Published in final edited form as:

J Acad Nutr Diet. 2016 December ; 116(12): 1932–1941. doi:10.1016/j.jand.2016.08.013.

Fourth-grade children's reporting accuracy for amounts eaten at school-provided meals: Insight from a reporting-error-sensitive analytic approach applied to validation-study data

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Abstract

Background—Validation studies that have directly assessed reporting accuracy for amounts eaten have provided results in various ways.

Objective—To analyze amount categories of a reporting-error-sensitive approach for insight concerning reporting accuracy for amounts eaten.

Design—For a cross-sectional validation study, children were observed eating school-provided breakfast and lunch, and randomized to one of eight 24-hour recall conditions (two retention intervals [short; long] crossed with four prompts [forward; meal-name; open; reverse]).

Participants/setting—Data collected during three school years (2011–2012 to 2013–2014) on 455 children from ten schools (four districts) in a southern USA state.

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FUNDING/SUPPORT DISCLOSURE

This research was supported by competitive grant R01HL103737 (with SD Baxter as Principal Investigator) from the National Heart, Lung, and Blood Institute of the National Institutes of Health. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health. The authors declare that they have no conflicts of interest.

CONFLICT OF INTEREST

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Main outcome measures—Items were classified as matches [observed and reported], omissions [observed but unreported], or intrusions [unobserved but reported]. Within amount categories (matches [corresponding, over-reported, under-reported], intrusions [over-reported], omissions [under-reported]), item-amounts were converted to kilocalories.

Statistical analyses performed—A multilevel model was fit with food-level explanatory variables (amount category, meal) and child-level explanatory variables (retention interval, prompt, sex, race/ethnicity). T-tests on three contrasts investigated inaccuracy differences.

Results—Inaccuracy differed by amount category ($P<0.001$; largest to smallest—omission, intrusion, under-reported match, over-reported match), meal ($P=0.01$; larger for breakfast), retention interval ($P=0.003$; larger for long), sex ($P=0.004$; larger for boys), race/ethnicity ($P=0.045$; largest for non-Hispanic Whites), and amount category- $\times$ -meal interaction ($P=0.046$). Over-reported amounts were larger for intrusions than over-reported matches ($P<0.0001$). Under-reported amounts were larger for omissions than under-reported matches ($P<0.0001$). Overall under-reported amounts (from omissions and under-reported matches) exceeded overall over-reported amounts (from intrusions and over-reported matches) ($P<0.003$).

Conclusions—Amount categories provide a standard way to analyze validation-study data on reporting accuracy for amounts eaten, and compare results across studies. Multilevel analytic models reflecting the data structure are recommended for inference. To enhance reporting accuracy for amounts eaten, focus on increasing reports of correct items, thereby yielding more matches with fewer intrusions and omissions.

Keywords

Children; accuracy for reporting amounts; dietary recall; school meals; validation

INTRODUCTION

Research shows that children have difficulty accurately reporting amounts eaten.^{1–11} Nevertheless, studies of fourth-grade children's dietary-reporting accuracy have consistently shown that for *matches* (items observed eaten and reported eaten), qualitatively reported amounts eaten (e.g., little bit, most) in reports of school-provided meals in 24-hour dietary recalls are reasonably accurate;^{12–15} on average, when quantified, reported amounts for *matches* were within 0.25 serving of what was observed. However, on average, after quantification of qualitative reports, children reported having eaten 0.76 serving of each *intrusion* (item reported eaten but not observed eaten) and were observed to have eaten an average of 0.80 serving of each *omission* (item observed eaten but not reported eaten).^{12–15} Thus, children falsely claimed to have eaten most of the serving of intrusions, and omissions were not eaten in small amounts.

Many validation studies do not directly assess, at the food item level, reporting accuracy for amounts eaten, but instead use a “conventional approach” in which all items and amounts in a reference set (e.g., from meal observations) are transformed to kilocalories (kcal); likewise, all items and amounts in a reported set (e.g., from 24-hour recalls) are transformed to kcal; then, kcal within each set are totaled for each respondent; finally, statistical tests are used to analyze report rate (ratio of total reported kcal to total reference kcal).¹⁶ Thus, this

conventional approach is insensitive to reporting errors of items and amounts, permitting, for example, over-report of some items to compensate for under-report of others.¹⁶

In contrast, in this article, a “reporting-error-sensitive approach”,¹⁶ which quantifies reporting error in a way that depends on what items and amounts are misreported, was used to assess reporting accuracy for amounts eaten in a validation study: First, each item was defined as a match, omission, or intrusion. Next, for each match, omission, and intrusion, amounts were categorized. For matches, amounts were categorized as corresponding, under-reported, or over-reported. By definition, amounts of intrusions are over-reported, and amounts of omissions are under-reported.¹⁶ Within each amount category, each item’s amount was converted to kcal. The reporting-error-sensitive approach has been shown previously^{16–20} to provide a different picture of dietary-reporting accuracy than the conventional approach.

In previous comparisons^{16–20} of the reporting-error-sensitive and conventional approaches to analysis of validation-study data, the reporting-error-sensitive measures analyzed were the kcal measures correspondence rate (index of correct reporting) and inflation ratio (index of false reporting). For an analyzed meal, the sum of the correspondence rate and inflation ratio is the conventional approach’s report rate, and each article’s focus was on investigating the relationship of these measures to manipulated or respondent variables. The current article is the first to formally analyze only the amount categories (with amounts for items in each category converted to kcal) of the reporting-error-sensitive approach to provide insight concerning children’s reporting accuracy for amounts eaten.

For the current article, data from a cross-sectional validation study²¹ of children’s reports of school-provided meals in 24-hour recalls were used to investigate hypotheses about reporting accuracy for amounts eaten (expressed in terms of kcal inaccuracy or “inaccuracy”) with the reporting-error-sensitive approach. The validation study²¹ was designed to investigate the combined influence of retention interval and prompts on fourth-grade children’s dietary recall accuracy. Retention interval is the time between the meals to be reported and the recall. Prompts are questions used to obtain reports of intake during the first pass of a multiple-pass recall procedure. Intake was validated with meal observations of school-provided breakfast and lunch. As in past studies,^{12–15,22,23} observers and children used qualitative terms of amounts eaten (e.g., half, most). There were three hypotheses.

Hypothesis 1 – Inaccuracy for amounts eaten will be greater for intrusions and omissions than for over-reported matches and under-reported matches (defined in Methods).

