call for critical re-examination of the ULs for vitamin A and zinc. Furthermore, additional data are needed regarding the long-term impacts of high levels of zinc intake by infants and toddlers.

Table 1. Major changes made to the WIC food benefits package for infants 0-12m in 2009 – 2010. Changes are listed by food group for each age and feeding practice category recognized by WIC.[18, 41, 91]

Food Type	**Summary of Changes**
Infant Formula	• Formula-fed infants 0-4m: no change • Formula-fed infants 4-5.9m: ↑ by 10% • Formula-fed infants 6-11.9m: ↓ by 23%
	• Fully breastfed infants 0-12m: removed
Infant Cereal	• All infants 6-11.9m: Added 24 oz
Baby Food Fruits & Vegetables	• Fully breastfed infants 6-11.9m: added 256 oz • Partially breastfed infants 6-11.9m: added 128 oz • Formula-fed infants 6-11.9m: added 128 oz
Baby Food Meats	• Fully breastfed infants 6-11.9m: added 77.5 oz
Juice (100% Fruit)	• All infants 6-11.9m: removed

Table 2. Major changes made to the WIC food benefits package for toddlers 12-24m in 2009 – 2010. Changes are listed by food group for each age and feeding practice category recognized by WIC.[18, 41, 91]

Food Type	**Summary of Changes**
Juice (100% Fruit)	• All toddlers 12 – 36m: ↓ by 55%
Adult Cereal	• All toddlers 12 – 36m: Unchanged (36 oz)
Milk	• All toddlers 12 – 36m: ↓ by 33%
Eggs	• All toddlers 12 – 36m: ↓ by 50%
Fruit/Vegetable Voucher	• All toddlers 12 – 36m: added ($6.00)
Whole Grains/Bread	• All toddlers 12 – 36m: added (2 lb)
Legumes/Peanut Butter	• All toddlers 12 – 36m: unchanged (1lb or 18 oz)

Table 3. Methods for the estimation of usual nutrient intakes within a population.

Method	Preliminary Adjustments	Transformation to Normal Scale	Estimation of Usual Intake	Transformation to Original Scale
With-in person means	None	None	Simple averaging across recalls	None
National Research Council (NRC)	None	Log or Power	1. Partition observed variance 2. Adjust observed distribution based on within-person variance	Inverse function of original transformation
Iowa State University (ISU)	Shifts intakes away from zero; Adjusts for "nuisance effects"	Power transformation + Grafted polynomial function transformation	1. Partition observed variance 2. Adjust observed distribution based on within-person variance	Inverse function (Adjusted to ensure mean of estimated distribution equals mean of original data)
Best Power	None	Power transformation	1. Partition observed variance 2. Adjust observed distribution based on within-person variance	Inverse function (Adjusted to ensure mean of estimated distribution equals mean of original data)
National Cancer Institute (NCI)	None	Box-Cox	Non-linear mixed-effects model, accounts for episodic consumption	Inverse function

Table 3 – Continued. Methods for the estimation of usual nutrient intakes within a population.

Method	Applications	Cautions & Assumptions	Software	References
With-in person means	May accurately estimate population mean intake	Overestimates tails of distribution	SPSS	
National Research Council (NRC)	Regularly consumed nutrients; Sample size < 45;	Cannot include covariates; assumes transformation to normality	SAS Macro	NRC 1986, Institute of Medicine 2003
Iowa State University (ISU)	Regularly consumed nutrients; Sample size > 100;	Cannot include covariates; assumes transformation to normality	C-SIDE (stand-alone software)	Dodd 2006, Institute of Medicine 2003, Nusser 1996
Best Power	Regularly consumed nutrients; Sample size < 100;	Cannot include covariates; assumes transformation to normality	SIDE (works with SAS)	Bailey 2010, Dodd 2006, Nusser 1996,
National Cancer Institute (NCI)	Regularly and episodically consumed nutrients; Sample size < 100; include covariates	Assumes transformation to normality	SAS Macro	Tooze 2006 & 2010

Table 4. Characteristics of caregivers and their children sampled in 2009 and 2011.

