




# Novel Method for Estimating Nutrient Intakes Using a Semistructured 24-Hour Diet Recall for Infants and Young Children in Rural Bangladesh

Zaynah T Chowdhury,<sup>1</sup> Kristen M Hurley,<sup>1</sup> Rebecca K Campbell,<sup>1</sup> Saijuddin Shaikh,<sup>1,2</sup>  Abu Ahmed Shamim,<sup>2</sup> Sucheta Mehra,<sup>1</sup> and Parul Christian<sup>1</sup>

<sup>1</sup>Department of International Health, Center for Human Nutrition, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA and <sup>2</sup>JiVitA Project, Gaibandha, Bangladesh

## ABSTRACT

**Background:** Nutrient-level intakes from home-prepared complementary foods are rarely estimated among infants and young children in low-income settings. The major constraints are related to lack of standard recipes and ingredients and portion sizes.

**Objectives:** This article describes the feasibility, applicability, and validity of a post hoc qualitative methodology to estimate nutrient intakes in children using 24-h dietary recall.

**Methods:** Semistructured, interviewer-administered caregiver 24-h diet recalls were conducted to assess food intake among children participating in a randomized trial of complementary food supplementation at ages 6, 9, 12, 15, 18, and 24 mo in rural Bangladesh. At the end of the diet data collection, focus group discussions with mothers ( $n = 6$ ) and cooking activities ( $n = 5$ ) were conducted to obtain standard recipes (and ingredients) and portion sizes for reported foods given at different ages. Nutrient intakes were calculated for children in the control group ( $n = 1438$ ), and convergent validity of the data was tested by examining the association of energy and protein intakes with child age and socioeconomic status (SES).

**Results:** Focus group discussions generated standardized recipes for 21 commonly consumed mixed dishes being fed to children. These recipes were cooked, and portion sizes of standardized measures used in 24-h recalls were quantified in grams. For discrete foods, we quantified women's perceptions of "small," "medium," and "large" in grams. Across all ages, food groups consumed consisted mostly of staples, with the most common being rice, potatoes, and biscuits. Using portion size data and recipe ingredients, the 24-h dietary data, and Bangladeshi food composition tables, we successfully estimated nutrient intakes in children. Convergent validity analysis showed that energy and protein intakes were strongly associated with age and SES (both  $P < 0.001$ ).

**Conclusions:** We demonstrated the use of a validated, qualitative methodology for estimating nutrient intakes in young children from complementary foods in undernourished contexts. This trial was registered at [clinicaltrials.gov](https://clinicaltrials.gov) as NCT01562379. *Curr Dev Nutr* 2020;4:nzaa123.

**Keywords:** 24-h dietary recall, nutrient intake, qualitative data, complementary foods, infants and children

Copyright © The Author(s) on behalf of the American Society for Nutrition 2020. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)

Manuscript received April 30, 2020. Initial review completed July 7, 2020. Revision accepted July 10, 2020. Published online July 15, 2020.

This work was supported by the USDA, National Institute of Food and Agriculture, Food and Nutrition Enhancement Program under award number 2010-38418-21732; the Bill & Melinda Gates Foundation under grant GH614; the Johns Hopkins Sight and Life Global Nutrition Research Institute; and the Johns Hopkins Center for Global Health. In-kind support was received from DSM and Nutriset.

Author disclosures: The authors report no conflicts of interest.

Address correspondence to PC (e-mail: [pchrist1@jhu.edu](mailto:pchrist1@jhu.edu)).

Abbreviations used: FGD, focus group discussion; LSI, living standards index; SES, socioeconomic status.

## Introduction

The first 2 y of life are characterized by rapid developmental changes related to eating and diet spanning from exclusive breastfeeding through the first 6 mo, introduction to complementary foods, and transitions from liquid to semisolid and solid foods with increasing frequency, portion sizes, and types of foods until only family foods are provided (1, 2). Infants and young children are particularly vulnerable to undernutrition during this time because this is when breast milk becomes insufficient to meet their nutritional requirements, and safe and appropriate complementary foods are essential (3).

Currently, commonly used indicators of infant and young child feeding, such as dietary diversity score and minimum acceptable diet, rely on dietary food frequency data and are limited. Comprehensive dietary assessment among infants and young children is essential for population-level monitoring of food, energy, and micronutrient intakes relative to requirements and for meeting gaps with effective interventions such as social and behavior change communications (4) and small quantity lipid-based nutritional supplements (5).

The gold standard methods for assessment of nutrient intakes of infants and young children are multiple weighted food records or unstructured 24-h dietary recalls with portion sizes (6). However, the

cost, time, participants' motivation, and literacy required by these methods are important factors limiting their use in large epidemiological studies in resource-poor populations (6). A semistructured, interviewer-administered questionnaire may accelerate the data collection process and reduce literacy requirement on the respondent.

As part of a large complementary food supplementation trial (7), we employed such an approach using trained interviewers and food lists generated from extant data to assess nutrient intakes in children from ages 6 to 24 mo. The assessment as administered in the field included portion sizes, but it did not allow for simultaneously recording food descriptions and recipes required to estimate nutrient intakes. Thus, we designed an adjunct study following completion of data collection to gather the additional details needed to estimate nutrient intakes using data collected via the semistructured 24-h recall. We used qualitative methods, including focus group discussions (FGDs) and cooking activities, to 1) develop standardized recipes for dishes reported to be consumed by infants and young children; 2) quantify exact weights of foods corresponding to mothers' perceptions of portion sizes; and 3) identify the most common brands and products consumed by infants and young children for purchased, processed foods. We also tested whether the estimated intake data met the criteria for convergent validation through expected associations with child age and household socioeconomic status (SES). Our goal was to demonstrate the feasibility, applicability, and validity of our methodology for future use in studies requiring nutrient intake assessment in children of this age group, which is rarely done in low-resource settings.

