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Conclusions about children's reporting accuracy for energy and macronutrients over multiple interviews depend on the analytic approach for comparing reported information to reference information

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Abstract

Objective—Validation-study data are used to illustrate that conclusions about children's reporting accuracy for energy and macronutrients over multiple interviews (ie, time) depend on the analytic approach for comparing reported and reference information—*conventional*, which disregards accuracy of reported items and amounts, or *reporting-error-sensitive*, which classifies reported items as matches (eaten) or intrusions (not eaten), and amounts as corresponding or overreported.

Subjects and design—Children were observed eating school meals on one day ($n = 12$), or two ($n = 13$) or three ($n = 79$) nonconsecutive days separated by ≥ 25 days, and interviewed in the morning after each observation day about intake the previous day. Reference (observed) and reported information were transformed to energy and macronutrients (protein, carbohydrate, fat), and compared.

Main outcome measures—For energy and each macronutrient: report rates (reported/reference), correspondence rates (genuine accuracy measures), inflation ratios (error measures).

Statistical analyses—Mixed-model analyses.

Results—Using the conventional approach for analyzing energy and macronutrients, report rates did not vary systematically over interviews ($P_s > .61$). Using the reporting-error-sensitive approach for analyzing energy and macronutrients, correspondence rates increased over interviews ($P_s < .04$),

indicating that reporting accuracy improved over time; inflation ratios decreased, although not significantly, over interviews, also suggesting that reporting accuracy improved over time. Correspondence rates were lower than report rates, indicating that reporting accuracy was worse than implied by conventional measures.

Conclusions—When analyzed using the reporting-error-sensitive approach, children’s dietary reporting accuracy for energy and macronutrients improved over time, but the conventional approach masked improvements and overestimated accuracy.

Applications—The reporting-error-sensitive approach is recommended when analyzing data from validation studies of dietary reporting accuracy for energy and macronutrients.

Keywords

children; 24-hour dietary recalls; validation; observation; energy; macronutrients

INTRODUCTION

People report what they have eaten in terms of food items, but validation studies of dietary reporting accuracy often evaluate reporting accuracy indirectly in terms of energy and nutrients (1,2). For example, a set of reported information (which consists of food items and their respective amounts) from a method such as dietary recalls may be compared to a set of reference information (which also consists of food items and their respective amounts) from a gold standard method such as direct observation. The “conventional approach” to evaluating reporting accuracy typically transforms the sets of reference information and reported information to energy and nutrients of interest, cumulates the values for energy and nutrients within each set of information for each person, and then uses statistical tests to compare total reported energy and nutrients to total reference energy and nutrients.

The Figure illustrates the levels at which reference and reported information may be compared; the Figure legend defines subsets of information at each level. When reported information is compared to reference information, items in the reference set can be classified as matches (items eaten and reported eaten) and omissions (items eaten but not reported), and items in the reported set can be classified as (the same) matches and intrusions (items reported but not eaten) (1,2). For each match, either a) the reported amount corresponds exactly to the reference amount, b) the reported amount corresponds to part of the reference amount and the remainder of the reference amount is unreported, or c) part of the reported amount corresponds to the reference amount and the remainder of the reported amount is overreported. For each omission, the entire reference amount is unreported. For each intrusion, the entire reported amount is overreported.

The conventional approach to evaluating reporting accuracy in dietary validation studies typically disregards the accuracy of reported items and amounts. Specifically, distinctions between matches and intrusions, and between corresponding and overreported amounts, are disregarded. Hereafter, we use the phrase “reporting errors” to refer to a) intrusions, the amounts of which are overreported, and b) overreported amounts from matches.

Our purpose is to illustrate that analyses of validation-study data using the conventional approach may provide a distorted picture of reporting accuracy. We use data from a validation study conducted to evaluate the consistency of children’s reporting accuracy in multiple dietary recalls over time (3). For that study, fourth-grade children were observed eating school meals on one day ($n = 12$), or on two ($n = 13$) or three ($n = 79$) nonconsecutive days separated by 25 to 99 days, and interviewed in the morning after each observation day about their intake on the previous day. Here, we use two analytic approaches—the conventional approach which

disregards reporting errors and the alternative approach which is reporting-error sensitive—to evaluate the consistency (ie, stability) of children's reporting accuracy for energy and macronutrients (ie, protein, carbohydrate, fat). We discuss conclusions from these approaches along with conclusions from the original food-item-level analyses (3).

