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A semi-quantitative food frequency questionnaire (FFQ) validated in Hispanic infants and toddlers 0–24 months

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There are no conflicts of interests to disclose.

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Abstract

Background—There are limited validated FFQs for infants and toddlers, most of which were evaluated in Europe or Oceania and the available ones for use in the US have important limitations.

Objective—To assess the validity of a food frequency questionnaire (FFQ) developed for infants and toddlers.

Design—A semi-quantitative FFQ was developed including 52 food items, their source and portion sizes. It enquired about diets over the previous 7 days. Its validity was assessed in a cross-sectional study. Participants completed the FFQ followed by a 24-hour recall on two occasions with one week between data collection.

Participants/setting—A total of 296 caregivers of infants and toddlers aged 0–24 months enrolled in WIC-Puerto Rico.

Main outcome measures—Intake of nutrients and food groups were averaged for the two FFQs and the two 24-h food recalls and adjusted for energy intake.

Statistical analyses performed—Spearman correlations were performed for intakes of energy, nutrients, and foods between administrations and between instruments. Correlation coefficients were de-attenuated to account for variation in the 24 hour recalls.

Results—A total of 241 participants completed the study. Intake of all nutrients and foods were significantly correlated between FFQs, 24-h recalls and between the average of FFQs and 24-h food recalls. The de-attenuated correlation for nutrients between the FFQs and 24-h recalls ranged from 0.26 (folate) to 0.77 (energy), with an average correlation of 0.53. The de-attenuated correlation for food groups between the FFQs and 24-h recalls ranged from 0.28 (sweets) to 0.80 (breast-milk) with an average correlation of 0.55. When analyses were restricted to those consuming foods other than breast milk or formula (N=186), results were similar.

Conclusions—This semi-quantitative FFQ is a tool that offers reasonably valid rankings for intake of energy, nutrients, foods and food groups in this sample of infants and toddlers.

Keywords

food frequency questionnaire; validity; infants; toddlers; Hispanics; nutrients; food groups

Introduction

Infant feeding during the first 1,000 days of life (from conception to age 24 months) is crucial for healthy growth and development.[1] This period is vital in the prevention of future chronic diseases, including obesity, later in childhood and adulthood. In particular, obesity is a major public health problem in children and adults with one of the highest prevalence among Hispanics.[2]

Understanding infant dietary intake is important as studies relate the following nutritional factors to excess weight: breastfeeding duration,[3] early introduction of complementary foods, juice intake,[4,5] formula feeding,[6] among others. However, assessing infant dietary intake is complicated, as there are many changes occurring in short periods of time. Infants generally move quickly from a largely milk-based diet to a diet with a variety of foods consumed also by the other family members.[7] Understanding infant dietary intake and how this relates to weight gain is also important for establishing infant diet recommendations, which currently vary widely among pediatricians and there are only a few authoritative guidelines available.[8] Studying the dietary patterns during the first 1,000 days allow for the identification of practices and patterns that are not healthy in the population from early on. Since food preferences develop early in life,[9] understanding dietary consumption patterns in infants can help develop specific recommendations for this group, fostering healthy eating habits from this stage of life and contributing to the prevention of childhood obesity.

Validated instruments are needed to accomplish these goals. Currently, there are only a few instruments to capture dietary patterns in infants and toddlers worldwide but most of the instruments available are not validated. The few validated FFQs available for infants and toddlers are for populations in Europe or Oceania.[10–16] To our knowledge, there are only four validated FFQs for use in infants and toddlers in the US,[17–20] with important limitations, such as not validated for both nutrients and food groups, only beverages included, limited foods validated, validated among a small sample of infants and toddlers, and not updated (this is important as the food industry has introduced many infant foods in the past years). Validated instruments are needed to accurately assess the diet of the population in any type of study.[21,22] Therefore, the objective of this study was to assess the validity a food frequency questionnaire (FFQ) developed specifically for infants and toddlers aged 0–24 months for both nutrients and food groups.

Methods

This was a cross-sectional study to assess the validity of a semi-quantitative FFQ among a sample of Hispanic and toddlers 0–24 months old. This FFQ enquired about infants and toddlers' diets over the previous 7 days. Caregivers of infants and toddlers completed two FFQs (at baseline and at week 3), followed by two 24-hour recalls (at weeks 2 and 4). Only one week was allowed between administrations of the instruments due to the high variability in infant's diet as new foods are introduced.

The University of Puerto Rico-Medical Sciences Campus Institutional Review Board approved the study protocol and all participants provided written informed consent.

Participants

We recruited a non-probabilistic convenient sample of caregivers aged 21 years or older with infants and toddler aged 0–24 months. Recruitment occurred daily in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic of the Municipality of Trujillo Alto in Puerto Rico, during a 3-month period (November 2014 to February 2015). This is the only WIC clinic in this municipality, allowing recruitment of all active participants of that clinic (total enrollment in September 2014 was 476 participants aged 0–24 months) as participants attend the clinic about once per month for either an appointment with the nutritionist or to pick-up their monthly check. Infants or toddlers with any serious health condition that could alter normal feeding practices were excluded as well as caregivers younger than 21 years of age.

Socio-demographic questionnaire

This questionnaire included items related to age of the caregivers, gender, educational attainment, and number of children in the household.

