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WHAT ARE PRESCHOOL CHILDREN EATING? A REVIEW OF DIETARY ASSESSMENT[1]

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■ **Abstract** Accurate assessment of dietary intake among preschool-aged children is important for clinical care and research, for nutrition monitoring and evaluating nutrition interventions, and for epidemiologic research. We identified 25 studies published between January 1976 and August 2000 that evaluated the validity of food recalls ($n = 12$), food frequency questionnaires ($n = 9$), food records ($n = 2$), or other methods ($n = 2$). We identified four studies that evaluated the reproducibility of food frequency questionnaires. Validity studies varied in validation standard and study design, making comparisons between studies difficult. In general, food frequency questionnaires overestimated total energy intake and were better at ranking, than quantifying, nutrient intake. Compared with the validation standard, food recalls both overestimated and underestimated energy intake. When choosing a method to estimate diet, both purpose of the assessment and practicality of the method must be considered, in addition to the validity and reproducibility reported in the scientific literature.

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INTRODUCTION

Assessment of dietary intake among preschool-aged children (≤5 years old) is essential for monitoring the nutritional status of the population as well as for conducting epidemiologic research on the link between diet and health. In addition, dietary assessment is important for pediatric clinical care and research. Dietary behaviors of particular interest are those emphasized in national dietary guidelines (37), in the nutrition objectives of Healthy People 2010 (38), in specific nutrient intake recommendations, such as *Dietary Reference Intakes* (19), and in clinical guidelines (6). Every evaluation of compliance with dietary guidelines or recommendations is limited, however, by the validity and reproducibility of the dietary assessment tool used for measuring intake. In addition, monitoring of trends in dietary intake is limited by changes in dietary assessment methods because caution must be used in comparing across surveys where dietary assessments were conducted differently.

Rapid change characterizes the diet of young children. Early on, most infants consume small quantities of milk at frequent intervals; older infants and toddlers consume larger quantities of milk and weaning foods or table foods. By age 2–3 years, most children consume foods eaten by the rest of the family. Assessment of dietary intake is also affected by social factors, such as day care, which can limit a parent's ability to report what a child actually consumed.

Techniques commonly used to assess the diets of preschool-aged children include respondent-based methods, such as dietary recalls, dietary records, and food frequency questionnaires (FFQs), investigator-based techniques, such as direct observation and collection of duplicate portions, and physiologic measures, such as doubly labeled water, or biomarkers of dietary intake, such as serum carotenoids (13). To measure dietary intakes of preschool children, valid, reliable, and age-appropriate assessment techniques are required that are both practical and suited to the needs of the researcher or clinician. In this paper, we review the methods currently used to measure dietary intake of preschool-aged children and the challenges of using such methods. Because the assessment of milk intake has been reviewed separately (KS Scanlon, manuscript in preparation), we did not include studies of this behavior.

METHODOLOGY

In the absence of an absolute gold standard for dietary assessment (39), measurement of the validity of a dietary assessment technique is based on comparison with a second technique. In this report, validity is defined as the degree to which results from one dietary assessment technique match the results obtained through the validity technique, in this report referred to as the validation standard. Reproducibility is the extent to which the questionnaire measurements are consistent across administrations at different times (39).

The studies we include were selected from those of preschool-aged children conducted in developed or developing countries and published in English between January 1976 and August 2000. Studies were identified through MEDLINE and POPLINE literature searches using the following key words: diet, nutrition assessment, infant food, infant nutrition, child nutrition, validity, reproducibility, comparability, and accuracy. Additional articles were identified using the references in the identified studies.

We included studies with children over age 5 only when they had a substantial number of preschool children. We excluded studies where the referent period (time period when the diet was measured by the dietary technique being evaluated) did not coincide or overlap with the referent period for the validation standard (15, 23, 29). We also excluded studies that evaluated dietary assessment measures for populations rather than individual children (32). Finally, we excluded studies of breastfeeding or infant formula feeding. Two reports (9, 24) were based on the same study; we counted them as a single study.

In all, we selected 29 studies from 23 published reports that assessed the validity or reproducibility of dietary intake methods. For clarity of presentation, when more than one validity or reproducibility study was included in the same publication that evaluated separate dietary methods, we discuss them as separate studies. We identified 25 studies that evaluated the validity of food recalls, food records, FFQs, and other methods. We identified an additional four studies that evaluated the reproducibility of FFQs.

We briefly describe each of these dietary assessment methods, discuss the results of the validity and reproducibility studies for that method, and present summary tables with details of each study.

FOOD RECALLS

Trained interviewers administer food recalls to collect information on everything a subject consumes during a specified period (35), most often the previous 24 h or less. Because of day-to-day variability, multiple recalls are required to estimate the usual nutrient intakes of individual children. A single recall can be used to calculate the group mean nutrient intake in a population, but multiple recalls are needed to estimate the prevalence of low or high intakes (39). How many recall days are needed to calculate usual intake depends on the nutrient (28). When the required recall days are not available, statistical methods can be used to estimate usual intake adjusting for predicted within-person and between-person variability (14). For preschoolers, caregivers may be asked to provide detailed information about dietary intake, such as brand names, ingredients of mixed dishes, and food preparation methods, and to estimate amounts consumed. Visual prompts for quantifying portion size, such as food models, pictures of foods, or standard household utensils, are often used. Once the recall data are collected, they are coded by skilled personnel, often by direct data entry into a software program for calculating nutrient intake.

