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Fourth-grade Children's Dietary Recall Accuracy is Influenced by Retention Interval (Target Period and Interview Time)

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Abstract

Background—For a 24-hour dietary recall, two possible target periods are the prior 24 hours (24 hours immediately preceding the interview time) and previous day (midnight to midnight of the day before the interview), and three possible interview times are morning, afternoon, and evening. Target period and interview time determine the retention interval (elapsed time between to-be-reported meals and the interview), which, along with intervening meals, can influence reporting accuracy.

Objective—The effects of target period and interview time on children's accuracy for reporting school meals during 24-hour dietary recalls were investigated.

Design and subjects/setting—During the 2004–05, 2005–06, and 2006–07 school years in (city), (state), each of 374 randomly selected fourth-grade children (96% Black) was observed eating two consecutive school meals (breakfast, lunch) and interviewed to obtain a 24-hour dietary recall

using one of six conditions defined by crossing two target periods with three interview times. Each condition had 62 or 64 children (half boys).

Main outcome measures—Accuracy for reporting school meals was quantified by calculating rates for omissions (food items observed eaten but unreported) and intrusions (food items reported eaten but unobserved); a measure of total inaccuracy combined errors for reporting food items and amounts.

Statistical analyses performed—For each accuracy measure, analysis of variance was conducted with target period, interview time, their interaction, sex, interviewer, and school year in the model.

Results—There was a target-period effect and a target-period by interview-time interaction on omission rates, intrusion rates, and total inaccuracy (six *P* values <0.004). For prior-24-hour recalls compared to previous-day recalls, and for prior-24-hour recalls in the afternoon and evening compared to previous-day recalls in the afternoon and evening, omission rates were better by one-third, intrusion rates were better by one-half, and total inaccuracy was better by one-third.

Conclusions—To enhance children's dietary recall accuracy, target periods and interview times that minimize the retention interval should be chosen.

Keywords

24-hour dietary recall; children; accuracy; validation; school-meal observations

INTRODUCTION

Parents cannot be expected to accurately report their children's intake because parents are not present everywhere children eat meals (e.g., at school). Thus, many studies rely on children's self-reported intake. For example, elementary-school children in upper-grade levels have provided 24-hour dietary recalls (or recalls of intake at school) without parental assistance for national surveys (1,2) and research studies (3,4), to evaluate nutrition interventions (5–9), and to assess the relative validity of food frequency questionnaires (10–12). Recalls do not require that subjects be literate, and the procedure is unlikely to alter intake (13). A single recall provides a poor estimate of a person's intake due to high daily intraindividual variation in intake, but information from one recall per subject often is used to estimate a group's intake (14). Other self-report methods may be less appropriate for children. For example, food frequency questionnaires may require cognitive skills (e.g., averaging consumption) that elementary-school children lack (10,15,16), and the process of completing food records may change eating behaviour (13,17,18). Various studies will undoubtedly continue to rely on elementary-school children in upper-grade levels to provide dietary recalls without parental assistance. Because validation studies have identified errors in children's dietary recalls (4, 19–29), methodological research is needed to identify limitations of the methods used and devise strategies to improve children's recall accuracy.

For a 24-hour dietary recall, two possible *target periods* are the *prior 24 hours* (24 hours immediately preceding the interview time) and the *previous day* (midnight to midnight of the day before the interview); for each of these, the *interview time* might be at any time of day (e.g., morning, afternoon, or evening). Target period and interview time determine the *retention interval* (elapsed time between to-be-reported meal[s] and the interview) which, along with intervening meals between to-be-reported meal(s) and the interview, can influence reporting accuracy. In general, reporting accuracy decreases as the retention interval increases, and as more intervening events occur (30,31). As Figure 1 illustrates, for dietary recalls targeting the prior 24 hours (hereafter referred to as “prior-24-hour recalls”), the end of the target period coincides with the interview start time, and there are no intervening meals. For dietary recalls

targeting the previous day (hereafter referred to as “previous-day recalls”), both the length of the retention interval and number of intervening meals increase as interviews are conducted later in the day. Thus, accuracy should be better for prior-24-hour recalls than previous-day recalls (20). Furthermore, for previous-day recalls, accuracy should decline as interviews are conducted later in the day; for prior-24-hour recalls, accuracy should be better when the interview time is close to the preponderance of that day’s intake (20).

To our knowledge, only one relative validation study with adults and three validation studies with children (all fourth graders) have investigated retention interval and dietary reporting accuracy. In the first study (32), adults kept food records for two or four weeks, and reported their intake for the recordkeeping period either at the end of that period or two, four, or six weeks later. Reporting accuracy deteriorated as the retention interval increased ($P<0.0001$).