Anthropometric assessment

Weight was assessed in infants by trained research personnel while infants wore light clothing and clean diaper using a manual scale (Detecto model 3p7044, Missouri), which was calibrated daily. Recumbent length was measured in cm using an infantometer (Perspective Enterprises model #PE-RILB-BRG2, Michigan). Measurements were taken in duplicates and averaged. Weight status was assessed calculating weight-for-length using the World Health Organization growth charts.[23] Weight was categorized as underweight (<5th percentile), healthy weight (5th – 89th percentile), and excessive weight (≥90th percentile).

Food frequency questionnaire (FFQ)

A semi-quantitative FFQ was developed adapting the Infant Feeding Practices Survey II conducted by the Centers for Disease Control and Prevention and Food and Drug Administration.[24] The original FFQ had 19 food items (without portion sizes) and frequency of consumption was assessed as feedings per day or per week. This FFQ was expanded in our revised version to include other food items with a brief description on how these were prepared and/or their source (e.g., raw, canned, etc.). Previous infant studies were used to identify the food items most typically consumed by infants and toddlers in the US, including the most frequently consumed foods in Hispanic infants, such as rice, tortilla, cereals and mixed dishes (pizza), bananas, raw and home cooked vegetables, starchy vegetables (plantains), and fruit juices.[7,25,26] This FFQ was pilot tested in a convenience sample of 60 mothers ≥21 years with infants 0–12 months in Puerto Rico to assess the clarity of the statements included and to assess if additional food items needed to be included.[27] In this pilot study, 60 mothers (28 with infants 0–4 months; 14 with infants 5–8 months and 18 with infants 9–12 months old) completed the FFQ. Most participants considered the statements included in the FFQ to be clear (90%). These results enabled us to further improve our modified FFQ for infants and toddlers.

The final FFQ included 52 food items; five were about milk intake (breast milk, formula, cow's milk, flavored milk, and other milks) and their portion size; four were about other dairy products and soy-based foods; seven were about water, juice and sugar sweetened beverages and their portion sizes; seven were about refined and whole grain cereals, rice, pasta, bread and crackers, and their portion sizes; six were about fruits, their source (fresh, baby food or canned/processed) and their portion sizes; five were about vegetables, their source (fresh, baby food or canned/processed) and their portion sizes; four were about starchy roots (potatoes, sweet potatoes, plantains, cassava); seven were about protein foods (beans, eggs, red meat, poultry and seafood) and their portion sizes; five were about sweets (candies, cookies, cakes, biscuits, muffins) and salty snacks and their portion sizes; and two were about fats (margarine, butter and oil). The frequency of consumption of each food over the past seven days was assessed as feedings per day if the food was consumed on a daily basis or times per week if it was consumed less often. The latter was divided by seven to transform into days. The frequency of each food item was multiplied by the serving size to obtain the total food consumed per day. For food items without portions, we assumed standard portions for this age group. These were: cheese (1 oz), ice cream (0.25 cups), and yogurt (0.5 cups), soy-based foods (1 oz) and margarine/oil (1 tsp). In the case of breast milk, we estimated the amount (mL) based on the age of the infant, type of feeding (determined by the number of times caregivers reported giving breast milk and formula per day in the FFQ) and if other foods had been introduced, using several sources, including the World Health Organization.[28–30] There were also five items about dietary supplement use and the frequency of use was assessed ranging from more than once per day to never. See the Infant and Toddler FFQ in Supplementary materials.

Trained research personnel administered the FFQ to caregivers by face-to-face interview. A photographic booklet was created to aid caregivers estimate the portion sizes of the food items in the FFQ. We included pictures of different sizes of cups, spoons, jars of baby food, Sippy cups and baby bottles. Also, we include several foods (bread, muffin, cookie, cake, and donut) with estimates of what represents a quarter, a half, or three quarters of each food, as some infants do not eat the entire portion of these foods. We also included examples of cereals, cookies, baby juice and other foods specially designed for babies to differentiate from other regular versions. The second administration of the FFQ was completed by phone two weeks later.

24-hr food recalls

Trained nutritionists administered two 24-hr recalls two weeks apart using the multi-pass method of the Program Nutrition Data System for Research (version 25, 2014, Nutrition Data System for Research; program 2.8, developed by the Nutrition Coordinating Center, University of Minnesota.[31] These were completed by phone on weeks two and four of the study, starting from the first FFQ. At the baseline visit, we provided a complete photographic booklet with black and white drawings of actual serving portions, including images of spoons, bowls, cups, and serving sizes of commonly eaten foods to use when we called them. These models aided participants in estimating portion sizes, to avoid over or underestimation.

Nutrient calculations

A food database was created to calculate energy and nutrient intake from the FFQ. We used NDSR to create the database. This database includes over 18,000 foods, including breast milk, with more than 160,000 food variants as there are various choices for ingredients added and preparation methods. This food database is continuously supplemented with data on new food items and nutrients.[32] However, we found several infant foods that were not included in the database; in these cases, detail description of these foods, such as specialized infant formulas and new infant baby foods, were sent to the Nutrition Coordinating Center in the University of Minnesota for calculation of energy and nutrient intake. These were incorporated into the database for final analyses. The NDSR also utilizes this database to calculate energy and nutrients intake from the 24-h food recalls. Dietary supplements were not included in the nutrient calculations for either method.