	2009	2011
Sample characteristics	**Frequency (% of total)**	
Total N	84 (100)	120 (100)
Completed second recall	67 (41.6)	94(58.4)
Child characteristics **Age**	**Frequency (% of total)**	
4 - 5.9m	17 (20.2)	26 (21.7)
6 - 11.9m	33 (39.3)	54 (45)
12 - 24m	34 (40.5)	40 (33.3)
Weight (oz)	**Frequency (SE)**	
4 - 5.9m	15.0 (0.72)	16.3 (0.77)
6 - 11.9m	19.9 (0.45)	20.3 (0.75)
12 - 24m	27.8 (0.97)	23.2 (0.45)*
Gender	**Frequency (% of total)**	
Female	37 (44)	61 (50.3)
Male	45 (53.6)	58 (48.3)
Race	**Frequency (% of total)**	
Hispanic	57 (67.9)	78 (65)
Non-Hispanic White	14 (16.7)	18 (15)
Other[a]	10 (11.9)	13 (20)
Breastfeeding Status	**Frequency (% of total)**	
Breastfeeding Initiated	79 (82.3)	107 (89.2)
Breastfed to 4m	50 (53.2)	70 (58.3)
Currently Breastfeeding, 4-5.9m	7 (41.2)	14 (56)
Currently Breastfeeding, 6-11.9m	7 (23.3)	16 (29.6)
Currently Breastfeeding, 12-24m	6 (17.6)	4 (10.3)
Insurance Status	**Frequency (% of total)**	
Has health insurance	72 (85.7)	113 (94.2)
Lacks health insurance	9 (10.7)	7 (5.8)
Caregiver Characteristics **Race**	**Frequency (% of total)**	
Hispanic	56 (66.7)	86 (71.7)
Non-Hispanic White	21 (25)	30 (25)
Other[a]	4 (4.8)	4 (3.3)
Family Income[b]	**Frequency (% of total)**	
$0 - 5,000		4 (3.3)
$5,000 - 10,000		13 (10.8)
$11,000 - 20,000		29 (24.2)
$21,000 - 40,000		38 (31.7)
$41,000 - 60,000		9 (7.5)
Relationship status	**Frequency (% of total)**	
Living with partner	54 (64.3)	64 (53.3)
Language spoken at home	**Frequency (% of total)**	
Spanish-only	20 (23.8)	36 (30)
English and Spanish	10 (11.9)	21 (17.5)
English-only	52 (61.9)	62 (51.7)
Percent of life spent in the US	**Frequency (% of total)**	
< 40%	16 (19)	26 (21.7)
40 - 99%	6 (7.1)	12 (10)
100%	15 (60.7)	82 (68.3)

Table 4 – Continued. Characteristics of caregivers and their children sampled in 2009 and 2011.

Sample characteristics	2009	2011
Country of origin	**Frequency (% of total)**	
US	54 (64.3)	81 (67.5)
Mexico	22 (26.2)	35 (29.2)
Other[c]	6 (7.1)	4 (3.3)
Age	**Frequency (% of total)**	
< 18	0 (0)	2 (1.7)
18-24	28 (33.3)	46 (38.3)
25-44	48 (57.1)	71 (59.2)
45-64	1 (1.2)	0 (0)
>65	0 (0)	1 (0.8)
Education level	**Frequency (% of total)**	
Middle school or less	10 (11.9)	23 (19.2)
High school	54 (64.3)	67 (55.8)
Some college	18 (21.4)	26 (21.7)
Employment status	**Frequency (% of total)**	
Unemployed	55 (65.5)	76 (63.3)
Part-time employment	13 (15.5)	22 (18.3)
Full-time employment	11 (13.1)	22 (18.3)

[a] "Other" includes African American, Native American, Asian, and Pacific Islander.
[b] Family income data were not collected in 2009.
[c] "Other" includes Guatemala, Honduras, Indonesia, El Salvador, Israel, and Germany.
[*] Significant difference (p=0.001)

Table 5a. Usual Intake percentiles of young infants (ages 4-5.9m).