## Methods

### Study participants

The study was conducted in rural northwestern Bangladesh and included children who participated in the JiVitA-4 study, a 5-arm cluster randomized controlled supplementation trial evaluating the impact of 4 different complementary food supplements on infants' and young children's stunting and growth compared with an unsupplemented control arm, with all groups receiving child-feeding counseling (7). All groups received infant and young child feeding messages and counseling throughout the study duration. The trial enrolled infants at age 6 mo and followed them for 1 y of daily supplementation and 6 mo postsupplementation to age 24 mo. The trial tested 2 locally designed and manufactured lipid-based supplements, 1 made from chickpea and 1 from rice and lentils; Plumpy'doz, a commercial lipid-based product manufactured by Nutriset; and a fortified food blend (wheat–soy blend ++). Plumpy'doz and the chickpea complementary food supplement, but not the other 2, reduced stunting by 5–6 percentage points relative to the control arm at the end of 1 y of supplementation (7).

### Administration of the semistructured 24-h recall

A semistructured 24-h diet recall was administered by trained study interviewers to mothers of children in the trial at 6, 9, 12, 15, 18, and 24 mo of age. The 24-h recall used a food list with 29 foods, including individual foods (e.g., banana), cooked recipes [e.g., suji (semolina porridge)], and food categories (leafy vegetables, fish, etc.) commonly consumed by infants and young children in rural Bangladesh. Space was provided for 8 additional open-ended items, with interviewers probing for "other

fruits," "other vegetables," and "other foods" not mentioned in the list. The preselected list of 29 foods was derived from the most frequently consumed foods reported in a 7-d FFQ administered to young children in the same study area (8). The 24-h diet recalls from participants in the control arm of the trial were included in this study.

Questions were structured as follows: "From yesterday morning to today morning, has the child been fed (name of food)?" If the mother answered "yes," the interviewer followed up by asking, "What was the amount (of food) offered to the child?" displaying different standard measures, after which the interviewer asked, "How much did the child eat?" and recorded the number or fraction of the selected serving unit. Standardized utensils of varying unit sizes (2 small spoons, 2 large spoons, 2 different sized bowls, and 1 glass) were used by interviewers to elicit serving sizes. For discrete food items, mothers were asked to report "small," "medium," or "large" (for, e.g., piece of fish).

### Qualitative study

After the parent trial was completed, a qualitative study was undertaken with the purpose of fully quantifying food intake in order to calculate nutrient intake in children at each age. Thus, the qualitative study aimed to 1) identify the most common foods provided to young children within food categories (e.g., dark green leafy vegetables) on the 24-h recall food list; 2) develop standard recipes with ingredient details for infant/child recipes/dishes reported in the 24-h recall questionnaire; 3) generate weight measures in grams for each food or recipe type with standard measures used, including generating consensus weight estimates for perceived sizes of foods reported by mothers as being consumed in small, medium, or large pieces; and 4) identify market-purchased foods commonly fed to young children through market surveys.

We conducted 6 FGDs with 8 mothers in each and 5 cooking activities (4 with mothers and 1 with a local food vendor) to develop standard recipes and cook them. The mothers were a convenience sample of project employees living in rural Gaibandha who were responsible for visiting homes within their areas to distribute the complementary food supplements and assess daily morbidity. They did not collect any other data for the study. These women were selected to participate in the FGDs because they had a child between ages 6 and 23 mo and were knowledgeable about the local food environment and young children's dietary patterns. One vendor was selected to provide recipes of cooked snack/dessert foods sold in local markets. The selection of the vendor was based on whether his shop served the local community and if he sold the most commonly consumed snack/dessert foods that were elicited from the market surveys.

### Ranking frequently consumed foods within food categories.

Through FGDs, we first aimed to identify the most common food items consumed by children aged 6–23 mo within broader food categories listed on the 24-h recall (e.g., green leafy vegetables and yellow fruits). To do this, mothers were asked to discuss these food groups and then come to a consensus about the 3 most common "type," "variety," or "brand" of foods that would be given to and consumed by young children, including foods purchased in the market. After reaching a consensus on the top 3 types, they were asked to estimate the relative frequency within the 3 types of food they thought were fed to young children. Relative frequency was reported by FGD members after com-

ing to a consensus and assigning a percentage (out of 100%) to how often a food type was consumed compared with the other food types assigned to that category, as “always” (considered as 100%), “almost always” (80–90%), “more than half the time” (60–70%), “half the time” (50%), “less than half the time” (30–40%), or “rarely” (10–20%). For example, for green leafy vegetables, FGD members came to consensus that the category consisted of 70% red amaranth leaves, 20% Indian spinach, and 10% bottle gourd leaves. Mothers reported considering availability as well as appropriateness for young children as examples of criteria used to make this determination.

#### **Standardized recipes.**

FGDs ( $n = 4$ ) were also conducted to elicit typical recipes (ingredients and cooking methods) for mixed dishes reported to be consumed by >1% of the children. Cooking activities (involving 4 with mothers and 1 with a local vendor) were then conducted to ascertain ingredient quantities and cooking methods. Foods were purchased according to the recipes developed in the FGDs. The weight of each raw ingredient (except for spices) was recorded during the cooking process, and the entire dish was weighed after being prepared.