Food groups

To assess the ability of the FFQ to capture the intake of important foods for infants, we also compared the intake of foods and food groups between the FFQs and the 24-h recalls. For the 24-food recalls, the NDSR automatically generates the food group assignments (e.g., servings of fruit, vegetables, etc.). There are a total of 168 subgroups generated from NDSR: seven for fruits, 10 for vegetables, 35 for grains, 28 for dairy and nondairy alternatives, 28 for meat, fish, poultry, eggs, nuts, seeds and meat alternatives, 14 for fats, eight for sweets, 26 for beverages, and 10 for miscellaneous foods[33]. For the present study, these were re-grouped into the 17 most common foods consumed in this age group: Breast-milk, Formula, Milk, Cheese, Ice cream & yogurt, Juice, Sugary sweetened beverages, Refined or Whole grains (cereals, rice, pasta), Fruits, Vegetables, Starchy roots, Beans, Meats, Eggs, Nuts and seeds, Sweets, Salty snacks and Added fat. The same food groups were generated for the FFQ.

Statistical Analyses

Descriptive analyses were used to assess the demographics of the study population. Only participants completing all study visits, including both 24-h food recalls, were included in the analyses. The average of the FFQs and the 24-h recalls was used in all analyses.[21] Adjustment for energy was conducted to account for the confounding effect of total energy intake on other nutrients; this also provided some correction for the tendency of some individuals to regularly over- or underestimates portion sizes with the FFQ. Energy adjustment was done by computing residuals from regression models with nutrient intake as the dependent variable and total energy intake as the independent variable. The residuals were added to the expected nutrient intake for a participant with the mean energy intake.[34]

Nutrient data were not normally distributed (based on the results of Shapiro-Wilk test of normality); therefore, non-parametric statistical methods were employed. We assess the correlations between the first and second administrations of the FFQ or 24-h recalls and between the average of the FFQs against the gold standard method, the 24-h food recalls, by Spearman's rank correlation and their 95% confidence intervals. Also, de-attenuated Spearman correlation coefficients and their 95% confidence intervals were calculated to account for variation in the 24 hour recalls using the probit transformation-based method developed by Rosner and Glynn.[35] We also used cross-classification analysis to assess the percent of agreement and the ability of the FFQ to classify subjects into similar quartiles of nutrient intake. We calculated the percent of subjects correctly classified (same quartile), classified within one quartile and grossly misclassified (classified within 2 or more quartiles).

Finally, validity of the FFQ was also assessed when only the first FFQ was used in the analyses. In addition, validity was also assessed when only infants with varied diet (inclusion of foods other than breast-milk or formula) were included in the analyses, to evaluate validity when several foods are consumed as opposed when only a single food is consumed.

Results

A total of 296 participants were recruited during a 3-month period. Only about 10 caregivers refused to participate and an additional 15 were younger than 21 years. From the total sample recruited, 54 did not complete both 24-h food recalls, even after several attempts to contact them, and one participant was older than 24 months. Therefore, the total sample size for analyses was 241. Table 1 shows the participants' characteristics. Most surveyed caregivers were mothers (97%), with median age of 27.0 years, with a level of education higher than high school (60.2%), and with a median of 2.0 children at home. There were slightly more male infants (55.6%) and median age was 9.0 months (range 0–24 months). In general, excessive weight (≥90th percentile) was found in 18.4% of the sample.

Correlations between FFQs and between 24-h recalls

There were significant correlations for energy and for all nutrients assessed between the first and the second administration of the FFQ (average correlation = 0.56) and between the first and the second 24-h recall (average correlation = 0.61) (Supplementary Table 1). In relation to food groups, there were also significant correlations between FFQs (average correlation = 0.48) and between 24-h recalls (average correlation = 0.50) (Supplementary Table 2).

Validity – Energy and Nutrients

Table 2 shows the intake of energy and of energy-adjusted nutrients from both the FFQs and the 24-h food recalls in the total sample. Energy and all nutrients were significantly correlated between both methods ($P<0.05$). The correlations ranged from 0.24 for copper to as high as 0.73 for energy, with an average correlation of 0.49. The de-attenuation improved the correlation, which ranged from 0.26 for folate to 0.77 for energy, with an average correlation of 0.53. On average, median intakes tended to be higher by 34% (range 19–51%) for nutrients assessed by the FFQ compared to those assessed by 24-hour recall. When only the first FFQ was used in the correlations, as opposed to the average of the FFQs, similar results were found, with correlations ranging from 0.13 for folate to 0.67 for energy and with an average correlation of 0.46 (data not shown).

We also conducted the analyses including only infants with varied diets (Table 3). Energy and all nutrients were significantly correlated between both methods ($P<0.05$), with a de-attenuated correlation ranging from 0.21 for folate to 0.71 for vitamin D, with an average correlation of 0.51. On average, median intakes tended to be higher by 32% (range 23–46%) for energy and nutrients assessed by the FFQ compared to those assessed by 24-hour recall. Similar results were obtained when only the first FFQ was used in the correlations (data not shown).

The results for the cross-classification analyses are shown as a Supplementary Table 3. Most participants were correctly classified into the same or adjacent quartile (average of 83%) by both assessment methods, with the highest for zinc (93%) and the lowest for copper (70%).

Gross misclassification was, on average, 17%, with the lowest for vitamin E (7%) and the highest for copper (30%).