Original food-item-level analyses (after classifying each item as a match, an omission, or an intrusion) showed that one measure, "total inaccuracy" (which cumulated errors in servings for all items and amounts whether they were matches, omissions, or intrusions), decreased significantly from the first to the third interview (mixed-model analyses; $P = .006$), suggesting that children's dietary reporting accuracy improved over time (3). However, two measures of reporting accuracy, "omission rate" (the percentage of observed items not reported) and "intrusion rate" (the percentage of reported items that were not observed), were inconsistent over interviews. Furthermore, reporting accuracy over all interviews was low with a mean omission rate of 51% and a mean intrusion rate of 39% (3). Because consistency of reporting accuracy over interviews was the focus of the original study, for this article, we investigated consistency of reporting accuracy (over interviews) for the energy and macronutrient variables analyzed.

Several investigators have suggested that insight gained from direct comparisons of foods reported eaten to foods actually eaten may guide research to improve methods for assessing intake that yield more accurate dietary self-reports and provide practical dietary guidance (4–6). To our knowledge, this is the first time validation-study data have been used to illustrate that conclusions about dietary reporting accuracy may be misguided if analyses are based on the conventional approach.

METHODS

The analyses and results described here illustrate that conclusions from a dietary validation study vary when different analytic approaches are used. Thus, the sample and data collection methods, which have been described previously in detail (3), are only summarized here. The text defines terminology, and the Figure legend provides a quick glossary.

Synopsis of subjects and data-collection procedures

Approval for human research was received from the appropriate institutional review board. During the 1999 to 2000 school year, all fourth-grade children ($n = 523$) from six public elementary schools in one school district were invited to participate. Schools were selected based on children's race and school-meal participation rates to obtain a final sample with equal numbers of children by race (Black, White) and sex who participated in school meals. Of the 382 children who provided written child assent and parental consent to participate, a random sample of 104 children (24 Black boys, 27 Black girls, 25 White boys, 28 White girls) was selected. Although the sample was stratified by race and sex to ensure equal representation of the race/sex groups, the original study was not powered to detect race or sex differences (3).

To obtain reference information, children were observed eating school breakfast and school lunch. Due to the difficulty of unobtrusively identifying contents of meals brought from home and eaten at school (7), only children who obtained meals at school were observed. One of three dietitians observed one to three children simultaneously and recorded, for each child, items and amounts eaten in servings. Observations covered entire school meal periods so that trading of food could be noted (10–13). Although children knew, in general, when they were being observed, they did not know, specifically, who was being observed or would be interviewed. These procedures have been used previously (8–10). Inter-observer reliability, assessed twice monthly throughout data collection, was satisfactory (3,14).

To obtain reported information, each child was interviewed individually in person at school in the morning after each observation day for a maximum of three interviews per child. At least 25 days, and as many as 99 days, separated consecutive interviews for an individual child. Each interview concerned the child's intake on the previous day. One of three dietitians conducted each interview: No dietitian ever interviewed a child about meals for which the interviewer was the observer; whenever possible, a different dietitian conducted each interview on a different weekday for each child interviewed multiple times (3). The interview protocol was modeled on the multiple-pass protocol of the Nutrition Data System for Research (NDS-R; version 4.03, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, 2000), but interviewers wrote children's reports on interview forms instead of using the NDS-R computerized version (3). Each interview was audio-recorded and transcribed. Monthly assessment of inter-interviewer reliability throughout data collection, and random selection and review of 5% of each interviewer's transcripts and audiotapes, indicated that interviewers conducted interviews according to protocol (3).

Analytic variables

We constructed variables for two different analytic approaches. Each involved arithmetic transformation of reference information and reported information to energy and macronutrients. The first approach was conventional—it *disregarded* reporting errors. The second approach was *sensitive* to reporting errors.

Analyses were restricted to reported information about school meals because reference information was available only for these meals. Children's reports were considered reports about school meals if children reported mealtimes to within an hour of observed mealtimes, referred to breakfast as *school breakfast* or *breakfast* and to lunch as *school lunch* or *lunch*, and identified *school* as the location where meals were eaten (3). These requirements were applied consistently to all reports.

As in previous studies (3,8,9), qualitative labels used to record reference information from observations and reported information from interviews were assigned numeric values as *none* = 0.00, *taste* = 0.10, *little bit* = 0.25, *half* = 0.50, *most* = 0.75, *all* = 1.00, or the actual number of servings if >1 was observed or reported. For each item, whether reference and/or reported, the NDS-R database was used to obtain information concerning energy and macronutrients for standard school-meal portions. For items not in the NDS-R database, the school district's nutrition program provided product information and recipes. Although the estimates of energy and macronutrients observed and reported yielded by these processes may be imprecise, the same processes were used for both observed and reported items.