Validity

Of the 12 food recall validity studies we reviewed (Table 1), most assessed a complete 24-h recall (2, 8, 11, 12, 17, 18, 21, 25, 30, 31). Two studies assessed a single meal (3, 9). The referent periods of the food recall and the validation standard coincided in all except one study, in which the referent period was not specified and was assumed to be the same (30).

The validation standard varied widely, making comparisons difficult. Food recalls were compared with direct observation in four studies, with food records in six, and total energy expenditure as measured by doubly labeled water, collection of duplicate portions, and serum lipid concentrations in one each. Recalls of dietary intake typically were obtained from parents or the primary caretaker without input from the child. The exception was the study by Eck et al (9), which evaluated recalls completed by the mother alone, the father alone, and the mother and father with input from the child (consensus). Studies used different strategies where the mother was unable to provide a complete recall because the child attended day care. In the studies that addressed this issue, one conducted separate recall interviews of day care personnel (18) whereas another excluded segments of both the recall and the validation standard when the mother was not with the child and unable to report (2).

In the studies that compared recalled with observed intake (2, 3, 8, 9), the relative difference in mean energy intake was within 10%. In the comparison using doubly labeled water (21), 24-h recalls underestimated mean energy intake by 3%. In the study using duplicate portions (17), recalls overestimated intake of energy by 10%. Similar results for energy and nutrient intake were reported in studies that used respondent-based measures (such as food records) as the validation standard (8, 11, 12, 18, 25, 30), with recalled energy intake within 15% of measured energy.

Among the nine studies that reported correlations for energy and macronutrients, in seven (3, 8, 9, 11, 17, 18, 25) the correlation coefficients were always $\geq$0.45. In the remaining two studies, correlations were usually much lower (12, 21). In the doubly labeled water study, the Pearson correlation coefficient was 0.25 for energy (21). In another study (12) that compared repeated 24-h recalls with weighed food records, correlations were 0.06–0.25 for energy and 0.30–0.48 for protein.

Agreement on food items between the food recalls and the validation standard varied by food group. Typically, main meal items were more likely to be recalled than snack foods and desserts (9, 11, 12). In general, respondents were more likely to omit than to add food items (2, 3, 8, 12, 25). There was no consistent pattern in the ability of respondents to estimate portion sizes, with studies reporting both overestimation and underestimation of various foods in the recalls. In their study of Senegalese weanling children (age 11–18 months), Dop et al (8) reported that mothers had more difficulty estimating portion sizes of foods served from the common household pot than of food served separately.

Only a few studies examined the effect of sex, ethnicity, or weight status on recall validity, and none examined the effect of age. No significant differences in validity by sex or by body mass index of the child or parents were found when doubly labeled water was used as the validation standard (21). When observation was used as the standard, Caucasian and Mexican-American mothers more likely to underreport energy and nutrient intakes and African-American mothers more likely to overreport (2). In this study, mothers who were with their preschool children most of the day ("at-home") were significantly more likely to be able to report intake for all of the day than were mothers whose preschoolers were in daycare more than 4.5 h per day ("not-at-home"). Among mothers able to report intake, however, not-at-home and at-home mothers demonstrated similar accuracy in estimating energy and nutrient intake.

FOOD RECORDS

With food records, caregivers record detailed information about all food and beverages (including preparation method) consumed during a specified time period (35). Methods used to quantify the amount consumed have included weighing or measuring food and visual estimation. Ideally, information is recorded at consumption, improving estimation of portion size and eliminating the problem of forgetting. Recording detailed information on food intake, which necessitates the immediate quantification of portion size, is labor intensive, however, and carries a higher respondent burden than do food recalls or FFQs. As with food recalls, multiple sample days are required to estimate usual intake, and the data must be coded by skilled personnel.

Validity

The only two studies that evaluated the validity of weighed food records for preschool-aged children (7, 16) used 4–5 days of records and were conducted in industrialized countries (Table 2). Population demographics and referent periods differed, however, as did the validation standard. The doubly labeled water method was the validation standard in one study (7), with diet history the method in the other (16).

Mean energy intake calculated from food records underestimated total energy expenditure from the doubly labeled water method by 3%, with a correlation of 0.41 between food records and doubly labeled water (7). Similarly, when compared with diet history, food records underestimated mean energy intake by approximately 7% (16).