Validity – Foods and Food groups

Table 4 shows the intake of energy-adjusted foods and food groups from both the FFQs and the 24-h food recalls in the total sample. All foods and food groups were significantly correlated between both methods (P<0.05). The de-attenuated correlations ranged from 0.28 for sweets to as high as 0.80 for breast-milk, with an average correlation of 0.55. When only infants with varied diets were included in the analyses (Table 5), we also found that intake of all foods and food groups were significantly correlated between methods (P<0.05), with an average correlation of 0.40.

Discussion

Only a few FFQs have been specifically developed and validated for use in infants. Assessing infant dietary intake is not easy, as there are many changes occurring in short periods of time.[7] However, it is important to understand early infant dietary patterns as certain patterns and behaviors are related to excess weight in infancy that could persist into childhood and adolescence.

The FFQ for infant and toddlers developed by our group had good reproducibility, as shown by high correlations between nutrient intakes assessed across the two administrations of the instrument. It also provided valid estimates for energy, nutrients, foods and food groups assessed, as these were significantly correlated with estimates obtained from the 24-h recalls. On average, the de-attenuated correlation for energy and nutrients was 0.53, with most well correlated between methods at above 0.40. In particular, high correlations (>0.7) were found for energy, vitamin D, vitamin E, iron and zinc. When infants with varied diet were taken into account, similar results were found. For foods and food groups, average correlation was 0.55 in the total sample and of 0.40 when only infants with a varied diet were included. High correlations (>0.6) were found in particular for beverages, as these were most consumed in this sample. These results are similar compared to the correlations coefficients as obtained in the other validated FFQs for this group,[10,16–20] in which most correlation coefficients ranged between 0.3 and 0.6.

It is important to note that the FFQ has consistently reported higher estimates of nutrients and foods evaluated compared to the recalls, with the latter well known to usually underestimate intake due to changes in reporting across days[21]. However, a report pooling 5 large validation studies of FFQ using recovery biomarkers as references found that a single 24-h recall provided better estimate of energy intake compared to the FFQ and even better when three 24-h recalls were averaged[36]. Therefore, this semi-quantitative FFQ cannot be used to assess absolute intakes, but it can be used to rank children into categories of intake correctly. This was evidenced by the good agreement between methods in the cross-classification, as most participants (83%) were correctly classified into the same or adjacent quartile of intake. These results are similar to the other validated FFQs for this group,[16,18,19] in which the intake of nutrients was correctly classified into the same or adjacent quartile/quintile in 78–81% of children.

There are only a few studies validating FFQs among infants and toddlers, most of which were done in Europe,[10,11,16] Australia[12,13] or New Zealand.[14,15] To our knowledge, there are only four FFQs validated for use in infants and toddlers in the US.[17–20] One of these FFQs is a modified version of the Harvard Service Food Frequency Questionnaire with 103 items and validated for nutrient intake in 233 white and Native American children 1–5 years in North Dakota about 20 years ago.[17] The food industry has introduced hundreds of new foods specifically designed for infants in the past 20 years; therefore, this FFQ may be outdated and not valid for current dietary patterns. The other FFQ is a modified version of a semi-quantitative FFQ originally developed and validated for Hispanic, African-American, and white adults.[18] This modified version included 107 foods grouped into nine categories and was validated among a small sample of 52 Hispanic, white and African American children 1–3 years old. This FFQ grouped all dairy products, a very important source of energy intake for this age group, into one category. Correlation coefficients ranged from 0.10 for starchy vegetables to 0.57 for non-starchy vegetables; however, the validity of energy and nutrient intakes was not assessed. The third FFQ is a questionnaire for evaluating consumption of only beverages among children aged 6 months to 5 years.[19] It was validated among 240 children participating in the IOWA Fluoride study and included human milk, infant formula, cow's milk, juice and juice drinks, soft drinks, prepared powdered soft drinks, and water. Recently, another FFQ was also validated for beverages only among Hispanic children 3–5 years.[20] Therefore, our developed FFQ is a valid instrument of broader analytic capacity, with inclusion of different common beverages used in young children as well as different foods regularly consumed by this group. In addition, it was validated for energy and nutrients and for the most common foods consumed by this group.

Although this FFQ was validated among a group of Hispanic infants and toddlers living in Puerto Rico, it could be used among other infants in the US as the foods and food groups were originally derived from the Infant Feeding Practices Survey II conducted by the Center for Disease Control and Prevention and expanded to include other food items most typically consumed by infants and toddlers in the US.[7] In addition, most foods consumed in Puerto Rico are imported from the US and only a few ethnic foods were included, such as plantain and cassava as part of the starchy roots group and tropical fruits (i.e. papaya) as part of the fruits groups.