		Usual Intake Percentiles					
Yr.	**Nutrient**	**10th**	**25th**	**Med.**	**Mean**	**75th**	**90th**
2009	Kilocalories	903	951	1003	1052	1101	1417
2011	Kilocalories	711	835	895	896	955	1037
2009	Carbohydrate (g/d)	110.5	120.6	125.7	132.8	139.9	175.4
2011	Carbohydrate (g/d)	95.1	113.1	120.4	120.5	127.4	145.1
2009	Protein (g/d)	26.3	29.2	31.6	32.5	36.4	41.6
2011	Protein (g/d)	20.6	23.7	26.1	25.8	27.8	30.6
2009	Total Fat (g/d)	42.5	42.6	42.9	42.9	43.1	43.3
2011	Total Fat (g/d)	35.5	35.6	35.8	35.8	36.0	36.2
2009	Zinc (mg)	5.69	5.86	6.27	6.49	6.82	7.95
2011	Zinc (mg)	4.75	4.98	5.19	5.21	5.53	5.85
2009	Iron (mg)	9.82	11.5	12.5	13.4	13.8	18.8
2011	Iron (mg)	8.34	9.27	10.3	10.6	12.1	12.9
2009	Vitamin A (RAE)	493.2	545.5	608.1	613.3	672.3	744.9
2011	Vitamin A (RAE)	484.6	536.0	594.3	601.3	660.9	725.3
2009	Vitamin D (µg)	5.78	6.43	7.12	7.37	8.09	9.89
2011	Vitamin D (µg)	4.86	5.46	6.20	6.19	6.96	7.57
2009	Calcium (mg)	770.0	770.9	772.0	771.9	772.9	773.8
2011	Calcium (mg)	651.1	651.9	652.8	652.8	653.7	654.5
2009	Folate (DFE) (µg/day)	248.6	259.2	271.6	272.5	285.8	297.5
2011	Folate (DFE) (µg/day)	182.2	199.6	199.6	200.3	209.7	219.5
2009	B 12 (µg/day)	2.84	2.85	2.85	2.97	3.25	3.26
2011	B 12 (µg/day)	1.83	2.30	2.30	2.27	2.30	2.65
2009	Vitamin E (mg/d)	4.43	5.17	5.53	5.88	6.83	7.83
2011	Vitamin E (mg/d)	3.75	4.71	5.19	5.20	5.68	6.38
2009	Vitamin C (mg/d)	41.3	44.1	60.1	65.9	74.3	103.5
2011	Vitamin C (mg/d)	43.7	45.7	57.8	58.4	66.1	73.5
2009	Sodium (mg)	972.6	975.3	977.9	977.9	980.6	983.1
2011	Sodium (mg)	739.1	741.1	743.2	743.2	745.3	747.2
2009	Potassium (mg)	1409	1410	1411	1411	1412	1414
2011	Potassium (mg)	1197	1198	1199	1199	1200	1201

Table 5a – Continued. Usual Intake percentiles of young infants (ages 4-5.9m).

		Usual Intake Percentiles					
Yr.	**Nutrient**	**10th**	**25th**	**Med.**	**Mean**	**75th**	**90th**
2009	Total Sugars (g)	62.6	70.2	76.1	83.3	81.5	137
2011	Total Sugars (g)	55.5	68.2	76.2	76.7	81.3	89.9
2009	Fructose (g)	10.6	11.3	11.4	11.6	11.5	14.2
2011	Fructose (g)	13.2	13.3	14.2	14.1	14.2	17.4
2009	Omega-3 FA (g)	0.87	0.90	0.94	0.99	1.03	1.23
2011	Omega-3 FA (g)	0.59	0.67	0.72	0.73	0.78	0.81
2009	Saturated FA (g)	14.3	15.2	16.1	16.2	17.2	18.1
2011	Saturated FA (g)	11.4	12.2	13.1	13.2	14.1	15.0

Table 5b. DRI intake guidelines for young infants (ages 4-5.9m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's		Inadequate/ Excessive	
Yr.	**Nutrient**	**AI**	**UL**	**% < AI**	**% > UL**
2009	Kilocalories	490	ND	0	ND
2011	Kilocalories	490	ND	0.00	ND
2009	Carbohydrate (g/d)	60	ND	0.00	ND
2011	Carbohydrate (g/d)	60	ND	0.00	ND
2009	Protein (g/d)	9.1	ND	0.00	ND
2011	Protein (g/d)	9.1	ND	0.00	ND
2009	Total Fat (g/d)	31	ND	0.00	ND
2011	Total Fat (g/d)	31	ND	0.00	ND
2009	Zinc (mg)	2	4	0.00	100
2011	Zinc (mg)	2	4	0.00	100
2009	Iron (mg)	0.27	40	0.00	0.00
2011	Iron (mg)	0.27	40	0.00	0.00
2009	Vitamin A (RAE)	400	600	0.54	53.28
2011	Vitamin A (RAE)	400	600	0.73	47.28
2009	Vitamin D (µg)	10	25	94.10	0.00
2011	Vitamin D (µg)	10	25	100	0.00
2009	Calcium (mg)	200	1000	0.00	0.00
2011	Calcium (mg)	200	1000	0.00	0.00
2009	Folate (DFE) (µg/day)	65	ND	0.00	ND
2011	Folate (DFE) (µg/day)	65	ND	0.00	ND
2009	B 12 (µg/day)	0.4	ND	0.00	ND
2011	B 12 (µg/day)	0.4	ND	0.00	ND
2009	Vitamin E (mg/d)	4	ND	0.00	ND
2011	Vitamin E (mg/d)	4	ND	11.53	ND
2009	Vitamin C (mg/d)	40	ND	5	ND
2011	Vitamin C (mg/d)	40	ND	0.00	ND
2009	Sodium (mg)	120	ND	0.00	ND
2011	Sodium (mg)	120	ND	0.00	ND
2009	Potassium (mg)	0.4	ND	0.00	ND
2011	Potassium (mg)	0.4	ND	0.00	ND