Variables for the conventional approach—To calculate the reference amount of energy and each macronutrient for each item, we multiplied the quantified serving of each reference item by the per-serving energy and macronutrient values. We applied the same process to reported items. To calculate total reference information for a child for a school day, we summed the reference amounts for energy (in kcal) and grams of each macronutrient across the items the child was observed to have eaten at the two school meals on that school day. To calculate total reported information for a child for a school day, we applied this same process to items reported eaten by the child for the school meals on the school day, regardless of whether reported items were intrusions or amounts of matches were overreported.

For each interview for each child, we calculated a "report rate" for energy and for each macronutrient. The report rate is the reported percentage of the reference amount ($[\text{total reported amount} / \text{total reference amount}] \times 100$). A report rate has a lower bound of 0%, which indicates that no energy or macronutrient was reported eaten (assuming that some was actually eaten), and no upper bound because there is no limit on what an individual can report eating.

Conventional interpretation of this measure is that values close to 100% indicate high reporting accuracy, values <100% indicate underreporting, and values >100% indicate overreporting (15–17).

Variables for the reporting-error-sensitive approach—As illustrated in the Figure, for each child for each school meal for each school day, we classified each reference item as a match or as an omission, and each reported item as a match or as an intrusion. Because children can report foods many ways, we classified reported items as matches unless it was clear their reports did not describe items observed eaten (3). For example, reports of all types of white milk (eg, lowfat, whole) were classified as matching all types of observed white milk, and reports of all types of pizza (eg, pepperoni, cheese) were classified as matching all types of observed pizza. However, reports of milk flavors (eg, strawberry, chocolate), fruit juices (eg, apple, orange), and vegetables (eg, broccoli, green peas) were not classified as matching if they differed from what had been observed. These requirements were applied consistently to all reports.

After each item was classified as a match, an omission, or an intrusion, the constituent amounts of energy and macronutrients of each item were classified as corresponding, unreported, or overreported. Each corresponding, unreported, and overreported number of servings was multiplied by the appropriate per-serving values of energy and macronutrients to obtain corresponding, unreported, and overreported amounts of energy and macronutrients. For each school day for each child, total energy (in kcal) and total grams of each macronutrient were calculated by summing, across items, the values for each of the five categories of amounts described in the second paragraph of the introduction and illustrated in the Figure, which shows calculations of these amounts for energy for one child for one school day. Note that reference energy is either corresponding or unreported, and that reported energy is either corresponding or overreported.

A “correspondence rate”—a genuine measure of reporting accuracy that is sensitive to reporting errors—was calculated for energy and each macronutrient for each child for each school day. For energy or any nutrient, the correspondence rate is the percentage of the reference amount that is reported correctly. A correspondence rate has a lower bound of 0%, which indicates that nothing observed eaten was reported, and an upper bound of 100%, which indicates that all observed items and amounts were reported correctly.

An “inflation ratio”—a measure of reporting error—was calculated for energy and each macronutrient for each child for each school day. For energy or any nutrient, the inflation ratio reflects overreporting from intrusions and overreported amounts of matches. An inflation ratio has a lower bound of 0%, which indicates no overreporting, and no upper bound because there is no limit on what an individual can overreport. The inflation ratio is the difference between the report rate and the correspondence rate.

Analyses

Analyses were conducted using SAS (Release 8.02, TS Level 02M0, SAS Institute, Inc, Cary, NC, 2001).

Conventional approach—We conducted conventional analyses used in validation studies of dietary reporting methods. Specifically, for each interview (first, second, third), we conducted paired t-tests to compare the mean differences of reported and reference values of energy and each macronutrient to zero. For each interview, we calculated Pearson correlations, over children, between reference and reported energy and each macronutrient, and then tested for differences from zero. Separate mixed-model analyses were conducted to determine whether reference amounts, reported amounts, and report rates for energy and each

macronutrient varied over interviews (first, second, third). Each mixed-model analysis included interview sequence (first, second, third) as a fixed effect and child as a random effect.

Reporting-error-sensitive approach—Separate mixed-model analyses were conducted to determine whether correspondence rates and inflation ratios for energy and each macronutrient varied over interviews (first, second, third). We analyzed these variables separately because Spearman's rank order correlations indicated a weak-to-moderate negative association (−0.1 to −0.4) between correspondence rates and inflation ratios. Each mixed-model analysis included interview sequence (first, second, third) as a fixed effect and child as a random effect.