Limitations and strengths

There are some limitations and strengths about the present study that should be taken into account when considering the results. The sample size and its selection limit generalizability to the full Puerto Rican population and other Hispanic groups. However, our sample was recruited from the only WIC clinic in one of the municipalities of Puerto Rico every day for 3 months, which ensured that all active WIC participants could be included in the study. Even though the sample selection might be cause of concern due to potential selection bias, more than 75% of children under 5 years of age in Puerto Rico and about 50% in the US participates in the WIC program,[37] a background fact that supports the sample is homogeneous and representative. The weight status of the caregivers was not assessed, which could possible bias the reporting of food. Another limitation was related to the difficulty for some caregivers to recall the foods and beverages consumed by their infants and to estimate the portion sizes of the different foods consumed, as frequently occurs in most nutrition studies. This was partly overcome by having a picture guide of portion sizes for the most common foods consumed by infants and toddlers to help caregivers estimate amounts consumed more accurately. Although the use of multiple 24-h food recalls is the gold standard for validating a FFQ, we could only include two recalls due to logistics, resources and the small time window for children of this age. However, we used de-attenuated correlation coefficients to deal with the issue of within-person variation in the recalls. Since there is a correlated measurement error between the two instruments, this could lead to overestimation of FFQ validity. Furthermore, the sequence of administering of the assessment methods meant that the 24-h recalls did not exactly represent the time period covered by the FFQ, which would tend to underestimate correlations between the methods. Therefore, our results are conservative. Although the FFQ offers less detail on dietary intakes, it is the most cost-effective method available for assessing usual intake.

Conclusions

In conclusion, this semi-quantitative FFQ specifically developed for infants and toddlers was able to capture relatively valid estimates of energy, nutrients and foods in a group of Hispanic infants and toddlers compared to the reference method (the 24-h food recalls). Although the FFQ estimates were systematically higher when compared to the reference method, it showed to be good in ranking individuals into quartiles. Therefore, nutritionists and dietitians could use this FFQ in similar groups to assess intake of energy, nutrients and food groups in infants and toddlers. Understanding dietary patterns in this group could help identify unhealthy dietary practices and patterns from early on and help develop specific recommendations and interventions for this group with the goal of preventing childhood and adulthood obesity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Practice Implications

What Is the Current Knowledge on this Topic?

There are only a few instruments to capture dietary patterns in infants and toddlers but most have not been validated. The few validated FFQs for use in infants and toddlers in the US have important methodological limitations.

How Does this Research Add to Knowledge on this Topic?

This short semi-quantitative FFQ specifically developed for infants and toddlers is able to capture valid estimates of energy, nutrients and foods in Hispanic infants and toddlers in the US.

How Might this Knowledge Impact Current Dietetics Practice?

This FFQ could be used in similar groups to assess diet in infants and toddlers to understand dietary patterns, help identify unhealthy dietary practices and help develop interventions for preventing obesity later in life.

Table 1

Socio-demographic characteristics in a sample of caregivers and their infants and toddlers' participants of the WIC program in Puerto Rico (N=241)

Variables	N (%) or Median (25th, 75th percentiles)
Caregivers	
Female	238 (98.8)
Mother	233 (96.7)
Age (years)	27.0 (24.0, 32.0)
Education	
≤High School	96 (39.8)
>High School	145 (60.2)
Number of Children	2.0 (1.0, 2.0)
Pregnancy duration (weeks)	39.0 (38.0, 40.0)
Infants and toddlers	
Gender	
Boy	134 (55.6)
Girl	107 (44.4)
Age (months)	9.0 (3.0, 15.0)
Weight-for-length percentile	
Underweight (<5th)	23 (9.6)
Healthy weight (5–89th)	172 (72.0)
Excessive weight (≥90th)	44 (18.4)
Type of feeding	
Varied diets	186 (77%)
Milk only	55 (23%)

[a]There were 2 infants with missing information on length and/or weight

Table 2

Energy and nutrients intakes in the FFQs and the 24-h recalls in a sample of infants and toddlers' participants of the WIC program in Puerto Rico (N=241)