TABLE 1 Validity of food recall[a]

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Baranowski et al (2)	3–5 years, 29 M/27 F, 48% Caucasian, 41% African-American, 11% Hispanic, US	24-h recall	12-h observation	Same day	—	—	−7% (1053 vs 1138 kcal)	Recall underestimated 2 of 9 nutrients and overestimated 2 (significance testing not shown)	Excluded from analysis times when mothers and/or observers were not with child and could not report Food items: 65% mean precise agreement, 7% mean partial agreement; mothers were more likely to underreport (18%) than overreport (10%) Regression analysis on differences in nutrient scores showed no effects for amount of time mother and child were together during the day or for socioeconomic status. Caucasion and Mexican-American mothers more likely to underreport intake and African-Americans more likely to overreport

									Mothers in the not-at-home group were less likely to be able to report on their child's intake for a whole or part of the day compared with at-home mothers; however, when not-at-home mothers reported, they were as accurate as at-home mothers
Basch et al (3)	4–7 years, 18 M/28 F, Latino, US	Evening meal recall excerpted from 24-h recall	Evening meal observation	Same day	Adjusted (energy) Pearson: 0.71 energy, 0.50 protein, 0.52 fat	Adjusted (energy) Pearson: −0.10 phosphorous to 0.82 iron (18 nutrients)	+9% (507 vs 465 kcal)	Recall significantly overestimated 7 of 18 nutrients	Food items: For 9 of 10 most frequently eaten food groups, observed and recalled frequencies were identical; mothers' recalls tended to omit foods more often than add them Portion sizes: 51% of recalled portion sizes were equivalent to observed, 16% were underestimated; 34% were overestimated
Dop et al (8)	11–18 months, 24 M/21 F, Senegal	24-h recall	12-h observation	Same day	—	—	—	—	Food items: Among consumers, millet-sorghum was omitted on 16% of recalls and fish on 24%. Mothers tend to omit foods rather than add them
		24-h recall, mean of 2 consecutive days	12-h weighed food records w/observation	Same day	Spearman: 0.75 energy, 0.75 protein, 0.70 fat	Spearman: 0.70 fat to 0.80 carbohydrate (4 nutrients)	+1% (413 vs 407 kcal)	No significant differences for 4 of 4 nutrients	Food items: Spearman correlations for 7 food groups ranged from 0.43 for fish

(*Continued*)

TABLE 1 (*Continued*)

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/qualitative and other differences
		(breast milk not included)	and test weighing (precise weighing technique), mean of 2 consecutive days (breast milk not included)						to 0.91 for millet-sorghum; among consumers, millet-sorghum was omitted in 11% of recalls and fish in 13% among nonconsumers, fish was added in 31% of recalls Portion sizes: Mothers had more difficulty estimating portion sizes of foods from the "common household pot" (e.g. rice, oil, & fish) than foods served in common household measures as standard portions (e.g. wheat products, beverages, gruel, dairy, etc)
Eck et al (9) [also Klesges et al (24)]	4–9.5 years, 34 M & F, US	Lunch recall interview of fathers, mothers, and consensus recall of mother, father, and child	Lunch observation	Same day	Unadjusted Pearson: fathers —0.83 energy, 0.79 protein[e], 0.72 fat[e], mothers —0.64 energy, 0.56 protein[e], 0.65 fat[e];	Unadjusted Pearson: mothers–0.56 protein[e]; consensus —0.91 protein[e] (9 nutrients)	Fathers, −5% (545 vs 572 kcal); mothers, −4% (550 vs 572 kcal); consensus, −2% (558 vs 572 kcal)	No significant differences for 9 of 9 nutrients.	Food items: Only fathers' recalls of number of nondairy beverage items and snacks/dessert items were significantly different from number of items observed; only mothers' recalls of calories from dairy foods/beverages and snacks/desserts were significantly different from observed; however, overestimation/underestimation ranged greatly—from 27%

					consensus —0.87 energy, 0.91 protein[e], 0.85 fat[e]				under for breads (fathers) to 50% over for fruits (fathers); obesity status of parents and child did not significantly affect accuracy of recall (24)
Ferguson et al (11)	4–6 years, 29 M & F, Malawi	24-h food recall	Weighed food record	Same day	Unadjusted Spearman: 0.47 energy, 0.50 protein	Unadjusted Spearman: 0.28 vitamin C to 0.55 zinc (6 nutrients)	−14% (1133 vs 1314 kcal) (medians)	No significant differences for 6 of 6 nutrients	Food items: Consumption of main meal dishes was more accurately recalled than snack foods; 44% of fruits to 90% of cakes were omitted by the recalls; fruit consumption was also recalled when not consumed; average grams recalled were significantly higher than recorded for fruit and lower for porridge; no significant differences for other food groups
Ferguson et al (12)	56 ± 9.4 months (mean ± SD), 33 M/39 F, Ghana (2 villages—Slepor and Gidantuba)	24-h recall, median of 2 consecutive days	Weighed food records, median of 2 consecutive days	Same day	Intraclass: Slepor—0.06 energy, 0.30 protein; Gidantuba—0.25 energy, 0.48 protein	Intraclass: Slepor−0.06 energy to 0.78 vitamin A (5 nutrients)	Slepor;−15% (1025 vs 1207 kcal) (medians); Gidantuba: +1% (1160 vs 1146 kcal) (medians)	Slepor: recall significantly underestimated 4 of 5 nutrients; Gidantuba: recall significantly underestimated 1 of 5 nutrients	Food items: Intraclass correlations for percentage of energy obtained from selected food groups ranged from 0.29 for meat, poultry, and fish (Slepor) to 0.79 for cereals (Slepor); less than 15% of main meal foods and purchased meals to over 60% of fruits and snacks were omitted; less than 20% of all food types were added when not consumed. Portion sizes: In Slepor, recall significantly underestimated banku (a staple) and stew and overestimated soup portions; in Gidantuba, recall significantly overestimated banku