RESULTS

Conventional approach

Table 1 shows results from the conventional approach for analyzing energy and macronutrients, by interview sequence. For each interview, mean reported amounts for energy and each macronutrient were significantly less than mean reference amounts (all 12 P values <.0003). Over interviews (first, second, third), neither mean reference amounts nor mean reported amounts for energy or any macronutrient varied systematically (for reference amounts, all 4 P values >.33; for reported amounts, all 4 P values >.85). For each interview, Pearson correlations, over children, between reference and reported amounts for energy and each macronutrient ranged from 0.27 to 0.53, and differed significantly from zero (all 12 P values <.006). Mean report rates for energy and each macronutrient did not vary systematically over interviews (all 4 P values >.61).

Reporting-error-sensitive approach

Table 2 shows results from the reporting-error-sensitive approach for analyzing energy and macronutrients, by interview sequence. Mean correspondence rates for energy and each macronutrient increased over interviews (all 4 P values <.04). Mean inflation ratios for energy and each macronutrient decreased, although not significantly, over interviews (all 4 P values between .05 and .15).

Table 3 shows descriptive statistics for energy and macronutrients, by interview sequence, for the five categories of amounts used to calculate variables for the reporting-error-sensitive approach. Increases over interviews in the mean corresponding amounts from matches, along with the relatively consistent mean overreported amounts from matches and mean unreported amounts from matches, clarify the increases over interviews in mean correspondence rates.

DISCUSSION

To investigate whether conclusions about dietary reporting accuracy for energy and macronutrients over time depend on the analytic approach—conventional versus reporting-error-sensitive—we conducted new analyses of data from a previously-described validation study with children who provided multiple dietary recalls.

The conventional approach yielded the following picture of reporting accuracy over interviews: Underreporting for energy and macronutrients was substantial, but did not vary systematically over interviews, and Pearson correlations between reference and reported amounts indicated that reporting accuracy for energy and macronutrients was acceptable according to conventional standards. Mean report rates for energy and macronutrients were high, ranging from 80% to 101%, suggesting high reporting accuracy according to conventional standards (15–17), and did not vary systematically over interviews.

The reporting-error-sensitive approach yielded a quite different picture of reporting accuracy over interviews. First, for energy and each macronutrient, mean correspondence rates were much lower than mean report rates, and mean inflation ratios were considerable. These results indicate that reporting accuracy for energy and macronutrients was lower than what was suggested by mean conventional report rates because much of what was reported was incorrect. Second, for energy and macronutrients, mean correspondence rates increased significantly over interviews, indicating that reporting accuracy improved over time. Third, mean inflation ratios for energy and macronutrients decreased over interviews, although not significantly; this contributed to improvement in reporting accuracy over time.

Mean values for the categories of amounts for energy and macronutrients in Table 3 indicate that for matches, reference amounts that were reported correctly (ie, corresponding amount from matches) were considerably larger than reference amounts that were reported incorrectly (ie, overreported amount from matches) or not reported (ie, unreported amount from matches). This suggests that when children correctly report *items* they have eaten, then *amounts* they report having eaten for those items are fairly accurate.

Furthermore, Table 3 shows that mean overreported amounts from intrusions and mean unreported amounts from omissions are not equal. Omissions and intrusions, along with their respective unreported and overreported amounts, are distinct types of errors that need not, and in any set of data, likely will not, balance each other. An inference that can be drawn naturally from the strategic-regulation-of-memory framework of Koriat and Goldsmith (18,19) is that omissions and intrusions likely stem from distinct psychological mechanisms and processes. By simply comparing total reported information to total reference information, the conventional approach disregards omissions and intrusions, and hence disregards their respective unreported and overreported amounts, and thus misrepresents reporting accuracy in dietary validation studies.

Conclusions from the conventional approach for analyzing energy and macronutrients, which indicated that children's reporting accuracy was high and consistent over interviews, conflict with conclusions from the original food-item-level analyses described in the introduction. In contrast, conclusions from the reporting-error-sensitive approach for analyzing energy and macronutrients, which indicated that children's reporting accuracy was low but did improve over interviews, was more similar to results for the "total inaccuracy" measure in the original food-item-level analyses.