Variable	FFQs	24-h food recalls	Spearman'scorrelation	De-attenuated correlation coefficient
	Median (25th, 75th percentiles)		r (95% CI)	r (95% CI)
Energy (kcal)	1096 (685 – 1589)	845 (620 – 1114)	0.73 (0.66, 0.78)	0.77 (0.69, 0.83)
Protein (g)	33.5 (30.1 – 37.6)	25.2 (21.8 – 31.3)	0.39 (0.27, 0.49)	0.45 (0.32, 0.56)
Carbohydrate (g)	159 (153 – 176)	120 (111 – 132)	0.31 (0.19, 0.42)	0.36 (0.22, 0.49)
Fat (g)	50.3 (43.7 – 52.8)	36.8 (30.8 – 42.1)	0.45 (0.35, 0.55)	0.53 (0.41, 0.64)
Saturated fat (g)	20.7 (17.9 – 22.1)	15.5 (12.7 – 18.6)	0.35 (0.23, 0.46)	0.42 (0.29, 0.53)
Monounsaturated fat (g)	16.9 (14.1 – 18.4)	12.3 (9.7 – 15.2)	0.50 (0.40, 0.59)	0.55 (0.43, 0.65)
Polyunsaturated fat (g)	9.0 (7.9 – 10.6)	5.7 (4.9 – 7.5)	0.48 (0.38, 0.57)	0.55 (0.43, 0.65)
Omega 3 Fatty acids (g)	0.8 (0.6 – 1.0)	0.6 (0.5 – 0.8)	0.55 (0.45, 0.63)	0.62 (0.50, 0.72)
Fiber (g)	8.0 (6.2 – 10.8)	4.3 (3.5 – 7.0)	0.35 (0.24, 0.46)	0.42 (0.29, 0.54)
Vitamin A - Retinol (µg)	732 (609 – 910)	498 (423 – 585)	0.43 (0.32, 0.53)	0.56 (0.44, 0.66)
Vitamin D (µg)	11.1 (6.6 – 14.5)	6.2 (2.9 – 9.0)	0.72 (0.66, 0.78)	0.73 (0.66, 0.80)
Vitamin E (mg)	7.7 (5.4 – 11.6)	3.4 (2.0 – 7.1)	0.70 (0.63, 0.76)	0.71 (0.63, 0.78)
Vitamin K (µg)	52.7 (28.3 – 78.4)	26.9 (10.3 – 53.2)	0.65 (0.57, 0.71)	0.63 (0.53, 0.71)
Vitamin C (mg)	107 (90 – 132)	70.0 (51.2 – 86.5)	0.52 (0.42, 0.60)	0.60 (0.48, 0.70)
Vitamin B1 (mg)	1.0 (0.8 – 1.1)	0.7 (0.5 – 0.9)	0.62 (0.54, 0.69)	0.62 (0.52, 0.71)
Vitamin B2 (mg)	1.5 (1.1 – 1.8)	0.9 (0.8 – 1.2)	0.59 (0.50, 0.67)	0.60 (0.50, 0.69)
Vitamin B3 (mg)	11.4 (8.6 – 14.4)	8.9 (5.6 – 10.4)	0.42 (0.31, 0.52)	0.54 (0.39, 0.65)
Vitamin B5 (mg)	4.6 (3.7 – 5.3)	3.2 (2.8 – 3.7)	0.59 (0.50, 0.66)	0.60 (0.50, 0.68)
Vitamin B6 (mg)	1.0 (0.9 – 1.2)	0.7 (0.5 – 0.9)	0.41 (0.30, 0.51)	0.42 (0.28, 0.55)
Vitamin B9 (µg)	250 (228 – 298)	143 (116 – 171)	0.26 (0.14, 0.38)	0.26 (0.11, 0.40)
Vitamin B12 (µg)	3.7 (3.2 – 4.3)	2.2 (1.5 – 2.9)	0.45 (0.34, 0.55)	0.45 (0.33, 0.56)
Calcium (mg)	906 (764 – 1061)	602 (481 – 751)	0.45 (0.34, 0.55)	0.43 (0.30, 0.54)
Phosphorus (mg)	692 (599 – 806)	495 (407 – 637)	0.47 (0.37, 0.56)	0.52 (0.40, 0.61)
Magnesium (mg)	148 (136 – 171)	104 (83.8 – 129)	0.44 (0.33, 0.54)	0.47 (0.34, 0.58)
Iron (mg)	12.2 (8.0 – 18.2)	8.4 (5.0 – 12.6)	0.69 (0.62, 0.75)	0.70 (0.61, 0.77)
Zinc (mg)	7.4 (5.6 – 9.6)	5.0 (3.6 – 6.2)	0.68 (0.60, 0.74)	0.71 (0.62, 0.79)
Copper (mg)	0.9 (0.8 – 1.1)	0.7 (0.6 – 0.7)	0.24 (0.11, 0.35)	0.34 (0.20, 0.47)
Potassium (mg)	1610 (1518 – 1933)	1161 (980 – 1380)	0.33 (0.21, 0.44)	0.37 (0.23, 0.50)

Table 3

Energy and nutrients intakes in the FFQs and the 24-h recalls among infants and toddlers' participants of the WIC program in Puerto Rico with varied diets (N=186)