Hypothesis 1a – Inaccuracy for over-reported amounts will be smaller for matches than for intrusions (which would not be true if only relatively small amounts are reported for intrusions). Hypothesis 1b – Inaccuracy for under-reported amounts will be smaller for matches than for omissions (which would not be true if omissions are of relatively small amounts). Hypothesis 1c – All inaccuracy for under-reporting (from omissions and under-reported matches) will be larger than all inaccuracy for over-reporting (from intrusions and over-reported matches). Hypothesis 1 and 1a–1c were based on results from research with fourth-grade children^{12–15} summarized earlier.

Hypothesis 2 – Inaccuracy for amounts eaten will differ by meal (breakfast, lunch). Specifically, inaccuracy will be smaller for lunch than for breakfast. Hypothesis 2 was based on results from research^{20,24} which showed that fourth-grade children's item accuracy in reports of school meals during 24-hour recalls was better for lunch than breakfast.

Hypothesis 3 – Inaccuracy for amounts eaten will vary for intrusions, omissions, over-reported matches, and under-reported matches as a function of retention interval, prompts, or sex, separately or combined. Specifically, inaccuracy for amounts eaten will be smaller for the short than for the long retention interval. The retention interval part of Hypothesis 3 was based on results from numerous studies^{15,21–23,25,26} with third-, fourth-, or fifth-grade children which showed that their item accuracy in reports of school meals during 24-hour recalls was better with the short than long retention interval. No specific hypotheses were made for inaccuracy for amounts eaten as a function of prompts or sex.

METHODS

A previous publication describes estimation for the validation study's sample sizes and results for food item and kcal accuracy measures²¹ along with details about the design, sample, data collection, and quality control;²¹ this section summarizes the latter information. The University of South Carolina Institutional Review Board approved the study. Written parental consent and child assent were obtained.

Data were collected during three school years (2011–2012, 2012–2013, 2013–2014) with fourth-grade children from ten schools in four districts in South Carolina, USA. Across the three school years, of 1,780 children invited to participate in the study, 1,208 children agreed (67.9%). Each child selected to participate was observed eating two consecutive school-provided meals (breakfast and lunch) on the same day, and interviewed to obtain a 24-hour recall under one of eight conditions constructed by crossing two retention intervals (short; long) with four prompts (forward [distant to recent]; meal-name [breakfast, lunch, etc]; open [no instructions]; reverse [recent to distant]). The rationale for the design is described elsewhere.²⁷ For the short retention interval, an afternoon interview concerned the prior-24-hours' intake (i.e., from 24 hours before the interview until the interview began). For the long retention interval, a morning interview concerned the previous-day's intake (i.e., midnight to midnight of the day before the interview). From the pool of consented children each school year, children were randomly selected subject to constraints imposed by the target composition (i.e., number and sex) of the eight conditions. Random assignment of selected children was subject to the constraint that each condition had 60 children (half girls), for 480 children total. Neither children nor school staff knew when observations and/or interviews would occur.

Three researchers observed school-provided meals using an established protocol.^{12–15,22,23} Each observer observed one to three children simultaneously during regular meal periods and recorded items and amounts eaten. Across three school years, 287 assessments of interobserver reliability, conducted weekly using established procedures,^{13–15,22,23,28} showed excellent^{29,30} mean agreement (98.8%) between observers to within one-fourth of a serving on amounts eaten.

Four researchers conducted face-to-face interviews in private locations at schools after breakfast for the long retention interval and after lunch for the short retention interval. A child's interviewer had not observed that child's meals. The multiple-pass protocols are described in detail elsewhere.²¹ Information about amounts was obtained during the third pass of each protocol: For each item reported eaten, the child was asked to use the response options "none", "taste", "little bit", "half", "most", "all", and "more than one serving" to report how much she or he had eaten; a child who responded "more than one serving" was asked how many servings and to use the previously listed response options to report how much of each serving. Interviews were audio-recorded and transcribed; a non-interviewing researcher conducted quality control on each interview using established procedures.^{13–15,22,23,31} Eighteen interviews that did not adhere to the assigned protocol were replaced. Additionally, one interview was replaced because it was incomplete when the child was dismissed early from school during the interview.

Accuracy was assessed only for the school-meal parts of 24-hour recalls because only school meals were observed. Using established procedures,^{12–15,22,23} for reported items to be treated as reports about school meals, children had to identify "school" as the location where items were eaten, refer to breakfast as "school breakfast" or "breakfast", refer to lunch as "school lunch" or "lunch", and report mealtimes to within one hour of observed mealtimes.

There were two sets of food items (reference and reported) for each school meal for each child. For each child, the reference set contained items and amounts observed eaten, and the reported set contained items and amounts reported eaten.

For each item in a child's reference set or reported set, the qualitative term used for the amount observed eaten or reported eaten was quantified as follows: none=0, taste=0.1, little bit=0.25, half=0.50, most=0.75, all=1, or the actual number of servings if >1.^{12–15,22,23} For each item, energy (in kcal) for a standard school-meal portion was obtained from the Nutrition Data System for Research (NDSR) database version 2014.³²

Reporting-Error-Sensitive Approach Measures

Using established definitions,^{12–15,22,23,26,33–38} for each child, an item in both the reference set and reported set was classified as a *match*; an item in the reported set but not in the observed set was classified as an *intrusion*; and an item in the observed set but not in the reported set was classified as an *omission*. Thus, the reference set contained matches and omissions, and the reported set contained matches and intrusions.

For amounts, for each *match*, the quantified serving reported eaten was categorized a) as corresponding, b) as corresponding and over-reported, or c) as corresponding and under-reported because for each match, the amount reported eaten either a) corresponded exactly to the amount observed eaten, b) exceeded the amount observed eaten, or c) was less than the amount observed eaten.¹⁶ For b), if the amount reported eaten exceeded the amount observed eaten, it did so by an *over-reported* amount. For c), if the amount reported eaten was less than the amount observed eaten, it did so by an *under-reported* amount. For each of b) and c), the amount by which the amount reported eaten overlapped with the amount observed eaten was a *corresponding* amount. For each *omission*, the entire amount observed

eaten was necessarily *under*-reported. For each *intrusion*, the entire amount reported eaten was necessarily *over*-reported.¹⁶

To calculate “kcal inaccuracy” for each item for each child, corresponding, over-reported, and under-reported amounts, in kcal, were obtained by multiplying each corresponding, over-reported, and under-reported number of servings by the appropriate per-serving value of kcal from NDSR. For analyses, all values of kcal inaccuracy were absolute (i.e., positive). Examples of kcal inaccuracy follow:

- An omission of 0.75 serving of cheese pizza at 337 kcal/serving had $0.75 \times 337 = 253$ under-reported kcal from an omission.
- An intrusion of 2 servings of ranch salad dressing at 34 kcal/serving had $2 \times 34 = 68$ over-reported kcal from an intrusion.
- A match of carrots with 0.25 serving observed eaten and 0.75 serving reported eaten at 25 kcal/serving had $0.50 \times 25 = 13$ over-reported kcal from a match.
- A match of chocolate milk with 1.0 serving observed eaten and 0.75 serving reported eaten at 140 kcal/serving had $0.25 \times 140 = 35$ under-reported kcal from a match.