Numerous studies have obtained multiple 24-hour dietary recalls from children over a period of several weeks or months to assess the relative validity of food frequency questionnaires (20–24) or to evaluate nutrition education interventions (25–28). Observation is commonly used to validate the accuracy of children's dietary recalls (3,8,9,12,15–17,29–39). To our knowledge, the study in which we collected these data is the only validation study to have examined the consistency of the accuracy of dietary recalls provided by children, without parental assistance, on multiple days (3). The results presented here extend previously-published food-item-level results and suggest that children's dietary reporting accuracy for energy and macronutrients improves over time.

Our illustration is limited by specific aspects of the original study's design and methods. The validation method involved observing two school meals instead of an entire 24-hour period. Qualitative terms converted to quantitative terms were used for amounts of standard servings, but these processes were applied consistently to both reference information and reported information to obtain estimates of energy and macronutrients. Because the sample consisted of children, we were lenient in classifying as matches items they reported (as explained in

Methods). Such leniency may have resulted in our overestimating the accuracy of children's reports. In dietary validation studies with adults, such leniency might not be necessary.

We believe these limitations are more than offset by several strengths. First, reports were obtained from children *without* assistance from their parents. This allowed us to identify errors in *children's* reporting accuracy, which was our objective, and was appropriate because the school meals that were observed were eaten when parents were not present. Second, observations of school meals were used to validate these parts of children's dietary reports. Mertz contended that observation is the best method for validating dietary reports, and recommended that observations occur in a cafeteria-type setting familiar to subjects (40). School cafeterias are familiar settings to the millions of children who eat school meals on a regular basis (13,41–43). Observation of meals eaten in private homes may cause substantial reactivity (44), but reactivity is less problematic when observations are conducted at school (13) where children are used to being watched while eating (13,32) and where groups may be observed in a manner that prevents individual children from knowing who, specifically, is being observed (33). When observation is the validation method, reference information is available to indicate whether reporting errors are due to inaccurate reporting of items, of amounts, or of both. A final strength is that quality control for observations and the interview process was assessed throughout data collection, and was acceptable (3,14,45).

Our goal in this article was not to provide “the answer” to the problems that plague studies that collect and analyze dietary self-reports, nor to identify “the way” to assess dietary intake. Instead, we hope to encourage a more sensitive approach to analyzing data from validation studies of dietary reporting accuracy. Our results suggest that the conventional approach is not “the way”. A better understanding of reporting errors in dietary self-reports can guide the development of data collection methods to improve the accuracy of dietary self-reports.

CONCLUSIONS

This illustration indicates that in validation-study data, conventional energy and macronutrient variables, such as report rates, are not measures of dietary reporting accuracy. Conventional report rates disregard reporting errors by failing to distinguish between matches and intrusions, and between corresponding and overreported amounts. The conventional report rate is the sum of the correspondence rate (a genuine measure of accuracy) and the inflation ratio (a measure of reporting error). This illustration using validation-study data from children shows that conventional report rates for energy and macronutrients 1) overestimate reporting accuracy and 2) mask actual improvements in dietary reporting accuracy over multiple interviews.

APPLICATIONS

These results have several applications for the practice of nutrition and dietetics.

- Practitioners and researchers who obtain multiple dietary recalls from children over a period of several weeks or months (eg, to assess the relative validity of food frequency questionnaires or to evaluate nutrition education interventions) should be aware that children's dietary reporting accuracy for energy and macronutrients may improve systematically over interviews. However, because our sample consisted only of fourth-grade children, we do not know the extent to which this is true of children of other ages or of adults.
- Validation studies of the consistency of the accuracy of dietary recalls over multiple interviews are needed with children, as well as with teenagers and adults. These studies should use the reporting-error-sensitive approach when analyzing energy and macronutrients.

- Although practitioners and researchers who obtain recalls from children may want to cite these results as justification for obtaining multiple recalls (or perhaps practice recalls prior to actual data collection) over *any* time frame to “improve children’s dietary reporting accuracy”, caution is warranted. In the validation study that provided data for the analyses presented in this article, consecutive interviews for an individual child were separated by as few as 25 or as many as 99 days. Thus, additional research is needed to provide insight into the effect on children’s reporting accuracy of multiple interviews over a more narrow range of days, and a lower minimum number of days.
- To help identify specific strategies to improve the accuracy of dietary recalls, such as prompting method (8), interview format (30), target period (period about which intake is to be reported) and time of interview (31), and instructions for reporting meals and snacks (33), future validation studies should use the reporting-error-sensitive approach when analyzing energy and macronutrients, and avoid using the conventional approach that simply compares total reported information to total reference information.
- Investigators who have conducted validation studies of dietary reporting accuracy and have published only comparisons of total reported information to total reference information might re-analyze their data using the reporting-error-sensitive approach.