Variable	FFQs	24-h food recalls	Spearman's correlation	De-attenuated correlation coefficient
	Median (25th, 75th percentiles)		r (95% CI)	r (95% CI)
Energy (kcal)	1279 (978, 1749)	981 (768, 1204)	0.56 (0.45, 0.65)	0.60 (0.47, 0.71)
Protein (g)	40.0 (34.8, 46.2)	30.4 (24.8, 38.4)	0.40 (0.27, 0.51)	0.45 (0.30, 0.58)
Carbohydrate (g)	190 (178, 207)	140 (129, 151)	0.27 (0.13, 0.40)	0.32 (0.16, 0.47)
Fat (g)	52.5 (47.1, 59.1)	37.3 (30.9, 43.1)	0.45 (0.32, 0.56)	0.53 (0.39, 0.65)
Saturated fat (g)	21.7 (18.7, 24.3)	15.8 (12.4, 19.4)	0.37 (0.24, 0.49)	0.43 (0.28, 0.56)
Monounsaturated fat (g)	17.4 (15.2, 20.3)	12.3 (9.6, 14.9)	0.46 (0.33, 0.56)	0.52 (0.37, 0.64)
Polyunsaturated fat (g)	10.3 (8.8, 11.8)	6.2 (4.8, 8.1)	0.43 (0.30, 0.54)	0.51 (0.37, 0.64)
Omega 3 Fatty acids (g)	0.9 (0.8, 1.1)	0.7 (0.5, 0.9)	0.47 (0.35, 0.57)	0.55 (0.40, 0.67)
Fiber (g)	10.6 (8.0, 13.6)	6.2 (4.6, 8.8)	0.34 (0.21, 0.46)	0.40 (0.24, 0.54)
Vitamin A-Retinol (μg)	787 (612, 970)	506 (390, 598)	0.41 (0.29, 0.52)	0.55 (0.41, 0.66)
Vitamin D (μg)	12.7 (8.6, 15.6)	6.8 (4.5, 9.1)	0.63 (0.54, 0.71)	0.71 (0.61, 0.78)
Vitamin E (mg)	9.1 (6.1, 12.7)	4.0 (2.6, 7.7)	0.67 (0.58, 0.74)	0.69 (0.59, 0.77)
Vitamin K (μg)	60.9 (33.1, 86.0)	33.5 (16.2, 58.3)	0.55 (0.44, 0.64)	0.54 (0.41, 0.65)
Vitamin C (mg)	122.6 (94.7, 151.2)	77.6 (48.6, 96.0)	0.48 (0.36, 0.58)	0.57 (0.42, 0.69)
Vitamin B1 (mg)	1.2 (1.1, 1.4)	0.8 (0.7, 1.0)	0.52 (0.41, 0.62)	0.57 (0.44, 0.68)
Vitamin B2 (mg)	1.8 (1.4, 2.1)	1.1 (0.9, 1.4)	0.54 (0.43, 0.64)	0.58 (0.45, 0.68)
Vitamin B3 (mg)	13.6 (10.3, 16.6)	10.1 (7.5, 11.9)	0.29 (0.15, 0.41)	0.50 (0.32, 0.65)
Vitamin B5 (mg)	5.2 (4.2, 5.8)	3.5 (3.1, 4.1)	0.48 (0.36, 0.59)	0.52 (0.39, 0.63)
Vitamin B6 (mg)	1.2 (1.1, 1.5)	0.9 (0.8, 1.0)	0.28 (0.14, 0.41)	0.29 (0.10, 0.45)
Vitamin B9 (μg)	308 (272, 373)	165 (141, 201)	0.22 (0.08, 0.35)	0.21 (0.03, 0.38)
Vitamin B12 (μg)	4.4 (3.6, 5.4)	2.6 (2.0, 3.1)	0.41 (0.28, 0.52)	0.41 (0.27, 0.54)
Calcium (mg)	1039 (833, 1204)	677 (555, 858)	0.36 (0.23, 0.48)	0.37 (0.21, 0.50)
Phosphorus (mg)	841 (701, 1071)	592 (491, 750)	0.53 (0.42, 0.63)	0.56 (0.43, 0.67)
Magnesium (mg)	181 (161, 209)	131 (106, 153)	0.48 (0.36, 0.58)	0.53 (0.39, 0.65)
Iron (mg)	14.5 (10.1, 20.3)	10.0 (7.0, 13.9)	0.60 (0.50, 0.68)	0.67 (0.56, 0.76)
Zinc (mg)	8.6 (6.8, 10.7)	5.5 (4.5, 6.7)	0.61 (0.51, 0.69)	0.70 (0.58, 0.79)
Copper (mg)	1.0 (0.9, 1.2)	0.7 (0.6, 0.8)	0.37 (0.24, 0.49)	0.46 (0.30, 0.59)
Potassium (mg)	1983 (1744, 2358)	1402 (1201, 1592)	0.35 (0.22, 0.47)	0.40 (0.24, 0.54)

Table 4

Foods and food groups in the infant FFQs and the 24-h recalls in a sample of infants and toddlers' participants of the WIC program in Puerto Rico (N=241)

Food or Food group	FFQs	24-h food recalls	Spearman correlations	
	Median (25th, 75th percentiles)		r (95% CI)	P value
Breast-milk (ml)	125 (9.34, 435)	50 (17.5, 520)	0.80 (0.73, 0.85)	<0.01
Formula (ml)	140 (0.02, 641)	558 (239, 801)	0.61 (0.52, 0.69)	<0.01
Milk (ml)	225 (47.5, 414)	155 (49.9, 206)	0.67 (0.58, 0.75)	<0.01
Cheese (serving)	0.17 (0.04, 0.26)	0.07 (0.01, 0.14)	0.33 (0.17, 0.48)	<0.01
Ice cream & yogurt (serving)	0.14 (0.03, 0.20)	0.03 (0.02, 0.07)	0.45 (0.31, 0.56)	<0.01
Juice (100%) (ml)	118 (48.9, 143)	53.4 (22.8, 93.7)	0.40 (0.25, 0.53)	<0.01
Sugary sweetened beverages (SSB) (ml)	10.9 (0.49, 22.7)	9.01 (0.49, 15.2)	0.62 (0.49, 0.72)	<0.01
Juice (100%) or SSB (ml)	135 (66.1, 162)	67.2 (29.5, 120)	0.49 (0.37, 0.60)	<0.01
Refined grains (cereals, rice, pasta) (serving)	0.96 (0.49, 1.21)	1.03 (0.55, 1.51)	0.45 (0.31, 0.58)	<0.01
Whole grains (cereals, rice, pasta) (serving)	0.10 (0.02, 0.15)	0.33 (0.15, 0.68)	0.34 (0.18, 0.48)	<0.01
Fruits (serving)	0.60 (0.42, 1.31)	0.24 (0.13, 0.72)	0.49 (0.35, 0.61)	<0.01
Vegetables (serving)	0.40 (0.22, 0.87)	0.15 (0.09, 0.53)	0.55 (0.40, 0.67)	<0.01
Starchy roots (serving)	0.07 (0.04, 0.12)	0.13 (0.02, 0.24)	0.30 (0.14, 0.44)	<0.01
Beans (serving)	0.25 (0.10, 0.31)	0.06 (0.01, 0.10)	0.58 (0.44, 0.70)	<0.01
Meats (serving)	0.43 (0.14, 0.55)	0.86 (0.38, 1.19)	0.51 (0.35, 0.63)	<0.01
Eggs (unit)	0.24 (0.04, 0.41)	0.04 (0.03, 0.09)	0.35 (0.20, 0.48)	<0.01
Nuts and seeds (serving)	0.08 (0.04, 0.21)	0.00 (0.00, 0.00)	0.34 (0.21, 0.46)	<0.01
Sweets (serving)	0.50 (0.06, 0.90)	0.22 (0.06, 0.38)	0.28 (0.11, 0.44)	<0.01
Salty snacks (serving)	0.01 (0.00, 0.03)	0.01 (0.02, 0.03)	0.37 (0.25, 0.49)	<0.01
Added fat (serving)	0.39 (0.14, 0.50)	0.50 (0.19, 0.68)	0.42 (0.27, 0.56)	<0.01