Table 5b – Continued. DRI intake guidelines for young infants (ages 4-5.9m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's		Inadequate/ Excessive	
Yr.	**Nutrient**	**AI**	**UL**	**% < AI**	**% > UL**
2009	Total Sugars (g)	ND	ND	ND	ND
2011	Total Sugars (g)	ND	ND	ND	ND
2009	Fructose (g)	ND	ND	ND	ND
2011	Fructose (g)	ND	ND	ND	ND
2009	Omega-3 FA (g)	ND	ND	ND	ND
2011	Omega-3 FA (g)	ND	ND	ND	ND
2009	Saturated FA (g)	ND	ND	ND	ND
2011	Saturated FA (g)	ND	ND	ND	ND

Table 6a. Usual Intake percentiles of older infants (ages 6-11.9m).

		Usual Intake Percentiles					
Year	**Nutrient**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
2009	Kilocalories	786	839	936	920	989	1034
2011	Kilocalories	707	813	853	866	938	989
2009	Carbohydrate (g/d)	97.8	108.9	117.2	119.5	131.3	142.5
2011	Carbohydrate (g/d)	90.3	102.9	110.3	112.0	122.7	132.0
2009	Protein (g/d)	21.8	23.5	31.6	30.0	34.0	38.8
2011	Protein (g/d)	17.6	21.5	23.7	24.1	26.0	29.9
2009	Total Fat (g/d)	36.7	36.9	37.1	37.1	37.3	37.5
2011	Total Fat (g/d)	36.1	36.2	36.4	36.4	36.6	36.8
2009	Zinc (mg)	5.13	5.48	5.89	5.87	6.29	6.67
2011	Zinc (mg)	4.43	4.73	5.07	5.27	5.66	6.08
2009	Iron (mg)	9.10	9.72	10.9	11.2	11.8	14.1
2011	Iron (mg)	8.19	9.41	10.4	10.7	11.5	13.1
2009	Vitamin A (RAE)	513.8	564.4	624.1	631.9	691.8	759.8
2011	Vitamin A (RAE)	522.3	577.6	637.7	643.1	703.7	769.9
2009	Vitamin D (µg)	6.13	6.80	7.51	7.57	8.12	9.14
2011	Vitamin D (µg)	4.34	4.90	5.69	5.66	6.32	6.90
2009	Calcium (mg)	731.0	731.8	732.7	732.7	733.7	734.5
2011	Calcium (mg)	591.3	592.1	592.9	592.9	593.7	594.4
2009	Folate (DFE) (µg/day)	218.8	228.6	240.5	240.3	251.1	261.6
2011	Folate (DFE) (µg/day)	176.8	184.7	194.3	194.6	203.9	212.8
2009	B 12 (µg/day)	2.28	2.82	2.83	2.81	3.22	3.23
2011	B 12 (µg/day)	2.05	2.05	2.06	2.10	2.38	2.38
2009	Vitamin E (mg/d)	3.37	4.17	4.65	4.82	5.75	5.87
2011	Vitamin E (mg/d)	3.47	4.20	4.79	5.07	5.38	5.97
2009	Vitamin C (mg/d)	51.0	57.0	62.6	64.2	72.1	77.1
2011	Vitamin C (mg/d)	53.9	56.8	65.3	67.3	72.3	81.8
2009	Sodium (mg)	875.9	878.1	880.5	880.5	882.9	885.0
2011	Sodium (mg)	703.5	705.3	707.4	707.4	709.5	711.4

Table 6a – Continued. Usual Intake percentiles of older infants (ages 6-11.9m).

		Usual Intake Percentiles					
Year	**Nutrient**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
2009	Potassium (mg)	1342.9	1343.9	1345.1	1345.1	1346.3	1347.3
2011	Potassium (mg)	1166.3	1167.3	1168.3	1168.3	1169.3	1170.3
2009	Total Sugars (g)	60.5	66.1	72.4	74.4	82.1	88.3
2011	Total Sugars (g)	55.0	61.8	71.2	70.9	77.8	81.9
2009	Fructose (g)	9.91	12.4	13.3	12.8	13.3	13.4
2011	Fructose (g)	11.2	11.3	12.0	12.0	12.1	14.9
2009	Omega-3 FA (g)	0.66	0.70	0.77	0.77	0.83	0.87
2011	Omega-3 FA (g)	0.61	0.63	0.70	0.70	0.75	0.84
2009	Saturated FA (g)	13.7	14.6	15.6	15.6	16.6	17.5
2011	Saturated FA (g)	13.0	13.9	14.9	14.9	15.9	16.8