(*Continued*)

TABLE 1 (*Continued*)

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Horst et al (17)	6 months, 41 M & F (nonbreastfed), Netherlands	24-h recall	24-h duplicate portion method	Same day	Unadjusted Spearman: 0.77 energy, 0.90 protein, 0.84 fat	Unadjusted Spearman: 0.69 potassium to 0.96 phosphorous (9 nutrients)	+10% (747 vs 680 kcal)	Recall significantly overestimated 7 of 9 nutrients	Food groups: Recall significantly overestimated amount (weight) of infant formula, fruit, and cooked dishes such as meat, potatoes, eggs, vegetables
Iannotti et al (18)	2–4 years, 17 M & F, US	24-h recall, mean of 3 days	Measured food records, mean of 3 days	Same day	Unadjusted Pearson: 0.45 energy	Unadjusted Pearson: 0.43 sodium to 0.79 cholesterol (5 nutrients)	−4% (1053 vs 1095 kcal)	No significant mean differences for 5 of 5 nutrients	Both usual caregivers and day caregivers provided recall information
Johnson et al (21)	4–7 years, 12 M/12 F, US	24-h recall, mean of 3 days	TEE with doubly labeled water over 14 days	Overlapping days—TEE encompassed 3 days of recall	Unadjusted Pearson: 0.25 energy	—	−3% (1553 vs 1607 kcal)	—	No difference in misreporting by BMI/obesity status of child or parent; misreporting of energy intake not statistically different between boys and girls
Klesges et al (25)	2–4 years, 17 M/13 F, US	24-h recall	24-h weighed food record	Same day	Unadjusted Pearson: 0.48 energy, 0.63 protein	Unadjusted Pearson: 0.48 energy to 0.75 saturated fat and cholesterol (7 nutrients)	+1% (1132 vs 1122 kcal	No significant differences for 7 of 7 nutrients	Food items: Correct recall of 96% of foods eaten; 4% underreporting (not identifying foods eaten); 0% overreporting (identifying food not eaten)

Persson & Calgren (30)	4 & 8 years, 477 M & F, Sweden	24-h recall	7-day food records	—	—	—	−0.2% (1780 vs 1784 kcal)	Recall overestimated 1 of 8 nutrients and underestimated 2 of 8 nutrients (significance testing not shown)	—
Shea et al (31)	4–5 years, 57 M/51 F, Hispanic, US	24-h recall, mean of 4 administered 4 times over 1 year	Serum lipid concentration	Overlapping	—	—	—	—	Total serum cholesterol and LDL cholesterol increased significantly across tertiles of total fat, saturated fat, calorie-adjusted saturated fat intake, and calorie-adjusted total fat (LDL cholesterol only); after adjusting for age, sex, and BMI, association remained significant

[a]M, male; F, female; TEE, total energy expenditure; FFQ, food frequency questionnaire; BMI, body mass index; LDL, low-density lipoprotein; SD, standard deviation of the mean.

[b]Correspondence of referent period of validation standard and instrument. The referent period is the time period of the diet, as measured by the dietary assessment technique.

[c]Mean energy difference, {[instrument (mean) − validation (mean) standard]/validation (mean) standard}.

[d]Differences in mean energy and nutrient intake; underestimation/overestimation indicates statistically significant difference or >5% difference when significance testing not shown.

[e]As percentage of kilocalories.

TABLE 2 Validity of food records[a]

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Davies et al (7)	1.5–4.5 years, 42 M/39 F, UK	Weighed food records from 4 days	TEE with doubly labeled water assessed over 10 days	Overlapping days—TEE encompassed 4 days of records	0.41 energy[e]	—	−3% (1141 vs 1178 kcal)	—	Mean energy difference was greatest for 1.0–2.5 year olds (6% underestimation) and smallest for 3.5–4.5 year olds (1% overestimation)
Harbottle & Duggan (16)	4–40 months, 117 M & F, Indo-Asians, UK	Weighed food records/ inventories from 4 days (children <12 months) to 5 days (children >12 months)	Diet history	—	—	—	−7% (778 vs 838 kcal)	Records significantly underestimated 2 of 5 nutrients	Mean differences varied by age group and were significant for energy at 12 to <18 months, for iron at 6 to <12 months and 12 to <18 months, and for vitamin C at <6 months

[a]M, male; F, female; TEE, total energy expenditure; FFQ, food frequency questionnaire; BMI, body mass index; LDL, low-density lipoprotein.

[b]Correspondence of referent period of validation standard and instrument. The referent period is the time of the diet, as measured by the dietary assessment technique.

[c]Mean energy difference, {[instrument (mean) − validation (mean) standard]/validation (mean) standard}.

[d]Differences in mean energy and nutrient intake; underestimation/overestimation indicates statistically significant difference or >5% difference when significance testing not shown.

[e]Type of correlation not specified.