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Figure. Comparing the sets of reference information and reported information using reporting-error-sensitive variables (as illustrated for energy)

^a **Set of reference information:** Food items (consisting of matches and omissions) and their respective amounts that were actually eaten.

^b **Set of reported information:** Food items (consisting of matches and intrusions) and their respective amounts that were reported eaten.

^c **Omission:** A food item that was actually eaten but was not reported eaten.

^d **Match:** A food item that was actually eaten and was reported eaten.

^e **Intrusion:** A food item that was not eaten, but was reported eaten.

^f **Corresponding amount from a match:** The smaller of the reported and reference amounts (or the reported amount if it is equal to the reference amount) for a match. In the figure, for energy, the corresponding amount from matches = 60 (from 3/4 c milk) + 100 (from 1/4 c baked beans) + 200 (from 1 biscuit) + 230 (from 1 brownie) + 50 (from 1/2 c grits) + 60 (from 1/2 c orange juice) = 700 kcal.

^g **Unreported amount from a match:** The part of the reference amount that exceeds the reported amount (or zero if the reference amount is smaller than the reported amount) for a match. In the figure, for energy, the unreported amount from matches = 20 (from 1/4 c milk) + 100 (from 1/4 c baked beans) = 120 kcal.

^h **Overreported amount from a match:** The part of the reported amount that exceeds the reference amount (or zero if the reported amount is smaller than the reference amount) for a match. In the figure, for energy, the overreported amount from matches = 25 (from 1/4 c grits) + 30 (from 1/4 c orange juice) = 55 kcal.

ⁱ Unreported amount from an omission: The entire reference amount for an omission. In the figure, for energy, the unreported amount from omissions = 100 (from 1 sausage) + 260 (from 1 hamburger) = 360 kcal.

^j Overreported amount from an intrusion: The entire reported amount for an intrusion. In the figure, for energy, the overreported amount from intrusions = 70 (from ½ c peaches) + 230 (from 1 hot dog) = 300 kcal.

Reference amount: Corresponding amount from matches + unreported amount from matches + unreported amount from omissions. In other words, *reference* = (*corresponding*) + (*unreported*). In the figure, for energy, *reference* = (60 + 100 + 200 + 230 + 50 + 60) + ([20 + 100] + [100 + 260]) = 1,180 kcal.

Reported amount: Corresponding amount from matches + overreported amount from matches + overreported amount from intrusions. In other words, *reported* = (*corresponding*) + (*overreported*). In the figure, for energy, *reported* = (60 + 100 + 200 + 230 + 50 + 60) + ([25 + 30] + [70 + 230]) = 1,055 kcal.

Reporting errors: Reporting errors include a) intrusions, the amounts of which are overreported, and b) overreported amounts from matches. (Although both omissions and unreported amounts from matches are sources of reporting errors, these are more appropriately described as “unreported errors.”)

Report rate: For an individual for energy or any nutrient, $\text{report rate} = (\text{reported} \div \text{reference}) \times 100$. It is a conventional measure of reporting accuracy that disregards reporting errors. It has a lower bound of 0%, which indicates that no energy or specific nutrient was reported eaten (assuming that some was actually eaten), and no upper bound because there is no limit on what an individual can report eating. Conventional interpretation of this measure is that values close to 100% indicate high reporting accuracy. For an individual, $\text{report rate} = \text{correspondence rate} + \text{inflation ratio}$. In the Figure, the report rate for energy is $(1,055 \div 1,180) \times 100 = 89\%$.

Correspondence rate: For an individual for energy or any nutrient, $\text{correspondence rate} = (\text{corresponding amount from matches} \div \text{reference amount}) \times 100$. It is the percentage of the reference amount to which the aggregate reported amount corresponds. It is a genuine measure of reporting accuracy that is sensitive to reporting errors. A correspondence rate has a lower bound of 0%, which indicates that nothing in the reference set was reported eaten, and an upper bound of 100%, which indicates that all items and amounts in the reference set were reported correctly. Higher correspondence rates reflect better reporting accuracy. In the Figure, the correspondence rate for energy is $(700 \div 1,180) \times 100 = 59\%$.

Inflation ratio: For an individual for energy or any nutrient, $\text{inflation ratio} = (\text{overreported amount from matches and intrusions} \div \text{reference amount}) \times 100$. It is a measure of reporting error. An inflation ratio has a lower bound of 0%, which indicates no overreporting from intrusions and overreported amounts of matches, and no upper bound because there is no limit on what an individual can overreport. Lower inflation ratios reflect better reporting accuracy. In the Figure, the inflation ratio for energy is $(355 \div 1,180) \times 100 = 30\%$.