Table 6b. DRI intake guidelines for older infants (ages 6-11.9m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's				Inadequate/ Excessive Intakes			
Year	**Nutrient**	**AI**	**EAR**	**RDA**	**UL**	**%<AI**	**%<EAR**	**%<RDA**	**%>UL**
2009	Kilocalories	720	ND	ND	ND	0.00	ND	ND	ND
2011	Kilocalories	720	ND	ND	ND	11	ND	ND	ND
2009	Carbohydrate (g/d)	95	ND	ND	ND	4.31	ND	ND	ND
2011	Carbohydrate (g/d)	95	ND	ND	ND	13.04	ND	ND	ND
2009	Protein (g/d)	ND	ND	11	ND	ND	ND	0.00	ND
2011	Protein (g/d)	ND	ND	11	ND	ND	ND	0.00	ND
2009	Total Fat (g/d)	30	ND	ND	ND	0.00	ND	ND	ND
2011	Total Fat (g/d)	30	ND	ND	ND	0.00	ND	ND	ND
2009	Zinc (mg)	ND	2	3	5	ND	0.00	0.00	94
2011	Zinc (mg)	ND	2	3	5	ND	0.00	0.00	60
2009	Iron (mg)	ND	7	11	40	ND	0.00	55	0.00
2011	Iron (mg)	ND	7	11	40	ND	0.00	64	0.00
2009	Vitamin A (RAE)	500	ND	ND	600	7.17	ND	ND	60.09
2011	Vitamin A (RAE)	500	ND	ND	600	6.13	ND	ND	66.19
2009	Vitamin D (µg)	10	ND	ND	38	100.00	ND	ND	0.00
2011	Vitamin D (µg)	10	ND	ND	38	100.00	ND	ND	0.00
2009	Calcium (mg)	260	ND	ND	1500	0.00	ND	ND	0.00
2011	Calcium (mg)	260	ND	ND	1500	0.00	ND	ND	0.00
2009	Folate (DFE) (µg/day)	80	ND	ND	ND	0.00	ND	ND	ND
2011	Folate (DFE) (µg/day)	80	ND	ND	ND	0.00	ND	ND	ND
2009	B 12 (µg/day)	0.50	ND	ND	ND	0.00	ND	ND	ND
2011	B 12 (µg/day)	0.50	ND	ND	ND	0.00	ND	ND	ND
2009	Vitamin E (mg/d)	5	ND	ND	ND	63.64	ND	ND	ND
2011	Vitamin E (mg/d)	5	ND	ND	ND	59.26	ND	ND	ND
2009	Vitamin C (mg/d)	50	ND	ND	ND	9	ND	ND	ND
2011	Vitamin C (mg/d)	50	ND	ND	ND	3	ND	ND	ND

Table 6b – Continued. DRI intake guidelines for older infants (ages 6-11.9m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's				Inadequate/ Excessive Intakes			
Year	**Nutrient**	**AI**	**EAR**	**RDA**	**UL**	**%<AI**	**%<EAR**	**%<RDA**	**%>UL**
2009	Sodium (mg)	370	ND	ND	ND	0.00	ND	ND	ND
2011	Sodium (mg)	370	ND	ND	ND	0.00	ND	ND	ND
2009	Potassium (mg)	700	ND	ND	ND	0.00	ND	ND	ND
2011	Potassium (mg)	700	ND	ND	ND	0.00	ND	ND	ND
2009	Total Sugars (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Total Sugars (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Fructose (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Fructose (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Omega-3 FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Omega-3 FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Saturated FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Saturated FA (g)	ND	ND	ND	ND	ND	ND	ND	ND

Table 6c. Comparison of means of day one intakes for older infants (ages 6-11.9m).