FOOD FREQUENCY QUESTIONNAIRES

On an FFQ, which typically includes a long list of foods and beverages, respondents are asked to report frequency of consumption and, on some instruments, portion size (35). For preschoolers, the usual referent period is the past month to the past year. Because of the longer referent period, usual individual intake may be inferred from a single FFQ. With quantitative FFQs, portion size is collected for all foods; on semiquantitative FFQs, this information is collected only for foods that are consumed in typical portion sizes (e.g. bread slices, milk glasses). On the nonquantitative FFQs, portion size is not collected; nutrient intakes are calculated based on standard portion sizes.

Validity

The validity of FFQs for measuring the intake of preschool children was examined in nine studies (5, 10, 18, 22, 30, 31, 33, 34, 36) (Table 3). All these studies used FFQs to assess general dietary intake, with one exception (34). This study investigated the validity of an abbreviated FFQ to measure intakes of calcium (34) and is discussed separately.

Frequency of food consumption was assessed for usual current intake (30) and for intake over the preceding week (18), month (5), 3 months (36), 6 months (33), or 1 year (10, 22). One study did not provide information on the referent period (31). Except for one study (30), all used an FFQ based on the Willett FFQ. Among the eight studies, 24-h recalls (5, 33, 36) and food records (18, 30) were most commonly used as the validation standard. FFQs were also compared with physiological measures—energy expenditure as measured by doubly labeled water (22) and serum lipid levels (31). Finally, one study (10) compared a 1-year FFQ with the mean of three 4-month FFQs administered at 4-month intervals.

When compared with multiple 24-h recalls, the FFQ overestimated mean energy intake by 0.2% (5), 41% (36), and 73% (33). The high percentage of overestimation in the latter study may be partially explained by the study design—foods consumed in the absence of the mother were deleted from food recalls, which was the validation standard. The percentage energy difference between the FFQ and the doubly labeled water study was 59% (22). In that study, the FFQ used adult portion sizes, which were 25%–33% greater than the typical serving suggested for preschoolers.

The correlations between FFQs and other methods of dietary assessment varied by the validation standard, the nutrients assessed, and how the correlations were adjusted. Unadjusted correlations between a 1-year FFQ and the mean of three consecutive 4-month FFQs were the highest: 0.61 for energy, 0.67 for protein, and 0.63 for fat (10). Two studies adjusted both for energy intake and for the effect of intraindividual variability in intake (5, 33). Stein et al reported adjusted correlations of 0.29 for protein and 0.28 for fat for boys and 0.51 and 0.39 for

TABLE 3 Validity of food frequency questionnaires[a]

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Standard/modified FFQ									
Blum et al (5)	1–5 years old, 233 M & F, 56% Native American, 44% Caucasian, US	Mean of two 1-month FFQs; administered 1 month apart	Mean of three 24-h recalls administered over 1 month	3 days of recall encompassed within 1-month FFQ	Adjusted[e] Pearson: 0.43 protein, 0.62 fat	Adjusted[e] Pearson: 0.26 fiber to 0.63 magnesium (20 nutrients)	+0.2% (1688 vs 1684 kcal)	FFQ overestimated 12 of 20 nutrients and underestimated 3 (significance testing not shown)	Average correlations were similar in younger and older children— 0.51 for 1–2 years and 0.49 for 3–5 years; average nutrient correlations not were similar between Native American (0.51) and Caucasian children (0.49)
Eck et al (10)	5.2 ± 0.6 years (mean ± SD), 108 M & F, US	1-year FFQ	Mean of three 4-month FFQ administered 4 months apart	Same 1-year period	0.61 energy, 0.67 protein, 0.63 fat[f]	0.53 carbohydrates to 0.74 calcium[e] (7 nutrients)	+0.9% (1967 vs 1949 kcal)	No differences for 7 of 7 nutrients (significance testing not shown)	—
Iannotti et al (18)	2–4 years, 17 M & F, US	1-week FFQ	Mean of 3 days of measured food records	3 days of food records encompassed within 1 week FFQ	Unadjusted Pearson: 0.37 energy	Unadjusted Pearson: 0.15 for fatty acid (% kilocalories) to 0.40 colsterol (5 nutrients)	—	—	—
C Kaskoun et al (22)	4–7 years, 22 M/23 F, 80% Caucasian, 20% Native	1-year FFQ	TEE with doubly labeled water assessed	Overlapping TEE within 1-year FFQ	—	—	+59% (2180 vs 1372 kcal)	—	FFQ serving sizes based on adult portions; no significant differences by sex or ethnicity; no difference by body composition of child