Table 1

Results from the conventional approach for analyzing energy and macronutrients, by interview sequence (first, second, third)*

	Reference (observed) Mean (SD)	Reported Mean (SD)	$t^{\dagger}$	$r^{\S}$	Mean (SD)	Report rate ‡ Minimum	Maximum ‡‡
Energy (kcal)							
First interview	825 (244)	643 (276)	-6.21, P < .0001	0.35, P = .0003	83% (43%)	10%	339%
Second interview	835 (232)	643 (258)	-6.74, P < .0001	0.38, P = .0002	81% (32%)	12%	184%
Third interview	830 (238)	647 (241)	-6.17, P < .0001	0.39, P = .0004	82% (34%)	18%	224%
Mixed-model results	F = 0.05, P = .9510	F = 0.01, P = .9947			F = 0.12, P = .8843		
Protein (g)							
First interview	34 (11)	29 (12)	-3.78, P < .0003	0.27, P = .0055	101% (116%)	12%	1,167%
Second interview	34 (11)	28 (14)	-4.89, P < .0001	0.53, P < .0001	89% (55%)	2%	527%
Third interview	33 (11)	28 (10)	-4.06, P < .0001	0.44, P < .0001	90% (44%)	15%	347%
Mixed-model results	F = 0.32, P = .7272	F = 0.16, P = .8529			F = 0.48, P = .6198		
Carbohydrate (g)							
First interview	122 (35)	97 (42)	-6.07, P < .0001	0.38, P < .0001	84% (45%)	12%	415%
Second interview	128 (37)	99 (39)	-6.40, P < .0001	0.33, P = .0014	81% (34%)	12%	203%
Third interview	130 (38)	99 (38)	-6.79, P < .0001	0.44, P < .0001	80% (38%)	16%	301%
Mixed-model results	F = 1.06, P = .3486	F = 0.08, P = .9196			F = 0.17, P = .8469		
Fat (g)							
First interview	24 (11)	17 (9)	-6.54, P < .0001	0.40, P < .0001	84% (64%)	3%	359%
Second interview	23 (9)	16 (9)	-6.60, P < .0001	0.52, P < .0001	80% (49%)	4%	375%
Third interview	22 (10)	17 (9)	-4.73, P < .0001	0.41, P = .0002	84% (49%)	4%	256%
Mixed-model results	F = 1.08, P = .3396	F = 0.11, P = .8932			F = 0.15, P = .8609		

* Sample sizes were 104 fourth-grade children for the first interview, 92 of the same 104 children for the second interview, and 79 of the same 92 children for the third interview. At least 25 days, and as many as 99 days, separated consecutive interviews for an individual child.

† For energy and each macronutrient, paired t-tests were used to compare mean within-interview differences of reported and reference amounts to zero. Differences were calculated as reported minus reference; thus, negative differences indicate underreporting (ie, reported < reference). All t statistics refer to $t(103)$ for the first interview, $t(91)$ for the second interview, and $t(78)$ for the third interview.

§ The association between reference and reported energy and each macronutrient for each interview was evaluated by Pearson correlations calculated over children. Pearson correlations were tested for differences from zero.

‡ For an individual, Report Rate = (Reported amount/Reference amount) $\times$ 100. A report rate has a lower bound of 0%, which indicates nothing was reported, but no upper bound, because there is no limit on what an individual can report.

‡‡ Because children's reports were compared to available reference (observed) information, there was nothing suspect about these values, so we thought it inappropriate to classify them as outliers and to exclude them from analyses.

Table 2

Results from the reporting-error-sensitive approach for analyzing energy and macronutrients, by interview sequence (first, second, third)