		Means of Day 1 Intakes			
Year	**Nutrient**	**Mean**	**SD**	**SE**	**P**
2009	Kilocalories	870.63	441.72	76.89	0.799
2011	Kilocalories	845.68	439.97	59.87	
2009	Carbohydrate (g/d)	112.99	63.09	10.98	0.745
2011	Carbohydrate (g/d)	108.52	60.32	8.21	
2009	Protein (g/d)	26.20	20.15	3.51	0.441
2011	Protein (g/d)	22.90	17.70	2.41	
2009	Total Fat (g/d)	35.88	16.71	2.91	0.861
2011	Total Fat (g/d)	36.57	19.82	2.70	
2009	Zinc (mg)	4.78	2.70	0.47	0.430
2011	Zinc (mg)	5.30	3.35	0.46	
2009	Iron (mg)	9.87	8.16	1.42	0.412
2011	Iron (mg)	11.53	10.44	1.42	
2009	Vitamin A (RAE)	590.58	291.23	50.70	0.333
2011	Vitamin A (RAE)	655.90	322.34	43.87	
2009	Vitamin D (µg)	6.90	5.19	0.90	0.433
2011	Vitamin D (µg)	6.01	4.89	0.67	
2009	Calcium (mg)	660.56	425.25	74.03	0.329
2011	Calcium (mg)	575.90	321.01	43.68	
2009	Folate (DFE) (µg/day)	203.83	173.63	30.22	0.835
2011	Folate (DFE) (µg/day)	196.08	158.12	21.52	
2009	B 12 (µg/day)	2.33	2.09	0.36	0.485
2011	B 12 (µg/day)	2.02	1.74	0.24	
2009	Vitamin E (mg/d)	4.72	3.70	0.64	0.361
2011	Vitamin E (mg/d)	5.53	4.47	0.61	
2009	Vitamin C (mg/d)	65.93	44.31	7.71	0.687
2011	Vitamin C (mg/d)	69.67	37.28	5.07	

Table 6c – Continued. Comparison of means of day one intakes for older infants (ages 6-11.9m).

		Means of Day 1 Intakes			
Year	**Nutrient**	**Mean**	**SD**	**SE**	**P**
2009	Sodium (mg)	782.35	876.70	152.61	0.811
2011	Sodium (mg)	735.29	898.48	122.27	
2009	Potassium (mg)	1,228.22	741.19	129.02	0.812
2011	Potassium (mg)	1,186.70	854.16	116.24	
2009	Total Sugars (g)	73.53	36.39	6.33	0.445
2011	Total Sugars (g)	67.55	33.15	4.51	

Means not compared for fructose, omega-3 fatty acids, and saturated fatty acids.

Table 7a. Usual Intake percentiles of toddlers (ages 12-24m).

		Usual Intake Percentiles					
Year	**Nutrient**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
2009	Kilocalories	957	1020	1140	1116	1190	1260
2011	Kilocalories	701	772	850	850	901	992
2009	Carbohydrate (g/d)	120.2	139.1	151.3	149.2	164.9	170.6
2011	Carbohydrate (g/d)	84.8	97.2	109.2	108.4	116.8	128.4
2009	Protein (g/d)	30.1	33.7	37.9	36.9	40.8	43.0
2011	Protein (g/d)	17.4	22.0	25.1	24.7	26.6	29.5
2009	Total Fat (g/d)	43.3	43.5	43.7	43.7	43.9	44.1
2011	Total Fat (g/d)	35.6	35.8	36.0	36.0	36.1	36.3
2009	Zinc (mg)	6.49	7.01	7.58	7.57	8.00	8.86
2011	Zinc (mg)	4.33	4.64	5.11	5.12	5.40	5.82
2009	Iron (mg)	9.53	13.0	14.3	14.7	16.0	19.6
2011	Iron (mg)	7.48	8.56	9.06	9.64	10.3	12.0
2009	Vitamin A (RAE)	648.7	709.0	782.6	789.3	863.8	941.5
2011	Vitamin A (RAE)	495.8	546.7	609.1	614.7	676.6	740.4
2009	Vitamin D (µg)	6.30	7.19	8.11	8.06	8.42	10.37
2011	Vitamin D (µg)	5.30	5.82	6.11	6.54	7.16	7.99
2009	Calcium (mg)	822.8	823.8	824.8	824.8	825.8	826.8
2011	Calcium (mg)	669.9	670.7	671.6	671.6	672.5	673.3
2009	Folate (DFE) (µg/day)	292.5	305.7	319.5	320.2	334.3	347.9
2011	Folate (DFE) (µg/day)	176.2	184.3	193.2	193.5	202.5	211.4
2009	B 12 (µg/day)	2.63	3.67	3.67	3.55	3.68	4.15
2011	B 12 (µg/day)	1.72	2.50	2.51	2.49	2.51	2.88
2009	Vitamin E (mg/d)	4.90	5.11	6.36	6.40	6.71	8.42
2011	Vitamin E (mg/d)	3.49	4.46	4.84	5.04	5.45	6.45
2009	Vitamin C (mg/d)	53.0	60.5	71.7	71.0	76.8	87.5
2011	Vitamin C (mg/d)	46.5	52.7	62.2	63.7	72.8	84.5
2009	Sodium (mg)	1137.7	1140.4	1143.6	1143.6	1146.8	1149.6
2011	Sodium (mg)	760.2	762.2	764.4	764.4	766.6	768.5

Table 7a – Continued. Usual Intake percentiles of toddlers (ages 12-24m).