	American, US		over 14 days						or mother; paternal percent body fat significantly correlated with misreporting
Persson & Calgren (30)	4 & 8 years, 477 M & F, Sweden	FFQ of "current" intake	7-day food records	—	—	—	—	—	Food items: FFQ significantly overestimated 14 of 27 food items and underestimated 9 of 27 food items for 4 year olds
Shea et al (31)	4–5 years, 57 M/51 F, Hispanic, US	Mean of two FFQs[g] administered 6 months apart	Serum lipid concentration	Overlapping	—	—	—	—	Total serum cholesterol and LDL cholesterol increased significantly across tertiles of total fat, saturated fat, calorie-adjusted total fat, and calorie-adjusted saturated fat. These associations remained significant after adjusting for age, sex, and BMI
			Mean of four 24-h recall interviews administered over 1 year	Same 1 year period	—	—	—	—	FFQ overestimated intake of total fat, saturated fat, and cholesterol; when mean intakes from the FFQ were compared with recalls, children in the highest tertile had values of 137.7 vs 79.3 g for total fat, 53.7 vs 31.4 g for saturated fat, and 578.9 vs 438.9 mg for cholesterol; overall mean intakes of percent calories from fat were 33.2% vs 33.0%, respectively
Stein et al (33)	44–60 months, 112 M/112 F, 91% Hispanic, 8% African-	Two 6-month FFQs adminis-	Four 24-h recall interviews admini-	Same 1-year period	Adjusted Pearson[e]: boys—0.34 energy, 0.29	Adjusted Pearson[e]: boys—0.05 poly-	Boys— +66% (2667 vs 1604 kcal); girls—+73%	Boys—FFQ significantly overestimated 10 of 10	Excluded from analysis of recall data times when food was consumed outside of parents' supervision;

(*Continued*)

TABLE 3 (*Continued*)

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
	American, 1% Caucasian, US	tered 6 months apart	stered over 1 year		protein, 0.28 fat; girls—0.59 energy, 0.59 protein, 0.39 fat	unsaturated fat to 0.71 potassium; girls—−0.14 sodium to 0.78 potassium (10 nutrients)	(2586 vs 1492 kcal)	nutrients; girls—FFQ significantly overestimated 10 of 10 nutrients	correlations were generally higher among girls than boys Food items: FFQ overestimated frequency of consumption of items such as dairy products, meat, fruits, and vegetables
Treiber et al (36)	3–5 years, 33 M & F, US	3-month FFQ ($n = 51$)	Mean of two 24-h recalls administered 1 week apart (N = 33)	Recall encom-passed within 3-month FFQ	Unadjusted Pearson: 0.41 protein	Unadjusted Pearson: 0.40 potas-sium to 0.62 cholesterol (4 nutrients)	+41% (2309 vs 1635 kcal)	FFQ overesti-mated 10 of 11 nutrients and underesti-mated 1 (significance testing)	Recall was administered only to parents who directly observed all food intake
Abbreviated FFQ									
Taylor & Goulding (34)	3–6 years 63 M & F New Zealand	1-year FFQ Specific to calcium intake	4-day estimated food records	—	—	0.52[f] calcium	—	+18.0% (942 mg vs 798 mg calcium)	—

[a]M, male, F, female, TEE, total energy expenditure; FFQ, food frequency questionnaire; BMI, body mass index; LDL, low-density lipoprotein; SD, standard deviation.

[b]Correspondence of referent period of validation standard and instrument. The referent period is the time of the diet as measured by the dietary assessment technique.

[c]Mean difference = {[instrument (mean) − validation (mean)]/validation (mean) standard}.

[d]Differences in mean energy and nutrient intake; underestimation/overestimation indicates statistically significant difference or >5% difference when significance testing not shown.

[e]Correlation coefficients adjusted for energy intake and within person variation. Energy correlations were adjusted for within person variability only.

[f]Type of correlation not specified.

[g]Referent period not specified.

girls (33). Blum et al reported adjusted correlations of 0.43 for protein and 0.62 for total fat (5).

Stein et al found that the FFQ consistently overestimated the frequency of intake of food servings such as meat, dairy products, and fruits and vegetables when compared with the mean of four 24-h recalls (33). In a similar analysis, when Persson & Carlgren compared FFQs with 7-day food records, the FFQ significantly overestimated 14 of 27 food items and underestimated 9 of 27 items (30).

Three studies examined the effect of demographic factors on FFQ validity. In one study, correlations between FFQs and recalls were generally higher among girls than boys (33). In another study, average correlations between the FFQ and multiple recalls were similar across age and ethnicity (5). Finally, correlations between the FFQ and doubly labeled water showed no significant differences between energy intake and energy expenditure by sex, ethnicity, or body composition of the child or mother (22).

One study evaluated the validity of using abbreviated FFQs for preschool children to estimate calcium intake (34). In this study, the FFQ and a 4-day food record were used to categorize children into quartiles of mean calcium intake. "Correct classification" was defined as the proportion of children placed by the FFQ in the same or adjacent quartile in which they were classified by the food record. "Gross misclassification" was defined as placing children in the lowest quartile by one method and the highest quartile by the other. The FFQ overestimated mean calcium intake by an average of 18%, but it correctly classified 84% of children and "grossly misclassified" only 3%.