#### **Portion sizes.**

To quantify the amount of food consumed by children, portion sizes were weighed in grams using a calibrated Tanita KD4063601 food weighing scale. Following the cooking activity for mixed dishes, weight of the cooked food in grams was measured for all the standardized utensils (e.g., teaspoons and bowls) used in the 24-h recall. Similarly, portion sizes of individual food items, such as milk, were also measured in grams using standardized utensils because such foods could be reported using different units of measure. For discrete food items and foods consumed in pieces (e.g., bananas and pieces of meat, fish, and cake), weight in grams for each piece size based on mothers' consensus on what they would consider small, medium, and large pieces was taken.

#### **Market surveys.**

Market surveys involved data collectors visiting different markets in their assigned area to obtain the types and brands of packaged foods for foods that were reported in the 24-h recalls: milk, powdered milk, baby formula, yogurt, white bread, cake, juice, chips, candy, and biscuits. The 3 most common varieties/brands for each food were used during the FGDs to rank the most common type.

#### **Converting foods and portion sizes into estimated nutrient intakes**

We converted reported food intakes from the 24-h recalls to nutrient intakes using a 2-step process. First, the questionnaire data on all food intakes were quantified (in grams) from the standard measure sizes reported and using the weight data from the qualitative study. Second, a study-specific food composition table was created containing nutrient values per 100 g for each item listed in the 24-h recall food list. Nutritive values of foods were taken from multiple sources to maximize the completeness of the study food composition table, but the primary source of food composition data was the published Bangladesh food composition tables (9). Other sources included USDA (10), ASEAN (11), and food composition tables from India (12), Nepal (13), Tanzania (14), and the United Kingdom (15). In instances in which multiple secondary sources

contained the same food item, a single source was selected first based on the similarity of the listed food to the local item of interest and then according to which source contained information for more nutrients.

For items that contained multiple varieties [e.g., *dal* (cooked lentil soup), leafy vegetables, and fish), the top 3 varieties and relative frequencies ranked by the FGD participants were used to create a weighted nutrient composition profile for the questionnaire item.

For mixed dishes, recipe information collected in FGDs was used and the nutritive value for each ingredient in the quantities used was applied along with “nutrient retention factors” from the Bangladesh food composition tables (9) to account for losses during the cooking process. Fat uptake of cooking fat was applied to recipes that entailed deep frying (9, 16). Weights recorded pre- and postcooking allowed for calculation of yield factors, which were applied to estimate the nutrient content of the cooked product. For recipes involving boiling or stewing in water, yield factors <1 were first attributed to water loss and then applied evenly to the other ingredients (16).

#### **Testing for convergent validity**

Nutrient intakes among children were tabulated for each age and compared with recommended nutrient intakes from complementary foods (1, 17–19) to explore the adequacy of the diet. Data were analyzed to examine convergent validity of the estimated nutrient intakes using our novel quantification method. Convergent validity refers to the extent to which 2 variables that theoretically should be related are, in fact, related (20). In this study, we measured convergent validity by examining the associations between estimated energy and protein intakes and 2 measures of theoretically related constructs—child age and household SES. Use of control group ( $n = 1438$ ) alone for testing convergent validity helped avoid the possible influence of the complementary food supplementation in the other arms of the study. We selected 2 nutrients—energy and protein—that are most likely to be influenced by the quantity of food consumed. SES was defined with a household living standards index (LSI) previously developed for this study area (21). Briefly, 11 household assets and 5 characteristics of the family dwelling were used to create this index. For this analysis, LSI was dichotomized using the median to categorize low compared with high SES households. Intakes of energy and protein were tabulated by child age and SES to assess the convergent validity of the nutrient intake data. Energy and protein intakes were expected to increase with age and with higher SES. The directionality and statistical significance of these trends were assessed with mixed effects models, which accounted for clustering of observations by sector, the unit of randomization in the trial, and for repeated observations in the same children over time. All statistical analyses were conducted using Stata version 13.1 (StataCorp).

The study was approved by the institutional review boards of the Johns Hopkins Bloomberg School of Public Health and the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr, b).

## **Results**

### **FGD findings**

A total of 21 foods were reviewed in the focus group discussions, and 16 recipes were generated during the recipe development activity (Table 1). Mothers also ranked the top 3 commonly consumed products for

**TABLE 1** Overview of 21 foods included in focus group discussions<sup>1</sup>

Food type	Market survey	Common foods FGD	Standard recipe	Portion size measurement
Animal milk	X	X		X
Powdered milk	X	X		X
Baby formula	X	X		
Yogurt <sup>2</sup>	X	X		X
White bread	X	X		X
Ruti <sup>3</sup>		X		X
Rice		X	X	X
Khichuri <sup>4</sup>			X	X
Da <sup>5</sup>		X	X	X
Large/medium fish		X	X	X
Small fish		X	X	X
Liver		X	X	X
Meat/chicken		X	X	X
Eggs		X	X	X
Potato		X		X
Leafy vegetables		X	X	X
Squash/gourd		X	X	X
Sheem <sup>6</sup>			X	X
Mixed vegetables			X	X
Parba <sup>7</sup>			X	X
Banana				X
Suji <sup>8</sup>			X	X
Apple				X
Cake	X	X		X
Juice	X	X		X
Chips	X	X		X
Candy	X	X		X
Biscuits	X	X		X
Puffed rice				X
Jilapi/khorma <sup>9</sup>			X	X
Shingara <sup>10</sup>			X	
Added oil				X
Added sugar				X

<sup>1</sup>FGD, focus group discussion.