Analyses

A multilevel model was fit with food items as the individual-level statistical observations and children as the group-level subjects; kcal inaccuracy of each item was the response variable. Amount category (intrusion, omission, over-reported match, under-reported match) and meal (breakfast, lunch) of each item were food-level explanatory variables, and retention interval, prompt, sex, and race/ethnicity were child-level explanatory variables. The model controlled for school year, school district, and school (nested within district). District and school were treated as random effects, and were included because responses may have been clustered within districts, and within schools in districts. Of interest was whether mean kcal inaccuracy differed across the four amount categories or between the two meals; and whether mean kcal inaccuracy differed between the two retention intervals; among the four prompts; between boys and girls; or across races/ethnicities. The three-way interaction of amount category, retention interval, and meal was investigated, too. In addition, two-way interactions were investigated between each of retention interval, prompt, and sex; between amount category and each of retention interval, prompt, and sex; between retention interval and meal; and between amount category and meal. The multilevel model was fit in SAS/STAT® version 9.4³⁹ using PROC MIXED. Type III F-tests were used to test significance. After fitting an initial model, interactions with *P*-values >0.20 were removed and the model refit, with the removed sums of squares pooled into the error sum of squares to improve power for the other F-tests.⁴⁰ For the directional questions of Hypotheses 1a–1c, t-tests were used to compare 1) amounts over-reported for matches and amounts reported for intrusions; 2) amounts under-reported for matches and amounts unreported for omissions; and 3) all under-reported amounts (from omissions and under-reported matches) and all over-reported amounts (from intrusions and over-reported matches). Due to the number of F-tests and t-

tests, the Benjamini-Hochberg method⁴¹ was used to adjust *P*-values, controlling the false discovery rate at 0.05; *P*-values given are adjusted.

RESULTS

Of 480 children (half girls), there were 261 non-Hispanic African American, 150 non-Hispanic White, 47 Hispanic, and 22 children from non-Hispanic other or non-Hispanic mixed races. For analyses, due to small numbers, Hispanic children and non-Hispanic children from other or mixed races were combined into one race and ethnicity category.

The criteria for any reported meals to be classified as school meals were not met by 25 children (8 girls; 15 non-Hispanic African American, 7 non-Hispanic White, 3 Hispanic),²¹ who had been randomized to the recall-protocol conditions as follows: 7 short retention interval (1 forward, 3 open, 3 reverse) and 18 long retention interval (5 forward, 2 meal-name, 4 open, 7 reverse). Because each of these 25 children did not meet criteria for any reported meals to be classified as school meals, each child had 0 matches, 0 intrusions, and all omissions, and so their data were not included in analyses.

Over the two meals of the 455 children whose data were analyzed, 3,561 items were observed eaten and 2,621 items were reported eaten. Per child across two meals, 7.8 ± 2.1 (mean $\pm$ standard deviation) items were observed eaten and 5.8 ± 2.4 items were reported eaten. Per child across two meals, 722 ± 240 kcal were observed eaten and 495 ± 249 kcal were reported eaten.

Over children and meals, by amount category, there were 667 intrusions, 1,607 omissions, 376 over-reported matches, and 608 under-reported matches; there were also 970 matches for which amounts reported eaten corresponded exactly to amounts observed eaten, and so were not included in analyses of reporting error. For observed items, the percentage with errors for reporting amounts eaten was the sum of the numbers of omissions, over-reported matches, and under-reported matches divided by the number of observed items, multiplied by 100; this was $[(1,607+376+608)/3,561] \times 100 = 72.5\%$. For reported items, the percentage with errors for reporting amounts eaten was the sum of the numbers of intrusions, over-reported matches, and under-reported matches divided by the number of reported items, multiplied by 100; this was $[(667+376+608)/2,621] \times 100 = 62.6\%$. Thus, the percentages with errors for reporting amounts eaten were substantial.

Table 1, Panel A, shows, over children and meals, the number of matches for each combination of amounts observed and reported eaten in servings. In Panel A, the numbers on the diagonal (e.g., 14, 60, 108) show the numbers of matches for which amounts observed and reported eaten in servings corresponded exactly. Above the diagonal are numbers of matches for which amounts in servings were over-reported, and below the diagonal are numbers of matches for which amounts in servings were under-reported. (For each panel in Table 1, all observed amounts >1 serving and/or all reported amounts >1 serving were categorized as >1 serving. Thus, the number of corresponding matches in Panel A on the diagonal do not sum exactly to 970, the number of over-reported matches in Panel A above the diagonal do not sum exactly to 376, and the number of under-reported matches

in Panel A below the diagonal do not sum exactly to 608.) Table 1, Panel B, shows, over children and meals, the number of omissions for each amount observed eaten in servings; because these items were observed eaten but unreported, there were no amounts reported. Table 1, Panel C, shows, over children and meals, the number of intrusions for each amount reported eaten in servings; because these items were reported eaten but not observed eaten, there were no amounts observed eaten.

Table 2 shows least squares means of kcal inaccuracy by amount category, meal, retention interval, prompt, sex, and race/ethnicity. Inaccuracy was related to amount category ($P<0.001$), meal ($P=0.01$), retention interval ($P=0.003$), sex ($P=0.004$), race/ethnicity ($P=0.045$), and the amount category- $\times$ -meal interaction ($P=0.046$).

By amount category, inaccuracy (per food item) from largest to smallest was: omission (81 kcal), intrusion (66 kcal), under-reported match (49 kcal), and over-reported match (40 kcal). Contrasts addressed specific questions about differences among the amount categories. The contrast for over-reported amounts showed that mean kcal inaccuracy was larger for intrusions than over-reported matches ($P<0.0001$). The contrast for under-reported amounts showed that mean kcal inaccuracy was larger for omissions than under-reported matches ($P<0.0001$). The contrast that compared over-reported amounts to under-reported amounts showed that mean kcal inaccuracy for the under-reported amount categories (omissions and under-reported matches) exceeded mean kcal inaccuracy for the over-reported amount categories (intrusions and over-reported matches) ($P<0.003$).