Reproducibility

Of the four studies that measured the reproducibility of FFQs in estimating dietary intake of preschool children (Table 4), one study evaluated reproducibility of instruments administered 1 week apart (36), one at 4 months apart (10), and two at 6 months (31, 33). Treiber et al (36) found no differences in energy intake between the first and second FFQ administration. Pearson correlations between the first and second FFQ were 0.46 for energy, 0.55 for protein, and 0.67 for fat. Correlations for energy and 10 nutrients ranged from 0.42 for carbohydrates to 0.74 for sodium. Eck et al administered a FFQ three times at 4-month intervals (10). No significant differences were found in the mean intake of energy or six nutrients between the first and second or second and third administration. Of the two studies that evaluated FFQs administered 6 months apart, Shea et al noted intraclass correlations of 0.39 for energy and 0.38 for fat (31). Correlations among energy and three nutrients ranged from 0.19 to 0.39. On the other hand, Stein et al found a wider range of correlations (33). Values of Cronbach's coefficient alpha, a special case of the intraclass correlation coefficient, ranged from 0.40 for protein to 0.73 for energy among boys and from 0.17 for sodium to 0.71 for energy among girls.

TABLE 4 Reproducibility of food frequency questionaires[a]

Reference	Population	Instrument	Time difference[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Eck et al (10)	5.2 ± 0.6 years (mean ± SD), 108 M & F, US	4-month FFQ	4-month intervals (4 months, 8 months, 12 months)	—	—	4 vs 8 months + 2% (1964 vs 1924), 8 vs 12 months − 2% (1924 vs 1959)	No differences between assessments for 7 of 7 nutrients, between assessments at 4 months and 8 months or 8 months and 12 months (significance testing not shown)	—
Shea et al (31)	4–5 years, 57 M/51 F, Hispanic, US	FFQ	6 months	Intraclass: 0.39 energy, 0.38 fat	Intraclass: 0.19 cholesterol to 0.39 energy (4 nutrients)	—	—	—
Stein et al (33)	44–60 months, 112 M/112 F, 91% Hispanic, 8% African-American, 1% Caucasian, US	6-month FFQ	6 months	Cronbach alpha: boys—0.73 energy, 0.40 protein, 0.48 fat; girls—0.71 energy, 0.30 protein, 0.32 fat	Cronbach alpha: boys—0.40 protein to 0.73 energy (10 nutrients); girls—0.17 sodium to 0.71 energy	—	—	—
Treiber et al (36)	3–5 years, 51 M & F, US	3-months FFQ	1 week	Unadjusted Pearson: 0.46 energy, 0.55 protein, 0.67 fat	Unadjusted Pearson: 0.42 carbohydrates to 0.74 sodium (11 nutrients)	+4% (2350 vs 2269 kcal)	Of 11 nutrients, no significant differences in mean intake between first and second FFQ	—

[a]M, male; F, female; TEE, total energy expenditure; FFQ, food frequency questionnaire; BMI, body mass index; LDL, low-density lipoprotein; SD, standard deviation.

[b]Time interval between first and second administration of the instrument.

[c]Mean energy difference, [(first administration−second administration)/first administration].

[d]Differences in mean energy and nutrient intake; underestimation/overestimation indicates statistically significant difference or >5% difference when significance testing not shown.

[e]Referent period not specified.

OTHER STUDIES

Two studies investigate the validity of other methods for assessing preschool diets (Table 5). In one, estimated energy intake from diet histories was compared with energy expenditure measured from the doubly labeled water method (26). Diet histories assess usual meal patterns, food intake, and other information in an extensive 1- to 2-h interview or questionnaire (35). In contrast to other diet assessment methods, a diet history is both qualitative and quantitative, allowing detailed information about food preparation, eating habits, and food consumption to be collected. In this study, diet history overestimated total energy expenditure by 12% in 3-year-old children and 8% in 5-year-olds (26).

Finally, the usefulness of an abbreviated questionnaire to measure intake of vitamin A was examined (1). Using the recommendations of the International Vitamin A Consultative Group, a food checklist was created using commonly eaten foods high in vitamin A, and mothers were asked about foods consumed in the previous 24 h. The Consumption Index, a simplified scoring system based on the vitamin A content of the food and standard portion size, was used to classify children into low, moderate, or high risk of vitamin A deficiency based on 6 days of 24-h food checklists and weighed food records. Although there were some differences in the mean scores on individual days, there were no significant differences in mean scores for all days combined for children classified at high risk.

DISCUSSION

The preschool years are critical for growth and development, with more rapid and frequent transitions in dietary patterns occurring than in other age groups. Although the importance of preschool diet has been well established, measuring dietary intake in children younger than 5 years remains a challenging area of study. We identified studies that examined the validity of food recalls, food records, FFQs, and diet history and also identified studies that examined the reproducibility of FFQs. The heterogeneity of study designs, the relatively small study populations, and the limited number of studies examined restrict our ability to draw general conclusions. Even among studies using the same dietary assessment method, there were differences in how the assessment was conducted. For example, FFQs varied as to whether portion-size information was collected, and if so, how portion sizes were assessed. The length and type of food lists also varied among FFQs. Both food recall and records varied in how many days of intake were collected. Food recalls also varied on how much probing was done and how portion-size information was collected.