<sup>2</sup>Yogurt in Bangladesh is generally sweetened.

<sup>3</sup>Flatbread made from flour and water.

<sup>4</sup>Dish made of rice, lentils, and assorted vegetables.

<sup>5</sup>Cooked lentil soup.

<sup>6</sup>Scarlet runner bean.

<sup>7</sup>Pointed gourd.

<sup>8</sup>Semolina porridge (with and without milk).

<sup>9</sup>Deep-fried sugar syrup-soaked sweets.

<sup>10</sup>Deep-fried refined wheat flour pastry stuffed with potatoes and chickpeas (aka samosa).

each of the 21 foods. In addition, we quantified and weighed portion sizes for 31 foods, of which 18 were measured with standard utensils used in the 24-h recall (teaspoon, tablespoon, bowl, glass, etc.), 9 were measured as whole items (e.g., banana, biscuit, and egg), and 4 were measured using piece sizes (e.g., fish).

The focus groups generally reported the same commonly consumed varieties for each food item, and we found convergence of opinions among the different groups. Examples of the data generated from these activities for fish are shown in **Tables 2–4**. *Pangash*, *Rui*, and *Batar musa* were the 3 most commonly consumed fish, although there was some variability between FGD groups (**Table 2**). A standard recipe for cooking *Pangash* (**Table 3**), which included ingredients such as oil, onion, and spices in addition to the fish, was developed by mothers and then cooked, weighing each ingredient before cooking and the final cooked

product. Pieces of cooked fish of varying sizes categorized by mothers as small, medium, or large were weighed (**Table 4**). Small, medium, and large pieces of cooked fish as determined by the participants had median weights of 22, 34, and 37 g, respectively, although 1 fish variety differed

**TABLE 2** Example of determination of most common variety of fish<sup>1</sup>

Fish type	FGD 1, %	FGD 2, %	FGD 3, %	Mean, %
<i>Pangash</i>	50.0	20.0	50.0	40.0
<i>Rui</i>	30.0	50.0	30.0	36.7
<i>Batar musa</i>	0.0	30.0	15.0	15.0
<i>Lal carpu</i>	20.0	0.0	0.0	6.7
Silver carp	0.0	0.0	5.0	1.7

<sup>1</sup>FGD, focus group discussion.

**TABLE 3** Example of a recipe developed through focus group discussion and cooking activity for *Pangash* fish

Ingredient	Raw weight, g
<i>Pangash</i> fish	887
Soybean oil	78
Water	550
Onion	151
Green chilies	28
Salt	24
Garlic	7
Ginger	5
Cumin	5
Turmeric	4
Chili powder	3
Garam masala	2
Coriander powder	1
Total cooked weight	1745

from the other 2 in its definition of size relative to its actual weight. Similar recipe development and portion size determination were done for 15 other dishes, including 2 that were done with a local vendor for the most common snack/dessert foods purchased outside of the home following the same process as described previously (data not shown).

### Food and nutrient intake

We present data on the food and nutrient intakes of children in the control group with at least 1 complete 24-h diet recall available at 6, 9, 12, 15, 18, or 24 mo of age. For the majority of children, the 24-h diet recall from all 6 time points is included in the analysis. Most caregivers reported at least 1 type of food being consumed by the infant in the previous 24 h at age 6 mo (data not shown). The top 10 most frequently consumed foods among children and amounts consumed are presented by age in [Table 5](#). Across all ages, food groups consumed consisted mostly of staples, with the most common staple items being rice, potatoes, and biscuits. The quantities of staples consumed increased with age ([Table 5](#)). Other foods commonly consumed included puffed rice, fish, eggs, milk, green leafy vegetables, and added oil and sugar. Quantities of milk indicated that higher amounts were consumed at different ages (6, 12, 15, and 24 mo), but other foods were consumed in small quantities, including green leafy vegetables and fish.

Estimated individual macro- and micronutrient intakes in children aged 6–24 mo are presented in [Table 6](#). Overall mean energy intakes were lower than recommended for children until age 18 mo. In contrast, mean protein intake was lower than recommended only at age 6 mo; it was higher at each of the other ages. Intakes of several micronutrients, such as iron, zinc, B-complex vitamins, and vitamin D, were lower than

**TABLE 4** Example of weights determined for small, medium, and large sizes of 3 common fish varieties as perceived by mothers in focus groups

Fish type	Small piece, g	Medium piece, g	Large piece, g
<i>Pangash</i>	28	34	46
<i>Rui</i>	22	34	37
<i>Batar musa</i>	14	22	33
Median for all fish	22	34	37

the estimated requirements, although on average children's nutrient intakes from home-based complementary foods were near or equal to the required Adequate Intake or RDA by age 18 mo and, more often, by age 24 mo ([Table 6](#)).

Both energy and protein intakes increased with child age ( $P < 0.001$ ) and baseline household SES defined using LSI ( $P < 0.001$ ) ([Figures 1 and 2](#)). Energy and protein intakes were not significantly different in children from low and high LSI households at age 6 mo, but the rate of increase in energy intake with age was statistically significantly greater in children of high LSI compared with low LSI (both  $P \leq 0.001$  for interaction term). At all subsequent ages, the mean intakes for both macronutrients differed significantly ( $P < 0.05$ ) by LSI, such that at age 24 mo the difference between energy intake in high and low LSI was 66 kcal (SE: 15;  $P < 0.001$ ) and the difference for protein between high and low LSI was 2.4 g (SE: 0.4;  $P < 0.001$ ).