Inaccuracy was larger for breakfast (63 kcal) than lunch (55 kcal). The significant interaction of amount category by meal is interpreted as follows: For both breakfast and lunch, the amount categories from most to least inaccurate were omission (90 kcal/item at breakfast; 72 kcal/item at lunch), intrusion (69 kcal/item at breakfast; 63 kcal/item at lunch), under-reported match (51 kcal/item at breakfast; 47 kcal/item at lunch), and over-reported match (40 kcal/item at breakfast; 40 kcal/item at lunch). Although, for each amount category, inaccuracy for breakfast was larger than that for lunch, the meal differences varied over amount categories and ranged (largest to smallest) from 18 kcal per omission, 6 kcal per intrusion, 4 kcal per under-reported match, and 1 kcal per over-reported match.

Inaccuracy was larger with the long (63 kcal) than short (55 kcal) retention interval; larger for boys (62 kcal) than girls (56 kcal); and larger for non-Hispanic White children (64 kcal) than non-Hispanic African American children (59 kcal) and children of other races/ethnicities (54 kcal). Inaccuracy was not systematically related to prompt ($P=0.47$).

No interactions other than amount category $\times$ meal were significant (all P -values >0.13), indicating that the retention interval effect did not depend on prompt or sex; the sex effect did not depend on retention interval or prompt; and the amount category and meal effects did not depend on retention interval, prompt, or sex. The significant variation in random effects across districts ($P=0.001$) and across schools nested within districts ($P=0.008$) justified inclusion of these random effects in the model.

DISCUSSION

A reporting-error-sensitive approach was used to address three hypotheses concerning fourth-grade children's reporting accuracy for amounts eaten at school-provided meals with data from a validation study in which retention interval and prompts were manipulated. Multilevel models were used to analyze reporting accuracy for amounts eaten expressed in kcal. These models accounted for the multilevel (item-level and child-level) structure of the data, and permitted answers to hypotheses about item-level variables such as amount category and meal. Because the multilevel models of the reporting-error-sensitive approach reflect the data structure, they are the optimal way to address the hypotheses articulated.

Hypothesis 1—that inaccuracy for amounts eaten is greater for intrusions and omissions than for over-reported matches and under-reported matches—was supported. Inaccuracy was largest for omissions, followed by intrusions, then under-reported matches, and smallest for over-reported matches. Hypothesis 1a—that inaccuracy for over-reported amounts is smaller for matches than for intrusions—was supported, too. Over-reported amounts were larger for intrusions than for over-reported matches. Hypothesis 1b—that inaccuracy for under-reported amounts is smaller for matches than for omissions—was supported as well. Under-reported amounts were larger for omissions than under-reported matches. Hypothesis 1c—that all inaccuracy for under-reporting (from omissions and under-reported matches) is larger than all inaccuracy for over-reporting (from intrusions and over-reported matches)—was supported also. Inaccuracy for the under-reported amount categories exceeded inaccuracy for the over-reported amount categories (intrusions and over-reported matches). These findings for kcal are similar to findings for servings from past validation studies with fourth-grade children in five school districts in two USA states (Georgia, South Carolina).^{12–15} These results, collectively, suggest that efforts to improve children's reporting accuracy for *amounts* eaten should focus first on helping children to report the correct *items*. That is because when reported items are matches, amounts reported eaten are reasonably accurate. However, when items are intruded, any reported amount is inaccurate, and when items are omitted, no amount is reported. Furthermore, these findings emphasize the importance, in analyses of validation-study data, of first defining each item as a match, omission, or intrusion, so that amounts reported eaten can be identified as corresponding for matches, over-reported for matches, or over-reported for intrusions, and so that unreported amounts can be identified as under-reported for matches or under-reported for omissions.

Hypothesis 2—that inaccuracy for amounts eaten differs by meal (breakfast, lunch)—was supported. Inaccuracy was larger for breakfast than lunch; thus, children's accuracy for reporting amounts eaten was better for lunch than breakfast. This finding is consistent with findings that children's item accuracy in reports of school meals during 24-hour recalls was better for lunch than breakfast for this validation study²⁰ and for two previous studies.²⁴

Hypothesis 3—that inaccuracy for amounts eaten for different amount categories (intrusion, omission, over-reported match, under-reported match) varies as a function of retention interval, prompts, or sex, separately or combined—was supported for retention interval and for sex. Reporting accuracy for amounts eaten was better with the short than long retention interval, which is consistent with findings concerning the effect of retention interval on item-

reporting accuracy from numerous validation studies with children.^{15,21–23,25,26} (This finding concerning retention interval is likely related to the Hypothesis 2 finding that amount-reporting accuracy was better for lunch than breakfast: For the short retention interval [afternoon interview about the prior-24-hours' intake], the 24-hour recall was approximately five hours after the to-be-reported school breakfast and one hour after the to-be-reported school lunch, whereas for the long retention interval [morning interview about the previous-day's intake], the approximate times were 25 and 21 hours, respectively. Thus, over children, the average time between eating breakfast and the 24-hour recall was 15 hours, whereas for lunch it was 11 hours.) There were differences by sex, with inaccuracy worse for boys. There was no significant interaction on amount-reporting inaccuracy of amount category with any of retention interval, prompts, or sex.