The validation standard chosen is an important consideration in interpreting study findings. We found a variety of validation standards, including two physiologic measures (doubly labeled water and serum lipids), investigator-based measurements, such as collection of duplicate portions or direct observation, and

TABLE 5 Other validity studies[a]

Reference	Population	Instrument	Validation standard	Referent period[b]	Macronutrient correlations	Range of correlations (all nutrients and energy)	Mean energy difference[c]	Nutrient and energy differences[d]	Quantitative/ qualitative and other differences
Abdullah Ahmed (1)	2–5 years, 121 M & F, Bangladesh	6 simplified 24-food check-lists (foods containing vitamin A)	6-day weighed food record	Same days	—	—	—	—	Consumption index, a simplified score based on vitamin A content of food and portion size, was calculated based on vitamin A content of food serving size for both the food checklists and the weighed food records. Matched pair analysis showed some differences between methods in the mean consumption index on individual days; however, no significant differences in the mean consumption index value for all days among children categorized at high risk
Livingstone et al (26)	3 & 5 years, 12 M/8 F, UK	Diet history	TEE with doubly labeled water; assessed over 10–14 days	Overlapping	—	—	3 years, +12% (1412 vs 1257 kcal); 5 years, +8% (1565 vs 1455 kcal)	—	No significant difference between estimates by sex

[a]M, male; F, female; TEE, total energy expenditure; FFQ, food frequency questionnaire; BMI, body mass index; LDL, low-density lipoprotein.

[b]Correspondence of referent period of validation standard and instrument. The referent period is the time of the diet, as measured by the dietary assessment technique.

[c]Mean energy difference, {[instrument (mean)−validation (mean) standard]/validation (mean) standard}.

[d]Differences in mean energy and nutrient intake; under/overestimation indicates statistically significant difference or >5% difference when significance testing not shown.

respondent-based measures, such as food recalls, FFQs, and food records. Because dietary intake cannot be measured with absolute precision in free-living populations, there is no true validation standard. Thus, validation studies are best seen as comparative studies, with the validity of the dietary method being assessed established by how well it compares with a second method of dietary assessment. Ideally, the errors inherent in the validation standard are independent of those in the method being assessed; to the extent that errors in the two methods are related, the comparison of the two methods will lead to artificially inflated correlations (39). To illustrate, related errors would be expected if both methods are respondent based (food recalls, food records, and FFQs). Most of the studies in this review used respondent-based methods for both the method being assessed and the validation standard. In contrast, errors in physiologic measures (biochemical markers or doubly labeled water) are independent of errors in respondent-based measures (4). Still, although biochemical markers such as serum nutrient concentrations provide an independent measure of nutrient intake, many are also influenced by nondietary factors and thus cannot be used as markers of intake. Some nutrient concentrations (e.g. calcium and vitamin A) are under tight physiologic regulation and thus respond less to diet, whereas others (e.g. carotenoids) vary with dietary intake and would be more appropriate markers.

Other factors to consider in interpreting validation studies are the effects of the dietary assessment method on dietary behaviors and the congruence of referent periods. The dietary assessment method itself may alter behavior; caregivers who are being observed may alter their child's diet to make it more socially acceptable. In addition, caregivers who are recording a diet may simplify it to make recording easier. A large difference in referent periods may influence results as well, but we could not gauge such effects. We found that multiple 24-h food recalls were commonly used to assess the validity of FFQs whose referent period was 3 months to 1 year, and that two or three 24-h periods were usually collected to assess dietary intake during that referent period.

Despite the key role of diet in the growth and development of young children, relatively few studies were available, especially in children under 3 years of age. Most of the studies investigated the validity of food recalls and full FFQs. Only two studies investigated abbreviated methods that assessed a single nutrient; future studies should further investigate the feasibility of abbreviated methods in young children. There were no consistent differences in the validity or reproducibility of the dietary assessment measures with regard to age or ethnicity, but few studies had adequate sample size to examine these factors. Future studies of dietary assessment techniques need to evaluate patterns of misreporting, particularly with regard to the maternal factors (e.g. education, stay-at-home status), age of the child, and ethnicity.

In conclusion, this review can serve as a guide to researchers and clinicians for selecting dietary methods for their work with preschool children. When choosing a method to estimate dietary intake, the intended purpose of the assessment, as well as its practicality, must first be considered. The FFQ is relatively easy to administer and is unlikely to affect dietary intake. In general, FFQs overestimate total energy intake and are better at ranking, rather than quantifying, usual intake. The differences in energy intake between the FFQ and other methods of assessment are greater than those required to determine precisely the energy balance parameters needed in the context of energy balance or obesity studies. In contrast, food records and recalls can be used to both rank and quantify nutrient intakes. Because of day-to-day variability in intake, however, food records and recalls require multiple days of collection to measure usual intakes of individual persons. Nevertheless, mean nutrient intakes of a population can be calculated from a single dietary recall or record. Compared with FFQs, food recalls and food records (in particular) require more effort on the part of the researcher/clinician and the respondent. On the other hand, methods for collecting food record or recall information require little adaptation for different population or age groups. In contrast, the FFQ requires the food list and portion sizes to be appropriate to the population under investigation. Once a method is selected, after considering the intended purpose of the assessment as well as the constraints of the setting, researchers and clinicians can use the results of published studies included here as a guide to evaluate and possibly adopt the chosen dietary method.

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