At age 24 mo, 62.6% and 52.8% of children in high and low SES households, respectively, had reported energy intake from complementary foods equal to or greater than the recommendation of 548 kcal. At the same age, 89.8% and 82.0% of children in high and low SES households, respectively, had reported protein intake from complementary food equal to or greater than the recommendation of 7.1 g (data not shown).

### Discussion

Our novel qualitative post hoc method gathered additional data on recipes and portion sizes needed to quantify reported food intake, estimate nutrient intakes, and test the convergent validity of dietary data collected using a semistructured 24-h diet recall for young children in rural Bangladesh, where such data are sparse. Our study generated expected estimates of nutrient intakes, and we were able to demonstrate convergent validity through associations between measured intakes and child age and household SES.

Qualitative data collection generated standardized recipes for foods fed to infants and children. Sixteen recipes were elucidated, and ingredients were quantified to determine their nutrient values. Subjective portion sizes for discrete food items described as small, medium, and large were quantified as weights in grams using focus group techniques. The weight gradations of the subjective portion sizes were plausible, and there was high convergence of opinions within and between FGDs. In addition, commonly consumed packaged foods such as biscuits were gathered in a market survey, which allowed the nutrient content of the most common brands available locally to be used for estimating their nutrient contents. There was a manageable amount of variety in the packaged foods identified throughout the study area in the market survey. Using this qualitative research methodology, we were able to estimate the nutrients that children aged 6–24 mo consumed in a rural Bangladeshi context.

As found in other studies conducted among infants and young children in Bangladesh, where dietary diversity scores were low ([22, 23](#)), we also saw staple foods being most commonly consumed, followed by egg, dairy, fish, and vegetables. We have previously also demonstrated low dietary diversity in our study population ([24](#)). At younger ages, micronutrient intakes were low and on average did not meet the estimated requirements as shown previously ([25](#)). This was expected and

**TABLE 5** Ten most frequently reported foods and their amounts consumed by child age

		6 mo (n = 1412)		9 mo (n = 1366)		12 mo (n = 1355)			
Rank	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>
1	Rice	666	22 ± 39	Rice	1242	77 ± 73	Rice	1288	123 ± 103
2	Biscuits	477	11 ± 8	Potato	865	16 ± 12	Potato	952	22 ± 14
3	Added sugar	263	11 ± 13	Biscuits	586	11 ± 8	Biscuits	629	13 ± 10
4	Suji no milk	224	76 ± 98	Added oil	399	2 ± 1	Puffed rice	446	8 ± 8
5	Added oil	215	1 ± 1	Fish, large	290	28 ± 17	Fish, large	391	34 ± 21
6	Potato	200	9 ± 6	Puffed rice	287	4 ± 5	Leafy vegetables	382	12 ± 9
7	Milk	139	96 ± 129	Leafy vegetables	272	8 ± 7	Egg	280	44 ± 19
8	Cake	111	10 ± 4	Egg	251	45 ± 20	Added sugar	277	9 ± 13
9	Leafy vegetables	80	6 ± 6	Added sugar	245	10 ± 12	Added oil	273	2 ± 2
10a	Egg	77	42 ± 19	Cake	195	12 ± 5	Milk	262	122 ± 118
		15 mo (n = 1341)		18 mo (n = 1312)		24 mo (n = 1307)			
Rank	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>	Food item	n <sup>1</sup>	Amount, g (mean ± SD) <sup>2</sup>
1	Rice	1278	149 ± 125	Rice	1247	176.8 ± 128.2	Rice	1267	217 ± 161
2	Potato	971	23 ± 12	Potato	1008	26.5 ± 14.5	Potato	1036	32 ± 18
3	Biscuits	670	15 ± 11	Biscuits	723	18.8 ± 16.2	Biscuits	681	22 ± 18
4	Puffed rice	507	11 ± 12	Puffed rice	548	15.6 ± 15.6	Puffed rice	576	23 ± 17
5	Fish, large	431	37 ± 24	Fish, large	482	42.0 ± 25.2	Fish, large	473	49 ± 31
6	Leafy vegetables	362	16 ± 12	Egg	372	50.4 ± 26.7	Leafy vegetables	408	21 ± 13
7	Egg	353	46 ± 24	Added sugar	364	10.7 ± 14.3	Added sugar	404	11 ± 11
8	Added sugar	346	9 ± 11	Eggplant	351	18.0 ± 11.2	Egg	403	48 ± 21
9	Milk	305	130 ± 122	Leafy vegetables	335	18.3 ± 13.0	Milk	369	146 ± 103
10	Eggplant	300	17 ± 11	Cake	317	14.4 ± 6.5	Cake	331	16 ± 13

<sup>1</sup>The number who reported consuming the food in the past 24 h with variable missing data out of an n = 1428.