	Mean (SD)	Correspondence rate [†] Minimum	Maximum	Mean (SD)	Inflation ratio [§] Minimum	Maximum
Energy (kcal)						
First interview	42% (23%)	0%	98%	42% (43%)	0%	308%
Second interview	47% (26%)	0%	100%	34% (29%)	0%	184%
Third interview	53% (24%)	9%	100%	29% (30%)	0%	200%
Mixed-model results	F = 4.74, P = .0095			F = 2.96, P = .0536		
Protein (g)						
First interview	48% (26%)	0%	98%	53% (121%)	0%	1,167%
Second interview	52% (29%)	0%	100%	37% (59%)	0%	527%
Third interview	61% (27%)	8%	100%	30% (37%)	0%	247%
Mixed-model results	F = 4.93, P = .0079			F = 1.91, P = .1497		
Carbohydrate (g)						
First interview	41% (21%)	0%	96%	42% (45%)	0%	386%
Second interview	45% (25%)	0%	100%	36% (30%)	0%	203%
Third interview	50% (22%)	5%	100%	30% (35%)	0%	265%
Mixed-model results	F = 3.37, P = .0358			F = 2.33, P = .0988		
Fat (g)						
First interview	39% (29%)	0%	100%	45% (61%)	0%	313%
Second interview	45% (31%)	0%	100%	35% (45%)	0%	309%
Third interview	54% (32%)	2%	100%	30% (42%)	0%	206%
Mixed-model results	F = 5.30, P = .0055			F = 2.04, P = .1325		

* Sample sizes were 104 fourth-grade children for the first interview, 92 of the same 104 children for the second interview, and 79 of the same 92 children for the third interview. At least 25 days, and as many as 99 days, separated consecutive interviews for an individual child.

[†] **Correspondence rate:** For an individual, correspondence rate = (corresponding amount from matches/reference amount) × 100. It is a genuine measure of reporting accuracy that is sensitive to reporting errors. It has a lower bound of 0%, which indicates that nothing in the reference set was reported eaten. It has an upper bound of 100%, which indicates that all items and amounts in the reference set were reported correctly. Higher correspondence rates reflect better reporting accuracy.

[§] **Inflation ratio:** For an individual, inflation ratio = (overreported amount from matches and intrusions/reference amount) × 100. It is a measure of reporting error. It has a lower bound of 0%, which indicates that there were no intrusions and that no amounts of matches were overreported. It has no upper bound. Lower inflation ratios reflect better reporting accuracy.

Descriptive statistics for energy and macronutrients, by interview sequence (first, second, third)^{*}, for the five categories of amounts used to calculate variables for the reporting-error-sensitive approach

Table 3

	Overreported amount from intrusions [†] Mean (SD)	Overreported amount from matches [§] Mean (SD)	Corresponding amount from matches [‡] Mean (SD)	Unreported amount from matches ^{††} Mean (SD)	Unreported amount from omissions ^{§§} Mean (SD)
Energy (kcal)					
First interview	257 (224)	43 (79)	344 (204)	69 (82)	412 (237)
Second interview	229 (195)	37 (66)	376 (212)	60 (75)	399 (267)
Third interview	185 (160)	31 (53)	431 (215)	70 (100)	329 (243)
Protein (g)					
First interview	10 (11)	2 (4)	16 (10)	3 (4)	15 (11)
Second interview	8 (9)	2 (4)	18 (12)	3 (4)	14 (12)
Third interview	7 (7)	2 (3)	19 (10)	3 (5)	11 (11)
Carbohydrate (g)					
First interview	40 (34)	7 (13)	51 (29)	11 (12)	61 (33)
Second interview	37 (28)	5 (10)	56 (31)	9 (12)	63 (39)
Third interview	30 (24)	4 (9)	64 (32)	11 (16)	54 (37)
Fat (g)					
First interview	7 (7)	1 (2)	9 (7)	2 (3)	13 (9)
Second interview	6 (7)	1 (2)	10 (7)	2 (3)	11 (10)
Third interview	4 (6)	1 (1)	12 (9)	2 (3)	9 (9)

^{*} Sample sizes were 104 fourth-grade children for the first interview, 92 of the same 104 children for the second interview, and 79 of the same 92 children for the third interview. At least 25 days, and as many as 99 days, separated consecutive interviews for an individual child.

[†] **Overreported amount from intrusions:** The entire reported amount for each intrusion (food items that were reported eaten but were not eaten).

[§] **Overreported amount from matches:** The part of the reported amount that exceeds the reference amount (or zero if the reported amount is smaller than the reference amount) for each match (food items that were actually eaten and were reported eaten).

[‡] **Corresponding amount from matches:** The smaller of the reported and reference amounts (or the reported amount if it is equal to the reference amount) for each match (food items that were actually eaten and were reported eaten).

^{††} **Unreported amount from matches:** The part of the reference amount that exceeds the reported amount (or zero if the reference amount is smaller than the reported amount) for each match (food items that were actually eaten and were reported eaten).

^{§§} **Unreported amount from omissions:** The entire reference amount for each omission (food items that were actually eaten but were not reported eaten).