Although some publications of past dietary-reporting validation studies in which fourth-grade children provided reports of school meals during 24-hour recalls have included results on reporting accuracy for amounts eaten,^{12–15} few other published dietary-reporting validation studies with children have included results on reporting accuracy for amounts eaten by amount category (match [corresponding; over-reported; under-reported], intrusion, omission). Exceptions were a validation study³³ of fourth-grade children and a small quasi-experimental study⁴² of children aged 9–11 years, for which results were included on reporting accuracy for amounts eaten for matches overall, but not for corresponding amounts for matches, over-reported amounts for matches, or under-reported amounts for matches; furthermore, neither of these studies included results for amounts of omissions or for reported amounts of intrusions. Other validation studies with children have included results on reporting accuracy for amounts eaten in various other ways. For example, Crawford and colleagues¹ included results for percentage absolute error with (observed [grams] minus reported [grams]) divided by observed (grams) times 100 grouped into four error categories for 10%, 11–25%, 26–50%, and >50%. Lytle and colleagues² included results for percentage of foods estimated by recall within 10% of observed, over-estimated by 11–49%, over-estimated by 50–100%, over-estimated by >100%, underestimated by 11–49%, and under-estimated by 50–100%. Weber and colleagues⁵ included results by food group for the percentage of foods with quantities within $\pm 10\%$ of observed, overestimated by 11–49%, over-estimated >100%, under-estimated by 11–49%, and under-estimated by 50–99%. Matheson and colleagues⁶ included results by food item, total amount of food, and total energy intake for the percentage overestimated, percentage underestimated, and percentage error based on absolute value difference between actual and estimated food intakes. Wolkoff and colleagues⁷ included results for directional differences (reported intake minus actual intake) and absolute difference (absolute value of reported intake minus actual intake). Turconi and colleagues⁹ included results for foods overall and by meal component using Pearson's correlation coefficients, t-tests, and Bland-Altman plots. Korkalo and colleagues¹⁰ included results for each food using percentage differences, Spearman's rank correlation coefficients, Bland-Altman plots, and the proportion of participants with estimates within $\pm 10\%$ of the actual portion size, below -10% of the actual portion size, and above $+10\%$ of the actual portion size. The various ways that results have been provided makes it difficult to compare results for reporting accuracy for amounts eaten across studies. The amount categories (intrusion, omission, over-reported match, under-reported match, corresponding

match) used in this article offer a standard and easily understood way to analyze validation-study data, provide results concerning reporting accuracy for amounts eaten, and compare such results across studies.

In some studies of amount-reporting accuracy, participants have been asked to judge portion sizes without consuming foods. For one example, the effect of portion-size estimation training⁴³ with 10 displayed real foods was evaluated in second- and third-grade children randomly assigned to group (training; no training). Training was a 45-minute hands-on, four-step estimation and measurement skill-building process that occurred in the classroom in groups of four. Compared to the no-training group, the trained group showed more accurate portion-size estimation.⁴³ For another example, a laboratory study⁴⁴ examined effects of image size and size cues on accuracy of portion-size estimates in children aged 8–13 years. Average percentage of foods with correct size estimates was 60.3% and did not depend on sex or age. Multiple images of successively larger portion sizes yielded faster portion size responses with no accuracy decrease.⁴⁴ However, in these two studies, because children only viewed various food portions but did not consume anything, the relevance of the results to situations in which accuracy is assessed for reporting amounts of foods actually eaten is unclear.

The focus of this article is reporting accuracy for amounts eaten, but information concerning inaccuracy by meal component (beverage, bread, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, miscellaneous, vegetable) is of interest, too. A post-hoc summary provided the frequency and mean kcal inaccuracy for each amount category of the reporting-error-sensitive approach by meal component. As shown in Table 3, each amount category was present for each meal component, and mean kcal inaccuracy was largest for omissions, then intrusions, then under-reported matches, and least for over-reported matches.

A limitation of the validation study that provided data for the current article's analyses is that qualitative terms were converted to quantitative terms for amounts eaten of standard school-meal servings; however, this was done consistently to observed and reported information for all eight interview conditions. Another limitation is that the sample included only fourth-grade children. A third limitation is that it was logistically impossible to validate recalls for an entire 24 hours of intake in a manner that was generalizable, economical, and only minimally reactive.

Strengths include the validation of recalls using direct meal observations at school; thus, the setting was free-living (i.e., children had choices of items and determined the amount eaten of each item). Rigorous quality control procedures were implemented for meal observations and interviews.

CONCLUSIONS

Assessment of reporting accuracy for amounts eaten is an important yet often overlooked aspect of dietary-reporting validation studies. When assessing reporting accuracy for amounts eaten, researchers are encouraged to use the reporting-error-sensitive approach, as

in the current article, with the amount categories intrusion, omission, over-reported for a match, and under-reported for a match. These amount categories provide a standard and easily understood way to analyze validation-study data concerning reporting accuracy for amounts eaten. Furthermore, when analyzing validation-study data to investigate reporting accuracy for amounts eaten, researchers are encouraged to use the multilevel models of the reporting-error sensitive approach because they better reflect the data structure and thus are the optimal way to address hypotheses. Also, when providing results of validation studies, researchers are discouraged from using overall descriptive terms of “under-reporting” and “over-reporting” which, unless used specifically for the amount categories, do not provide insight into reporting accuracy because they do not indicate whether error is due to items or to amounts or both. Finally, to enhance children’s reporting accuracy for amounts eaten, efforts should first focus on improving children’s accuracy to report the correct items; this will yield more matches (for which amounts reported eaten are reasonably accurate) with fewer intrusions (for which any reported amounts are inaccurate) and fewer omissions (for which no amounts are reported). Note that for the current study, inaccuracy was largest for omissions (n=1,607), followed by intrusions (n=667), then under-reported matches (n=608), and smallest for over-reported matches (n=376); there were 970 matches for which reported amounts corresponded exactly to observed amounts that were excluded from analyses of inaccuracy. Because children’s reporting accuracy for amounts eaten was better with the short than long retention interval (which is consistent with findings concerning the effect of retention interval on item-reporting accuracy from numerous validation studies with children^{15,21–23,25,26}), practitioners and researchers are encouraged to use a shorter rather than a longer retention interval to obtain 24-hour recalls from children.

Acknowledgments

This research was supported by competitive grant R01HL103737 (with SD Baxter as Principal Investigator) from the National Heart, Lung, and Blood Institute of the National Institutes of Health. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health.

Gratitude is expressed to four school districts (Richland One, Lexington Three, Lexington Four, Lexington-Richland Five) in South Carolina, USA, and staff and children at ten elementary schools, for allowing data collection.

Appreciation is extended to Megan P. Puryear, MS, RD, LD, Kathleen L. Collins, BS, Alyssa L. Smith, MPH, Kate K. Vaadi, RD, LD, and Christina M. Devlin, RD, LD for help with data collection and/or scheduling.