<sup>2</sup>Mean ± SD among those who reported consuming that food.

corresponds with the high rates of underweight and stunting in this sample and population (7). However, the increases of nutrient adequacy with age concur with previous research findings from another study (26) and our own (24). For example, a previous study in Bangladesh found

that energy and nutrient intakes (except for protein) in children age 6–12 mo were inadequate but increased slightly with age, based on direct observations of complementary food and breast milk intakes (26). In that study, trained observers remained in the child's home to

**TABLE 6** Nutrient intakes from home-based complementary foods by child age

Nutrient	Estimated requirement <sup>1</sup>		Mean ± SD by age					
	6–11 mo	12–24 mo	6 mo	9 mo	12 mo	15 mo	18 mo	24 mo
Energy, kcal <sup>2</sup>	255	548	67.0 ± 72.6	214.1 ± 136.6	331.6 ± 190.9	429.5 ± 238.3	511.1 ± 257.9	660.4 ± 322.1
Protein, g <sup>3</sup>	4.2	7.1	1.5 ± 2.3	5.7 ± 4.6	8.7 ± 5.8	11.2 ± 7.1	13.7 ± 7.8	17.0 ± 9.3
Carbohydrates, g	ND	ND	10.8 ± 13.0	33.8 ± 23.5	52.9 ± 32.5	67.3 ± 40.6	80.8 ± 44.4	108.7 ± 56.5
Fat, g	ND	ND	1.9 ± 2.6	5.8 ± 4.9	8.8 ± 6.8	11.9 ± 8.6	13.9 ± 9.1	16.1 ± 10.4
Calcium, mg <sup>5</sup>	219.5	346	22.4 ± 44.6	59.4 ± 64.3	94.6 ± 84.7	121.0 ± 104.7	143.6 ± 117.2	182.0 ± 144.1
Iron, mg <sup>5</sup>	9.1	5.6	0.3 ± 0.4	1.2 ± 1.2	1.7 ± 1.2	2.3 ± 1.5	2.7 ± 1.7	3.5 ± 2.3
Magnesium, mg <sup>5</sup>	37	41	6.9 ± 9.5	30.2 ± 22.2	51.4 ± 34.6	66.9 ± 45.1	76.0 ± 46.4	105.8 ± 62.9
Phosphorus, mg <sup>4</sup>	185	383	28.8 ± 43.6	95.4 ± 74.9	146.0 ± 97.2	187.0 ± 119.4	225.4 ± 127.4	285.7 ± 154.7
Potassium, mg <sup>4</sup>	361.5	2712	41.1 ± 67.4	154.1 ± 128.0	273.0 ± 207.5	372.5 ± 271.2	406.5 ± 270.3	597.5 ± 393.8
Zinc, mg <sup>5</sup>	3.4	3.4	0.2 ± 0.3	1.0 ± 0.8	1.5 ± 0.9	1.9 ± 1.2	2.2 ± 1.2	2.9 ± 1.6
Copper, mg <sup>4</sup>	0	0.2	0.0 ± 0.1	0.2 ± 0.2	0.3 ± 0.2	0.5 ± 0.3	0.5 ± 0.2	0.7 ± 0.6
Vitamin A, μg <sup>5</sup>	127.5	126	17.9 ± 42.6	73.8 ± 114.3	108.3 ± 142.2	143.6 ± 181.3	129.7 ± 178.8	204.1 ± 246.8
Vitamin D, μg <sup>5</sup>	4.7	4.7	0.0 ± 0.2	0.2 ± 0.4	0.2 ± 0.4	0.3 ± 0.4	0.3 ± 0.5	0.3 ± 0.5
Vitamin E, mg <sup>5</sup>	2.7	5	0.1 ± 0.3	0.5 ± 0.6	0.8 ± 0.8	1.1 ± 1.0	1.1 ± 0.9	1.5 ± 1.4
Thiamin, mg <sup>5</sup>	0.2	0.4	0.0 ± 0.0	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.3 ± 0.2
Riboflavin, mg <sup>5</sup>	0.2	0.3	0.0 ± 0.1	0.1 ± 0.2	0.2 ± 0.2	0.2 ± 0.2	0.3 ± 0.2	0.4 ± 0.3
Niacin, mg <sup>5</sup>	3	5	0.4 ± 0.6	1.8 ± 1.3	2.8 ± 1.8	3.6 ± 2.2	4.3 ± 2.4	5.4 ± 2.9
Vitamin B-6, mg <sup>5</sup>	0	0	0.0 ± 0.0	0.1 ± 0.1	0.2 ± 0.1	0.2 ± 0.2	0.3 ± 0.1	0.4 ± 0.3
Folate, μg <sup>5</sup>	48	103	4.3 ± 7.6	19.8 ± 25.6	31.1 ± 33.4	45.5 ± 49.1	39.3 ± 35.3	71.5 ± 81.7
Vitamin C, mg <sup>5</sup>	5	8	1.0 ± 4.6	7.8 ± 16.2	19.5 ± 44.9	31.0 ± 71.7	20.0 ± 54.3	57.7 ± 110.5

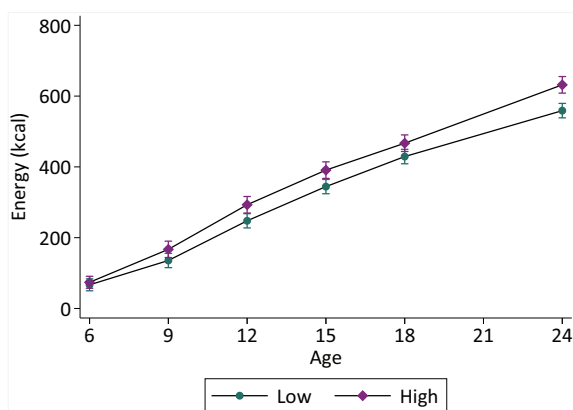
<sup>1</sup>Estimated requirements are RNIs, RDAs, and AIs as noted. Values for moderate iron bioavailability and 10% zinc bioavailability were used. Requirements from complementary foods is derived after subtracting the value of nutrients consumed from average breast milk intake as defined by WHO (17) according to the method used by Dewey and Brown (1). AI, Adequate Intake; ND, not defined; RNI, reference nutrient intake.