In the second study (22), children were observed eating school lunch and interviewed to obtain lunch-only recalls within 90 minutes of eating, the next morning, or three mornings later (on Monday about Friday’s lunch). Analyses of omission rates (percentages of observed food items that were unreported) and intrusion rates (percentages of reported food items that were unobserved) showed that accuracy was better for lunch-only recalls within 90 minutes of eating than the next morning ($P<0.05$), and better the next morning than three mornings later ($P<0.05$). Lunch-only recalls were a limitation of this study because secondary analysis of data from this study and another study found that fourth-grade children’s accuracy for recalling school lunch as a single meal was different than that for recalling school lunch during a 24-hour dietary recall. Specifically, omission rates and intrusion rates for every meal component were worse for the school-lunch parts of 24-hour dietary recalls than for lunch-only recalls (33).

In the third study (20), 60 children were observed eating two school meals (breakfast, lunch) and interviewed to obtain 24-hour dietary recalls using one of six conditions shown in Figure 1. Analyses of omission rates, intrusion rates, and total inaccuracy (a single measure combining errors for reporting food items and amounts) showed that accuracy was better for prior-24-hour recalls than previous-day recalls (P values <0.01). A marginally significant target-period by interview-time interaction was found for omission rate ($P=0.08$), with accuracy best for prior-24-hour recalls in the afternoon and worst for previous-day recalls in the afternoon. For intrusion rate and total inaccuracy, the target-period by interview-time interaction was not significant, probably due to the small sample (10 children per condition).

In the fourth study (34), 20 children of low-body mass index (BMI) ($\geq 5^{\text{th}}$ and $<50^{\text{th}}$ percentiles) and 20 children of high-BMI ($\geq 85^{\text{th}}$ percentile) were observed eating two school meals (breakfast, lunch), and interviewed to obtain prior-24-hour recalls in the evening or previous-day recalls in the morning, with 10 low-BMI and 10 high-BMI children per condition. Analyses of omitted kilocalories (from omissions and under-reported amounts of matches [i.e., observed food items that were reported]) and intruded kilocalories (from intrusions and over-reported amounts of matches) showed that accuracy was marginally better for prior-24-hour recalls in the evening than previous-day recalls in the morning (P values <0.11). The small sample was a limitation of this study.

The current study investigated the effects of target period and interview time on fourth-grade children’s accuracy for reporting school meals during 24-hour dietary recalls. The sample was sufficient for testing the target-period by interview-time interaction, and the study was conducted in a different school district than the second through fourth studies described above. We hypothesized that accuracy would be better for prior-24-hour recalls than previous-day recalls, and for interview times closer to the majority of that day’s intake.

METHODS

Approval was obtained from the appropriate institutional review board for research involving human subjects. Written child assent and parental consent were obtained.

Participants and design

Data were collected during the 2004–05, 2005–06, and 2006–07 school years in 17, 17, and 8 elementary schools, respectively. These schools (out of 28 elementary schools in one district in [city], [state]) were selected based on high participation in school-meal programs. At these schools, for the three respective school years, 84% (range by school: 52 to 96%), 83% (49 to 95%), and 89% (76 to 95%) of children were eligible for free or reduced-price school meals. The district had implemented “*offer-versus-serve*,” so children could refuse some meal items (35).

At the beginning of each school year, researchers visited each regular fourth-grade class to recruit children into the study by distributing assent and consent forms, reading the assent form aloud, and asking and responding to questions. When researchers returned to each class two or three days later, children who had returned forms signed by parents received small prizes (e.g., rulers) regardless of participation decisions. For the 2004–05, 2005–06, and 2006–07 school years, of the 933, 959, and 499 children invited to participate, 687 (74%), 733 (76%), and 360 (72%) agreed; for each school year, the race/sex composition of children who agreed was similar to that of children who were invited.

For each school year, among children who had agreed to participate, those in the upper 2.5% and lower 2.5% of the age distribution as of September 1 were neither observed nor interviewed for data collection. (To help avoid cognitive changes that occur during childhood, this study was limited to fourth graders. Children in the upper 2.5% or lower 2.5% of the age distributions could have either repeated or skipped a grade, respectively.)

From children who had agreed to participate and were within the center 95% of the age distribution, *usual school-meal eaters* were randomly selected with the constraint that half were boys. The usual-eater criterion was satisfied if a child obtained school breakfast and school lunch during (a) at least four of five practice observations at the beginning of the school year and (b) at least four of five previous observations as data collection progressed throughout the school year. Each sampled child was observed eating two consecutive school meals (breakfast, lunch) and interviewed to obtain a 24-hour dietary recall using one of six conditions in Figure 1. Assignment to condition was random with the constraint that data collection continued until each condition in the final sample had 62 or 64 children (half boys). To the extent possible within school year and school, randomization to condition by sex was stratified across classes. The final sample consisted of 374 children (half boys; 96% Black; mean [SD] 10.0 [0.88] years).