1 serving is equivalent to: cheese = 1 oz.; ice cream = 0.25 cups, yogurt = 0.5 cups; refined or whole grains= 0.5 cup; fruits = 0.5 cups; vegetables = 0.5 cup; starchy vegetables = 0.5 cup; beans = 0.5 cups; beef, chicken or fish = 4 oz.; eggs = 1 unit; sweets = 1 medium cookie, cupcake or muffin/1 regular size candy bar/1 tablespoons of gummies, candies/0.4 cups of marshmallows/1 lollipop; Salty snacks = 1 oz.; added fat = 1 tsp.

Table 5

Foods and food groups in the infant FFQ and the 24-h recalls in a sample of infants and toddlers' participants of the WIC program in Puerto Rico with varied diets (N=186)

Food or Food group	FFQs	24-h food recalls	Spearman correlations	
	Median (25th, 75th percentiles)		r (95% CI)	P value
Breast-milk (ml)	41.5 (20.9, 207)	3.77 (1.82, 38.3)	0.39 (0.25, 0.51)	<0.01
Formula (ml)	57.3 (1.81, 641)	467 (72.5, 796)	0.44 (0.31, 0.55)	<0.01
Milk (ml)	254 (72.3, 618)	170 (69.3, 371)	0.63 (0.52, 0.72)	<0.01
Cheese (serving)	0.19 (0.07, 0.31)	0.08 (0.02, 0.15)	0.22 (0.01, 0.41)	<0.01
Ice cream & yogurt (serving)	0.15 (0.06, 0.29)	0.03 (0.01, 0.07)	0.39 (0.22, 0.53)	<0.01
Juice (100%) (ml)	142 (77.2, 224)	62.4 (26.3, 130)	0.40 (0.24, 0.55)	<0.01
Sugary sweetened beverages (SSB) (ml)	13.3 (1.16, 25.8)	8.97 (0.71, 22.1)	0.57 (0.40, 0.70)	<0.01
Juice (100%) or SSB (ml)	167 (94.8, 231)	73.6 (39.4, 170)	0.50 (0.36, 0.62)	<0.01
Refined grains (cereals, rice, pasta) (serving)	1.16 (0.73, 1.63)	1.25 (0.73, 2.02)	0.43 (0.27, 0.57)	<0.01
Whole grains (cereals, rice, pasta) (serving)	0.11 (0.02, 0.22)	0.43 (0.17, 0.89)	0.30 (0.11, 0.47)	<0.01
Fruits (serving)	0.94 (0.44, 1.70)	0.43 (0.09, 0.98)	0.46 (0.30, 0.59)	<0.01
Vegetables (serving)	0.59 (0.25, 1.13)	0.33 (0.05, 0.77)	0.51 (0.34, 0.65)	<0.01
Starchy roots (serving)	0.09 (0.05, 0.16)	0.12 (0.03, 0.41)	0.30 (0.12, 0.46)	<0.01
Beans (serving)	0.31 (0.15, 0.48)	0.07 (0.02, 0.12)	0.63 (0.55, 0.69)	<0.01
Meats (serving)	0.50 (0.23, 0.71)	1.01 (0.52, 1.65)	0.46 (0.27, 0.61)	<0.01
Eggs (unit)	0.30 (0.09, 0.50)	0.04 (0.02, 0.09)	0.23 (0.05, 0.40)	<0.01
Nuts and seeds (serving)	0.11 (0.05, 0.25)	0.00 (0.00, 0.00)	0.22 (0.08, 0.35)	<0.05
Sweets (serving)	0.60 (0.12, 1.11)	0.23 (0.09, 0.54)	0.23 (0.02, 0.42)	<0.01
Salty snacks (serving)	0.02 (0.00, 0.03)	0.01 (0.02, 0.03)	0.24 (0.09, 0.39)	<0.01
Added fat (serving)	0.43 (0.23, 0.76)	0.57 (0.26, 0.93)	0.38 (0.19, 0.55)	<0.01

1 serving is equivalent to: cheese = 1 oz.; ice cream = 0.25 cups, yogurt = 0.5 cups; refined or whole grains= 0.5 cup; fruits = 0.5 cups; vegetables = 0.5 cup; starchy roots = 0.5 cup; beans = 0.5 cups; beef, chicken or fish = 4 oz.; eggs = 1 unit; sweets = 1 medium cookie, cupcake or muffin/1 regular size candy bar/1 tablespoons of gummies, candies/0.4 cups of marshmallows/1 lollipop; Salty snacks = 1 oz.; added fat = 1 tsp.