<sup>2</sup>FAO (19).

<sup>3</sup>RDA (27).

<sup>4</sup>AI (27).

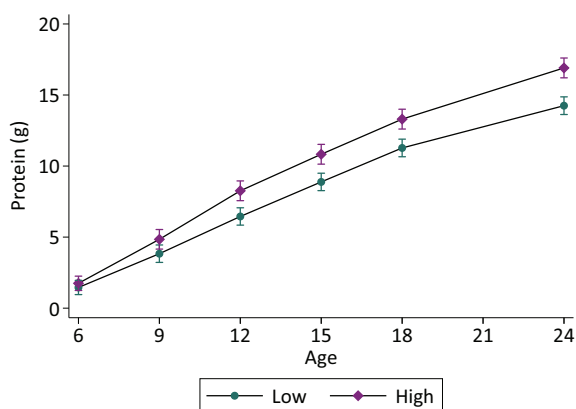
<sup>5</sup>RNI (18).



**FIGURE 1** Energy intake by living standards index (low compared with high) and child age.

complete a 12-h dietary record for each infant. A recent review examined adequacy of protein and amino acid intake among children in multiple settings and reported that 24% of Bangladeshi children had inadequate protein intake from non-breast milk sources (28). There are few other studies that compare values for nutrients in Bangladesh. We derive confidence in the validity of our data and method for quantifying nutrient intakes based on the results of our convergent validity findings, which showed a clear age gradient and an SES variation by SES in protein but not energy as expected.

The major strength of this study is that we were able to demonstrate that with the addition of a relatively limited set of qualitative data collection activities, and with the use of multiple publicly available sources of local and setting-specific food composition tables, we were able to estimate nutrient intakes among infants and children using a rapid interviewer-administered semiquantitative 24-h recall questionnaire, which we deployed in a large population of ~5000 children aged 6–24 mo 6 times during a study period of 18 mo. Our methods can be reproduced in other settings and age groups, and we now have data that can be applied to past and future diet data in this study area and possibly more broadly to diet data for young children in rural northwestern Bangladesh.



**FIGURE 2** Protein intake by living standards index (low compared with high) and child age.

Limitations of this study include the assumptions made related to the use of only the most frequently consumed foods and “standard” recipes and portion sizes for quantifying nutrient composition of questionnaire food items, erring toward homogeneity in consumed dishes, types, and varieties. This limitation is counterbalanced by the ability to derive nutrient intakes, which would have been impossible to do in a rural context in the absence of dietary, recipe, ingredient, and brand name databases and composition available in high-income settings. Moreover, in young children, our assumptions are less of a problem because the diversity of complementary foods introduced while breastfeeding tends to be low and increases very gradually. We were unable to validate our results with a gold standard 24-h quantitative dietary intake assessment, and the accuracy of the intakes and variability should be tested in future research. One other constraint faced was the composition of our FGDs, which comprised mothers who were on average of slightly higher SES than the mothers in the larger parent trial. The sample was largely a convenience sample and not selected to be representative of the community. These participants were selected based on their greater knowledge of feeding practices in the area compared with typical mothers.

Our findings have 3 important implications. First, from a measurement standpoint, the quantification and validation of an easy-to-administer semiquantitative 24-h recall along with the use of a corresponding food composition table will allow future investigators to use a similar methodology to estimate food and nutrient intakes among infants and young children in Bangladesh and other contexts. Such food and nutrient data are critically needed for monitoring food, energy, and nutrient intakes relative to requirements on the population level to prevent poor growth, health, and development in the first 2 y of life. Second, we present the details of the methodology that can be adopted and applied in other contexts for quantifying nutrient intakes. Third, from a programmatic standpoint, our findings support the need for interventions that increase dietary diversity and the consumption of nutrient-dense foods among infants and young children, especially early in the complementary feeding period when nutrient requirements are not met.

In summary, the applicability of the methodology used in this study is most suitable to other samples of young children and low-resource settings, in which dietary diversity is relatively limited, the variety of foods consumed is not extensive, and traditional recipes are common.

### Acknowledgments

ZTC, KMH, AAS, and PC: designed the research; ZTC, KMH, RKC, SS, and SM: conducted the research; ZTC, KMH, and RKC: analyzed the data; ZTC, KMH, RKC, and PC: wrote the paper; PC: had primary responsibility for final content; and all authors: read and approved the final manuscript.