References

1. Crawford PB, Obarzanek E, Morrison J, Sabry ZI. Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. *J Am Diet Assoc.* 1994; 94(6):626–630. [PubMed: 8195550]
2. Lytle LA, Nichaman MZ, Obarzanek E, Glovsky E, Montgomery DH, Nicklas T, Zive MM, Feldman H. Validation of 24-hour recalls assisted by food records in third-grade children. *J Am Diet Assoc.* 1993; 93(12):1431–1436. [PubMed: 8245378]
3. Meredith A, Matthews A, Zickefoose M, Weagley E, Wayave M, Brown EG. How well do school children recall what they have eaten? *J Am Diet Assoc.* 1951; 27(9):749–751. [PubMed: 14880399]
4. Samuelson G. An epidemiological study of child health and nutrition in a northern Swedish county. II. Methodological study of the recall technique. *Nutr Metab.* 1970; 12(6):321–340. [PubMed: 5519001]

5. Weber JL, Lytle L, Gittelsohn J, Cunningham-Sabo L, Heller K, Anliker JA, Stevens J, Hurley J, Ring K. Validity of self-reported dietary intake at school meals by American Indian children: The Pathways Study. *J Am Diet Assoc.* 2004; 104(5):746–752. [PubMed: 15127059]
6. Matheson DM, Hanson KA, McDonald TE, Robinson TN. Validity of children's food portion estimates: A comparison of 2 measurement aids. *Arch Pediatr Adolesc Med.* 2002; 156(9):867–871. [PubMed: 12197792]
7. Wolkoff LE, Tanofsky-Kraff M, Shomaker LB, Kozlosky M, Columbo KM, Elliott CA, Ranzenhofer LM, Osborn RL, Yanovski SZ, Yanovski JA. Self-reported vs. actual energy intake in youth with and without loss of control eating. *Eat Behav.* 2011; 12(1):15–20. [PubMed: 21184968]
8. Foster E, O'Keefe M, Matthews JNS, Mathers JC, Nelson M, Barton KL, Wrieden WL, Adamson AJ. Children's estimates of food portion size: The effect of timing of dietary interview on the accuracy of children's portion size estimates. *Br J Nutr.* 2008; 99(1):185–190. [PubMed: 17651522]
9. Turconi G, Gurarcello M, Berzolari FG, Carolei A, Bazzano R, Roggi C. An evaluation of a colour food photography atlas as a tool for quantifying food portion size in epidemiological dietary surveys. *Eur J Clin Nutr.* 2005; 59(8):923–931. [PubMed: 15928683]
10. Korkalo L, Erkkola M, Fidalgo L, Nevalainen J, Mutanen M. Food photographs in portion size estimation among adolescent Mozambican girls. *Public Health Nutr.* 2012; 16(9):1558–1564. [PubMed: 22874096]
11. Hunsberger M, Pena P, Lissner L, Grafstrom L, Vanaelst B, Bornhorst C, Pala V, Eiben G. Validity of self-reported lunch recalls in Swedish school children aged 6–8 years. *Nutr J.* 2013; 12:129. [PubMed: 24047239]
12. Baxter SD, Thompson WO, Litaker MS, Frye FHA, Guinn CH. Low accuracy and low consistency of fourth-graders' school breakfast and school lunch recalls. *J Am Diet Assoc.* 2002; 102(3):386–395. [PubMed: 11905461]
13. Baxter SD, Thompson WO, Litaker MS, Guinn CH, Frye FHA, Baglio ML, Shaffer NM. Accuracy of fourth-graders' dietary recalls of school breakfast and school lunch validated with observations: In-person versus telephone interviews. *J Nutr Educ Behav.* 2003; 35(3):124–134. [PubMed: 12773283]
14. Baxter SD, Thompson WO, Smith AF, Litaker MS, Yin Z, Frye FHA, Guinn CH, Baglio ML, Shaffer NM. Reverse versus forward order reporting and the accuracy of fourth-graders' recalls of school breakfast and school lunch. *Prev Med.* 2003; 36(5):601–614. [PubMed: 12689806]
15. Baxter SD, Hardin JW, Guinn CH, Royer JA, Mackelprang AJ, Smith AF. Fourth-grade children's dietary recall accuracy is influenced by retention interval (target period and interview time). *J Am Diet Assoc.* 2009; 109(5):846–856. [PubMed: 19394471]
16. Smith AF, Baxter SD, Hardin JW, Nichols MN. Conventional analyses of data from dietary validation studies may misestimate reporting accuracy: Illustration from a study of the effect of interview modality on children's reporting accuracy. *Public Health Nutr.* 2007; 10(11):1247–1256. [PubMed: 17381899]
17. Baxter SD, Guinn CH, Royer JA, Hardin JW, Smith AF. Shortening the retention interval of 24-hour dietary recalls increases fourth-grade children's accuracy for reporting energy and macronutrient intake at school meals. *J Am Diet Assoc.* 2010; 110(8):1178–1188. [PubMed: 20656093]
18. Baxter SD, Smith AF, Hardin JW, Nichols MN. 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. *J Am Diet Assoc.* 2007; 107(4):595–604. [PubMed: 17383265]
19. Baxter SD, Smith AF, Hardin JW, Nichols MN. Conventional energy and macronutrient variables distort the accuracy of children's dietary reports: Illustrative data from a validation study of effect of order prompts. *Prev Med.* 2007; 44(1):34–41. [PubMed: 16959308]
20. Baxter SD, Guinn CH, Smith AF, Hitchcock DB, Royer JA, Puryear MP, Collins KL, Smith AL. Children's school-breakfast reports and school-lunch reports (in 24-h dietary recalls): conventional and reporting-error-sensitive measures show inconsistent accuracy results for retention interval and breakfast location. *Br J Nutr.* 2016; 115(7):1301–1315. [PubMed: 26865356]