		Usual Intake Percentiles					
Year	**Nutrient**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
2009	Potassium (mg)	1607.4	1608.7	1610.1	1610.1	1611.4	1612.6
2011	Potassium (mg)	1234.3	1235.3	1236.4	1236.4	1237.6	1238.5
2009	Total Sugars (g)	72.0	77.7	87.8	87.9	96.5	106.5
2011	Total Sugars (g)	55.6	59.6	67.6	68.4	75.5	83.6
2009	Fructose (g)	16.1	16.2	17.2	17.1	17.3	21.0
2011	Fructose (g)	10.7	10.8	11.5	12.0	13.0	14.0
2009	Omega-3 FA (g)	0.75	0.87	0.95	0.95	1.05	1.12
2011	Omega-3 FA (g)	0.65	0.68	0.75	0.75	0.79	0.86
2009	Saturated FA (g)	15.2	16.0	17.1	17.1	18.1	19.1
2011	Saturated FA (g)	12.5	13.4	14.4	14.4	15.3	16.3

Table 7b. DRI intake guidelines for toddlers (ages 12-24m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's				Inadequate/ Excessive Intakes			
Year	**Nutrient**	**AI**	**EAR**	**RDA**	**UL**	**%<AI**	**%<EAR**	**%<RDA**	**% > UL**
2009	Kilocalories	990	ND	ND	ND	17	ND	ND	ND
2011	Kilocalories	990	ND	ND	ND	88	ND	ND	ND
2009	Carbohydrate (g/d)	ND	100	130	ND	ND	0.00	20.60	ND
2011	Carbohydrate (g/d)	ND	100	130	ND	ND	30.00	92.49	ND
2009	Protein (g/d)	ND	ND	13	ND	ND	ND	0.00	ND
2011	Protein (g/d)	ND	ND	13	ND	ND	ND	0.00	ND
2009	Total Fat (g/d)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Total Fat (g/d)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Zinc (mg)	ND	2.50	3.00	7.00	ND	0.00	0.00	76
2011	Zinc (mg)	ND	2.50	3.00	7.00	ND	0.00	0.00	0.00
2009	Iron (mg)	ND	3	7	40	ND	0.00	0.00	0.00
2011	Iron (mg)	ND	3	7	40	ND	0.00	0.00	0.00
2009	Vitamin A (RAE)	ND	210	300	600	ND	0.00	0.00	96.42
2011	Vitamin A (RAE)	ND	210	300	600	ND	0.00	0.01	53.31
2009	Vitamin D (µg)	ND	10	15	63	ND	88.24	100	0.00
2011	Vitamin D (µg)	ND	10	15	63	ND	97.50	100	0.00
2009	Calcium (mg)	ND	500	700	2500	ND	0.00	0.00	0.00
2011	Calcium (mg)	ND	500	700	2500	ND	0.00	100	0.00
2009	Folate (DFE) (µg/day)	ND	120	150	300	ND	0.00	0.00	82.82
2011	Folate (DFE) (µg/day)	ND	120	150	300	ND	0.00	0.06	0.00
2009	B 12 (µg/day)	ND	0.70	0.90	ND	ND	0.00	0.00	ND
2011	B 12 (µg/day)	ND	0.70	0.90	ND	ND	0.00	0.00	ND
2009	Vitamin E (mg/d)	ND	5	6	200	ND	17.42	43.92	0.00
2011	Vitamin E (mg/d)	ND	5	6	200	ND	55.12	84.99	0.00
2009	Vitamin C (mg/d)	ND	13	15	400	ND	0.00	0.00	0.00
2011	Vitamin C (mg/d)	ND	13	15	400	ND	0.00	0.00	0.00

Table 7b - Continued. DRI intake guidelines for toddlers (ages 12-24m), and the percentage of the sample with intakes outside of those guidelines.

		DRI's				Inadequate/ Excessive Intakes			
Year	**Nutrient**	**AI**	**EAR**	**RDA**	**UL**	**% < AI**	**%<EAR**	**%<RDA**	**% > UL**
2009	Sodium (mg)	1000	ND	ND	1500	0.00	ND	ND	0.00
2011	Sodium (mg)	1000	ND	ND	1500	0.00	ND	ND	0.00
2009	Potassium (mg)	3000	ND	ND	ND	100	ND	ND	ND
2011	Potassium (mg)	3000	ND	ND	ND	100	ND	ND	ND
2009	Total Sugars (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Total Sugars (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Fructose (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Fructose (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Omega-3 FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Omega-3 FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2009	Saturated FA (g)	ND	ND	ND	ND	ND	ND	ND	ND
2011	Saturated FA (g)	ND	ND	ND	ND	ND	ND	ND	ND

Table 7c. Comparison of means of day one intakes for toddlers (ages 12-24m).