### References

1. Dewey KG, Brown KH. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food Nutr Bull* 2003;24(1):5–28.

2. Black MM, Hurley KM. Helping children develop healthy eating habits. In: Tremblay RE, Boivin M, Peters RDeV, editors. *Encyclopedia on early childhood development* [online] 2013 [Internet]. [Accessed 2020 Apr 15]. Available from: <http://www.child-encyclopedia.com/sites/default/files/dossiers-complets/en/nutrition-pregnancy.pdf>.
3. WHO, UNICEF, USAID, AED, UC Davis, IFPRI. Indicators for assessing infant and young child feeding practices. Part II: measurement. Geneva (Switzerland): WHO; 2010.
4. Lassi ZS, Rind F, Irfan O, Hadi R, Das JK, Bhutta ZA. Impact of infant and young child feeding (IYCF) nutrition interventions on breastfeeding practices, growth and mortality in low- and middle-income countries: systematic review. *Nutrients* 2020;12(3):722.
5. Das JK, Salam RA, Hadi YB, Sadiq Sheikh S, Bhutta AZ, Weise Prinzo Z, Bhutta ZA. Preventive lipid-based nutrient supplements given with complementary foods to infants and young children 6 to 23 months of age for health, nutrition, and developmental outcomes. *Cochrane Database Syst Rev* 2019;2019(5):CD012611.
6. Gibson RS. *Principles of nutritional assessment*. 2nd ed. New York: Oxford University Press; 2005.
7. Christian P, Shaikh S, Shamim AA, Mehra S, Wu L, Mitra M, Ali H, Merrill RD, Choudhury N, Parveen M, et al. Effect of fortified complementary food supplementation on child growth in rural Bangladesh: a cluster-randomized trial. *Int J Epidemiol* 2015;44(6):1862–76.
8. Christian P, Kim J, Mehra S, Shaikh S, Ali H, Shamim AA, Wu L, Klemm R, Labrique AB, West KP, Jr. Effects of prenatal multiple micronutrient supplementation on growth and cognition through 2 years of age in rural Bangladesh: the JiVitA-3 Trial. *Am J Clin Nutr* 2016;104(4):1175–82.
9. Shaheen N, Rahim ATMA, Mohiduzzaman M, Banu CP, Bari ML, Tukum AB, Mannan M, Bhattacharjee L, Stadlmayr B. *Food composition table for Bangladesh*. Dhaka (Bangladesh): Institute of Nutrition and Food Science, Centre for Advanced Research in Sciences, University of Dhaka; 2013.
10. USDA, Agricultural Research Service. *USDA national nutrient database for standard reference*, release 26. Beltsville (MD): USDA; 2013.
11. Institute of Nutrition, Mahidol University. *ASEAN food composition database*, electronic version 1. Bangkok (Thailand): Institute of Nutrition, Mahidol University; 2014.
12. Gopalan C, Rama Sastri BV, Balasubramanian SC. *Nutritive value of Indian foods*. Hyderabad (India): National Institute of Nutrition, Indian Council of Medical Research; 1971.
13. National Nutrition Program. *Food composition table for Nepal*. Kathmandu (Nepal): Nepal Government Ministry of Agriculture Development; 2012.
14. Lukmanji Z, Hertzmark E, Mlingi N, Assey V, Ndossi G, Fawzi W. *Tanzania food composition tables*. Dar es Salaam (Tanzania): Muhimbili University of Health and Allied Sciences, Tanzania Food and Nutrition Centre, and Harvard School of Public Health; 2008.
15. Public Health England. *McCance & Widdowson's composition of foods integrated dataset (CoF IDS)*. London (UK): Public Health England; 2002.
16. Vásquez-Caicedo AL, Bell S, Hartmann B. Report on collection of rules on use of recipe calculation procedures including the use of yield and retention factors for imputing nutrient values for composite foods. Brussels (Belgium): European Food Information Resource Network; 2008.
17. WHO. *Complementary feeding of young children in developing countries*. Geneva (Switzerland): WHO; 1998.
18. WHO, FAO. *Vitamin and mineral requirements in human nutrition*. 2nd ed. Geneva (Switzerland): WHO; 2004.
19. FAO, United Nations University, WHO. *Human energy requirements: report of a Joint FAO/WHO/UNU expert consultation*. Rome (Italy): FAO; 2004.
20. DeVellis RF. *Scale development: theory and applications*. 2nd ed. Los Angeles (CA): Sage; 2012.
21. Gunnsteinsson S, Labrique AB, West KP, Jr, Christian P, Mehra S, Shamim AA, Rashid M, Katz J, Klemm RDW. Constructing indices of rural living standards in northwestern Bangladesh. *J Health Popul Nutr* 2010;28(5):509–19.
22. Nguyen PH, Avula R, Ruel MT, Saha KK, Ali D, Tran LM, Frongillo EA, Menon P, Rawat R. Maternal and child dietary diversity are associated in Bangladesh, Vietnam, and Ethiopia. *J Nutr* 2013;143(7):1176–83.
23. Arsenault JE, Yakes EA, Islam MM, Hossain MB, Ahmed T, Hotz C, Lewis B, Rahman AS, Jamil KM, Brown KH. Very low adequacy of micronutrient intakes by young children and women in rural Bangladesh is primarily explained by low food intake and limited diversity. *J Nutr* 2013;143(2):197–203.
24. Campbell RK, Hurley KM, Shamim AA, Shaikh S, Chowdhury ZT, Mehra S, de Pee S, Ahmed T, West KP, Jr, Christian P. Effect of complementary food supplementation on breastfeeding and home diet in rural Bangladeshi children. *Am J Clin Nutr* 2016;104(5):1450–68.
25. Campbell RK, Hurley KM, Shamim AA, Shaikh S, Chowdhury ZT, Mehra S, Wu L, Christian P. Complementary food supplements increase dietary nutrient adequacy and do not replace home food consumption in children 6–18 months old in a randomized controlled trial in rural Bangladesh. *J Nutr* 2018;148(9):1484–92.
26. Kimmons JE, Dewey KG, Haque E, Chakraborty J, Osendarp SJM, Brown KH. Low nutrient intakes among infants in rural Bangladesh are attributable to low intake and micronutrient density of complementary foods. *J Nutr* 2005;135(3):444–51.
27. Institute of Medicine. *Dietary Reference Intakes: the essential guide to nutrition requirements*. Otten JJ, Hellwig JP, Meyers LD, editors Washington (DC): National Academy Press; 2006.
28. Arsenault JE, Brown KH. Dietary protein intake in young children in selected low-income countries is generally adequate in relation to estimated requirements for healthy children, except when complementary food intake is low. *J Nutr* 2017;147(5):932–9.