21. Baxter SD, Smith AF, Hitchcock DB, Guinn CH, Royer JA, Collins KL, Smith AL, Puryear MP, Vaadi KK, Finney CJ, Miller PH. Effectiveness of prompts on fourth-grade children's dietary recall accuracy depends on retention interval and varies by gender. *J Nutr*. 2015; 145(9):2185–2192. [PubMed: 26224752]
22. Baxter SD, Smith AF, Litaker MS, Guinn CH, Shaffer NM, Baglio ML, Frye FHA. Recency affects reporting accuracy of children's dietary recalls. *Ann Epidemiol*. 2004; 14(6):385–390. [PubMed: 15246326]
23. Baxter SD, Hitchcock DB, Guinn CH, Vaadi KK, Puryear MP, Royer JA, McIver KL, Dowda M, Pate RR, Wilson DK. A validation study concerning the effects of interview content, retention interval, and grade on children's recall accuracy for dietary and/or physical activity. *J Acad Nutr Diet*. 2014; 114(12):1902–1914. [PubMed: 24767807]
24. Baxter SD, Royer JA, Hardin JW, Guinn CH, Smith AF. Fourth-grade children are less accurate in reporting school breakfast than school lunch during 24-hour dietary recalls. *J Nutr Educ Behav*. 2007; 39(3):126–133. [PubMed: 17493562]
25. Baxter SD, Smith AF, Litaker MS, Guinn CH, Nichols MN, Miller PH, Kipp K. Body mass index, sex, interview protocol, and children's accuracy for reporting kilocalories observed eaten at school meals. *J Am Diet Assoc*. 2006; 106(10):1656–1662. [PubMed: 17000199]
26. Baxter SD, Hitchcock DB, Guinn CH, Royer JA, Wilson DK, Pate RR, McIver KL, Dowda M. A pilot study of the effects of interview content, retention interval, and grade on accuracy of dietary information from children. *J Nutr Educ Behav*. 2013; 45(4):368–373. [PubMed: 23562487]
27. Baxter SD, Smith AF, Guinn CH, Hitchcock DB, Puryear MP, Vaadi KK, Finney CJ. Retention interval and prompts: Creation and cross-sectional pilot-testing of eight interview protocols to obtain 24-hour dietary recalls from fourth-grade children. *J Acad Nutr Diet*. 2015; 15(8):1291–1298.
28. Baglio ML, Baxter SD, Guinn CH, Thompson WO, Shaffer NM, Frye FHA. Assessment of interobserver reliability in nutrition studies that use direct observation of school meals. *J Am Diet Assoc*. 2004; 104(9):1385–1393. [PubMed: 15354155]
29. Baranowski T, Dworkin R, Henske JC, Clearman DR, Dunn JK, Nader PR, Hooks PC. The accuracy of children's self-reports of diet: Family Health Project. *J Am Diet Assoc*. 1986; 86(10):1381–1385. [PubMed: 3760429]
30. Simons-Morton BG, Baranowski T. Observation in assessment of children's dietary practices. *J Sch Health*. 1991; 61(5):204–207. [PubMed: 1943043]
31. Shaffer NM, Baxter SD, Thompson WO, Baglio ML, Guinn CH, Frye FHA. Quality control for interviews to obtain dietary recalls from children for research studies. *J Am Diet Assoc*. 2004; 104(10):1577–1585. [PubMed: 15389417]
32. NDS-R. Minneapolis, MN: Nutrition Coordinating Center; 2014. Version 2014
33. Baranowski T, Islam N, Baranowski J, Cullen KW, Myres D, Marsh T, de Moor C. The Food Intake Recording Software System is valid among fourth-grade children. *J Am Diet Assoc*. 2002; 102(3):380–385. [PubMed: 11902371]
34. Baxter SD, Thompson WO, Davis HC. Prompting methods affect the accuracy of children's school lunch recalls. *J Am Diet Assoc*. 2000; 100(8):911–918. [PubMed: 10955049]
35. Paxton A, Baxter SD, Fleming P, Ammerman A. Validation of the School Lunch Recall questionnaire to capture school lunch intake of third- to fifth-grade students. *J Am Diet Assoc*. 2011; 111(3):419–424. [PubMed: 21338742]
36. Smith, AF. Cognitive Processes in Long-term Dietary Recall. Hyattsville, MD: National Center for Health Statistics, Vital and Health Statistics; 1991. Series 6 https://www.cdc.gov/nchs/data/series/sr_06/sr06_004.pdf [Accessed July 25, 2016]
37. Smith AF, Jobe JB, Mingay DJ. Retrieval from memory of dietary information. *Appl Cognit Psychol*. 1991; 5(3):269–296.
38. Warren JM, Henry CJK, Livingstone MBE, Lightowler HJ, Bradshaw SM, Perwaiz S. How well do children aged 5–7 years recall food eaten at school lunch? *Public Health Nutr*. 2003; 6(1):41–47. [PubMed: 12581464]
39. SAS/STAT®. Cary, NC: SAS Institute Inc; 2002–12. Version 9.4©

40. Kutner, MH.; Neter, J.; Nachtsheim, CJ.; Li, W. Applied Linear Statistical Models. 5. Boston: McGraw-Hill/Irwin; 2004.
41. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc Series B (Methodol)*. 1995; 57(1):289–300.
42. Diep CS, Hingle M, Chen TZ, Dadabhoy HR, Beltran A, Baranowski J, Subar AF, Baranowski T. The Automated Self-Administered 24-Hour Dietary Recall for Children, 2012 version, for youth aged 9 to 11 years: A validation study. *J Acad Nutr Diet*. 2015; 115(10):1591–1598. [PubMed: 25887784]
43. Weber JL, Cunningham-Sabo L, Skipper B, Lytle L, Stevens J, Gittelsohn J, Anliker J, Heller K, Pablo JL. Portion-size estimation training in second- and third-grade American Indian children. *Am J Clin Nutr*. 1999; 69(Suppl):782S–787S. [PubMed: 10195603]
44. Baranowski T, Baranowski JC, Watson KB, Martin S, Beltran A, Islam N, Dadabhoy H, Adame SH, Cullen K, Thompson D, Buday R, Subar A. Children's accuracy of portion size estimation using digital food images: effects of interface design and size of image on computer screen. *Public Health Nutr*. 2011; 14(3):418–425. [PubMed: 21073772]

Practice Implications

What is the current knowledge on this topic?

Children have difficulty accurately reporting amounts eaten. The few validation studies that have directly assessed reporting accuracy for amounts eaten have provided results in a variety of ways.

How does this research add to knowledge on this topic?

Child interviews to obtain a 24-hour recall under various conditions result in substantial errors for reporting amounts eaten with larger inaccuracies for incorrect items (omissions and intrusions) and a long retention interval.

How might this knowledge impact current dietetics practice?

Enhance reporting accuracy for amounts eaten by increasing reports of correct items (to yield more matches with fewer intrusions and omissions) and obtaining dietary recalls with a short instead of long retention interval.