		Means of Day 1 Intakes			
Year	**Nutrient**	**Mean**	**SD**	**SE**	**P**
2009	Kilocalories	1,174.34	619.18	106.19	**0.017**
2011	Kilocalories	867.88	410.21	64.86	
2009	Carbohydrate (g/d)	158.64	88.02	15.09	**0.012**
2011	Carbohydrate (g/d)	112.05	60.57	9.58	
2009	Protein (g/d)	40.73	27.37	4.69	**0.006**
2011	Protein (g/d)	25.00	17.65	2.79	
2009	Total Fat (g/d)	43.53	24.73	4.24	0.174
2011	Total Fat (g/d)	36.69	16.37	2.59	
2009	Zinc (mg)	7.91	3.95	0.68	**0.004**
2011	Zinc (mg)	5.33	3.49	0.55	
2009	Iron (mg)	15.02	11.32	1.94	**0.045**
2011	Iron (mg)	10.11	8.90	1.41	
2009	Vitamin A (RAE)	862.26	715.70	122.74	0.100
2011	Vitamin A (RAE)	628.74	415.49	65.69	
2009	Vitamin D (µg)	7.95	3.78	0.65	0.071
2011	Vitamin D (µg)	6.29	4.00	0.63	
2009	Calcium (mg)	863.76	462.31	79.29	**0.039**
2011	Calcium (mg)	661.63	337.33	53.34	
2009	Folate (DFE) (µg/day)	333.71	229.76	39.40	**0.011**
2011	Folate (DFE) (µg/day)	202.87	192.00	30.36	
2009	B 12 (µg/day)	3.64	2.14	0.37	**0.008**
2011	B 12 (µg/day)	2.39	1.68	0.26	
2009	Vitamin E (mg/d)	5.94	3.43	0.59	0.592
2011	Vitamin E (mg/d)	5.44	4.53	0.72	
2009	Vitamin C (mg/d)	68.95	45.52	7.81	0.383
2011	Vitamin C (mg/d)	59.94	42.15	6.67	

Table 7c – Continued. Comparison of means of day one intakes for toddlers (ages 12-24m).

		Means of Day 1 Intakes			
Year	**Nutrient**	**Mean**	**SD**	**SE**	**P**
2009	Sodium (mg)	1,329.98	1,411.00	241.98	0.082
2011	Sodium (mg)	838.33	854.11	135.05	
2009	Potassium (mg)	1,743.54	973.69	166.99	**0.010**
2011	Potassium (mg)	1,220.81	658.30	104.09	
2009	Total Sugars (g)	92.53	47.77	8.19	**0.006**
2011	Total Sugars (g)	66.19	26.57	4.20	

Means not compared for fructose, omega-3 fatty acids, and saturated fatty acids.

Table 8. **U**sual caloric intakes and recommendations for infants and toddlers.

		Weight (kg)		Usual Caloric Intakes		DRI Guidelines	
Age Group	**Year**	**Ave.**	**Max.**	**Lowest**	**Highest**	**Ave. Weight**	**Max. Weight**
4-5.9m	2009	6.8	9.1	862	1453	562.53	763.39
	2011	7.4	11.3	661	1208	613.15	965.24
6-11.9m	2009	9.0	12.0	702	1163	727.24	991.80
	2011	9.2	15.4	628	1274	742.89	1,294.57
12-24m	2009	12.6	22.7	822	1338	1,040.90	1,938.48
	2011	10.5	12.7	650	1121	857.40	1,050.35

Comparison to caloric intake recommendations based on the DRI formula for energy needs using the average (Ave.) and maximum (Max.) weights of children in the sample population.

Table 8 - Continued. Usual caloric intakes and recommendations for infants and toddlers.

		Comparison to DRI for Ave. Weight		Comparison to DRI for Max. Weight	
Age Group	**Year**	**% > DRI**	**% < DRI**	**% > DRI**	**% < DRI**
4-5.9m	2009	100	0	100	0
	2011	100	0	79	21
6-11.9m	2009	2	98	75	25
	2011	16	84	0	100
12-24m	2009	26	74	0	100
	2011	53	47	6	94

Comparison to caloric intake recommendations based on the DRI formula for energy needs using the average (Ave.) and maximum (Max.) weights of children in the sample population.

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