Table 1

Numbers of matches (panel A) for each combination of observed and reported amounts eaten in servings, omissions (panel B) for each amount observed eaten in servings, and intrusions (panel C) for each amount reported eaten in servings, over children and school meals (breakfast and lunch) for 455 fourth-grade children

Panel A. Matches ^a		Amount reported eaten (in servings)						
		0.10	0.25	0.50	0.75	1.0	>1 ^b	Total
Amount observed eaten (in servings)		----- number of matches -----						
0.10		14	19	19	3	11	0	66
0.25		5	60	33	25	12	3	138
0.50		2	19	108	38	48	2	217
0.75		3	43	100	76	131	4	357
1.0		6	71	148	135	693	12	1,065
>1 ^b		2	6	16	7	32	48	111
Total		32	218	424	284	927	69	1,954

Panel B. Omissions ^c		Item unreported, so no amount reported						
		----- number of omissions -----						
Amount observed eaten (in servings)								
0.10		106						
0.25		138						
0.50		173						
0.75		275						
1.0		833						
>1 ^b		82						
Total		1,607						

Panel C. Intrusions ^d		Amount reported eaten (in servings)						
		0.10	0.25	0.50	0.75	1.0	>1 ^b	Total
Item unobserved, so no amount observed		----- number of intrusions -----						
		10	94	210	104	244	5	667

^a A match was an item observed eaten and reported eaten.

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For each panel in Table 1, all observed amounts > 1 serving and/or all reported amounts > 1 serving were categorized as > 1 serving. Thus, in Panel A, numbers on the diagonal for corresponding matches (for which the servings of observed and reported amounts eaten were equivalent) do not sum to 970, numbers above the diagonal for over-reported matches do not sum to 376, and numbers below the diagonal for under-reported matches do not sum to 608.

^c An omission was an item observed eaten but not reported eaten.

^d An intrusion was an item reported eaten but not observed eaten.

Table 2

Results for the reporting-error-sensitive approach to assess reporting accuracy for amounts eaten by amount category, meal, retention interval, prompt, sex, and race/ethnicity for 455 fourth-grade children

	Kilocalorie inaccuracy (in kcal per item)		
	Least squares mean	Standard error	P value
Amount category ^a			<0.001
Intrusion	66	3	
Omission	81	2	
Over-reported match	40	3	
Under-reported match	49	3	
Meal			0.01
Breakfast	63	2	
Lunch	55	2	
Retention interval ^b			0.003
Short	55	2	
Long	63	2	
Prompt ^c			0.47
Forward	61	2	
Meal-name	57	2	
Open	60	2	
Reverse	58	2	
Sex			0.004
Boys	62	2	
Girls	56	2	
Race and ethnicity ^d			0.045
non-Hispanic African American	59	2	
non-Hispanic White	64	2	
Hispanic and non-Hispanic other or mixed	54	3	

^aDefinitions for amount categories: For each *intrusion* (an item reported eaten but not observed eaten), the entire amount reported eaten was necessarily over-reported. For each *omission* (an item observed eaten but not reported eaten), the entire amount observed eaten was necessarily under-reported. For each *match* (an item observed eaten and reported eaten), if the amount reported eaten exceeded the amount observed eaten, it did so by an *over*-reported amount. Also, for each *match*, if the amount reported eaten was less than the amount observed eaten, it did so by an *under*-reported amount.

^bRetention interval is the time between the meals to be reported and the dietary recall. For the short retention interval, an afternoon interview concerned the prior-24-hours' intake (i.e., from 24 hours before the interview until the interview began). For the long retention interval, a morning interview concerned the previous-day's intake (i.e., midnight to midnight of the day before the interview).

^cPrompts are questions used to obtain reports of intake during the first pass of a multiple-pass dietary recall procedure. The four prompts were forward (distant to recent), meal-name (breakfast, lunch, etc), open (no instructions), and reverse (recent to distant).

^dFor analyses, due to small numbers, Hispanic children and non-Hispanic children from other or mixed races were combined into one race and ethnicity category.

Table 3

Frequency and mean (SD) kcal inaccuracy (per item) by amount category of the reporting-error-sensitive approach for each of 10 meal components from two school meals (breakfast and lunch) for 455 fourth-grade children

Amount categories of the reporting-error-sensitive approach											
Meal component	Intrusion ^a		Omission ^b		Over-reported match ^c		Corresponding match (perfect) ^d		Under-reported match ^e		Total
	n	kcal inaccuracy mean (SD)	n	kcal inaccuracy mean (SD)	n	kcal inaccuracy mean (SD)	n	kcal inaccuracy mean (SD) ^f	n	kcal inaccuracy mean (SD)	
Beverage	256	65 (33)	337	72 (37)	162	41 (29)	263	0 (–)	179	44 (24)	1,197
Bread	106	93 (52)	300	121 (70)	49	55 (52)	178	0 (–)	101	67 (48)	734
Breakfast meat	36	74 (42)	103	101 (48)	6	56 (33)	52	0 (–)3	23	48 (20)	220
Combination entrée ^g	37	193 (106)	96	223 (92)	21	127 (81)	93	0 (–)3	40	143 (86)	287
Condiment	44	28 (27)	205	30 (27)	45	10 (8)	80	0 (–)3	99	19 (19)	473
Dessert	18	72 (67)	71	69 (43)	3	38 (20)	33	0 (–)3	16	48 (35)	141
Entrée	31	94 (44)	82	123 (68)	12	58 (37)	93	0 (–)3	60	75 (59)	278
Fruit	79	49 (24)	215	52 (29)	31	25 (12)	99	0 (–)3	48	39 (31)	472
Miscellaneous ^h	4	66 (39)	34	54 (55)	3	46 (7)	9	0 (–)3	1	35 (–)	51
Vegetable	56	33 (31)	164	53 (39)	44	27 (41)	70	0 (–)3	41	27 (25)	375
Total	667		1,607		376		970		608		4,228

^aFor each *intrusion* (an item reported eaten but not observed eaten), the entire amount reported eaten was necessarily over-reported.

^bFor each *omission* (an item observed eaten but not reported eaten), the entire amount observed eaten was necessarily under-reported.

^cFor each *match* (an item observed eaten and reported eaten), if the amount reported eaten exceeded the amount observed eaten, it did so by an *over-reported amount*.

^dFor each *match*, the amount by which the amount reported eaten agreed with the amount observed eaten was a *corresponding amount*.

^eFor each *match*, if the amount reported eaten was less than the amount observed eaten, it did so by an *under-reported amount*.

^fThere was zero kcal inaccuracy for the corresponding match amount category for each meal component because for each food item, the amount reported eaten agreed perfectly with the amount observed eaten.

^gExamples of items in the *combination entrée* meal component are pepperoni pizza and spaghetti with meat sauce.

^hItems (e.g., candy, chips) that did not fit into one of the other nine meal components were assigned to the *miscellaneous* meal component.