Neither school staff nor children knew in advance to which condition children were assigned, or on which days observations and/or interviews would occur. Because more children were recruited than would be interviewed, children could not determine who specifically was being observed at a given meal and/or would be interviewed. An individual child was interviewed once at most, though when recruited, children were told that they might be interviewed zero, one, or two times (so that being interviewed did not indicate to a child [or classmates] that the child would not be interviewed again).

Observations

Observations were conducted on Mondays through Fridays by three, six, and three researchers during the 2004–05, 2005–06, and 2006–07 school years, respectively. Children randomized

to prior-24-hour recalls in the morning were observed eating lunch on one day and breakfast on the next day; for all other children, both meals were observed on the same day. Observations followed a written protocol based on procedures used previously (20,23–25,34,36). For each observation, a researcher observed one to three children simultaneously, noting items and amounts eaten in servings of standardized school-meal portions. Children were observed during regular meal periods while seated according to their school's typical arrangement. Only children who obtained meals at school were observed because it is difficult to unobtrusively identify contents of meals brought from home (37). Entire meal periods were observed to note food trades (26,38–41). Practice observations (at least five per school) at the beginning of each school year helped familiarize children with the presence of observers (41). Observer training included review of the written protocol, modeling, practice, and pre-data-collection interobserver reliability assessment (42).

Throughout data collection, interobserver reliability assessment for each pair of observers utilized established procedures (20,24,25,34,36,42), with each observer involved in at least one assessment per week. For the 2004–05, 2005–06, and 2006–07 school years, respectively, for *breakfast*, interobserver reliability was assessed on 33, 79, and 18 children, and mean agreement between observers to within one-fourth serving on amounts eaten was 98%, 98%, and 100%; for *lunch*, interobserver reliability was assessed on 48, 83, and 18 children, and mean agreement between observers to within one-fourth serving on amounts eaten was 94%, 96%, and 97%. These levels of agreement are satisfactory (41,43).

Interviews

Interviews were conducted on Tuesdays through Fridays by three, three, and two non-observing researchers during the 2004–05, 2005–06, and 2006–07 school years, respectively. Morning and afternoon in-person interviews were conducted in private locations at children's schools after breakfast and lunch, respectively. Evening telephone interviews were conducted between 6:30 p.m. and 9:00 p.m. (A previous validation study (24) found no significant differences between in-person and telephone dietary recalls in fourth-grade children's accuracy.) Interviewers followed written multiple-pass protocols similar to ones used previously (20,34) and modeled on the Nutrition Data System for Research (NDSR) protocol (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN); however, instead of using NDSR software during interviews, interviewers used paper forms to note information reported by children. Because the NDSR protocol concerns the previous-day target period (44), it was adapted for prior-24-hour recalls by asking about the interview day first, and then the previous day. Figure 2 describes the interview protocols. Interviews were audio recorded and transcribed. Each interviewed child was mailed a \$20 check. Interviewer training included review of written protocols, modeling, practice interviews with fourth-grade children (at least one per class each school year), and pre-data-collection assessment of quality control for interviews (45).

Throughout data collection, quality control for interviews was assessed using established procedures (20,24,25,34,36,45). Because this was a methodological dietary-reporting validation study, both the audio recording and typed transcript of each interview were reviewed by an interviewer other than the one who had conducted the interview. The reviewer completed a checklist concerning various aspects of the interview. An experienced interviewer (and co-author) who did not interview for this study, along with the Principal Investigator, provided oversight and decided whether each interview passed or failed quality control. Of 442 interviews conducted, 46 (30 prior-24-hour recalls [12 morning, 6 afternoon, 12 evening]; 16 previous-day recalls [4 morning, 6 afternoon, 6 evening]) failed due to interviewer errors during interviews; these were excluded from further analyses. An additional 22 interviews (13 prior-24-hour recalls [3 morning, 3 afternoon, 7 evening]; 9 previous-day recalls [2 morning,

1 afternoon, 6 evening]) were excluded for other reasons (e.g., interviewer was assigned or used the wrong target-period protocol, observation errors, interview was severely interrupted by uncontrollable circumstances, telephone problems). Because quality control for interviews occurred throughout data collection, as interviews were identified for exclusion from further analyses, data collection continued until the final sample had 62 or 64 children (half boys) per condition.

Analyses

Accuracy was assessed for foods rather than nutrients because people report intake as foods. Also, accuracy was assessed for only the school-meal parts of the 24-hour dietary recalls because only school meals were observed. Meals in children's 24-hour dietary recalls were treated as referring to school meals if children identified *school* as the location, referred to breakfast as *school breakfast* or *breakfast*, referred to lunch as *school lunch* or *lunch*, and reported mealtimes to within one hour of observed mealtimes; these criteria were used previously (20,23–25,34,36). Recalls from 39 (21 boys) of 374 children (10%) failed to meet these criteria for both school breakfast and school lunch (14 prior-24-hour recalls [4 morning, 4 afternoon, 6 evening]; 25 previous-day recalls [14 morning, 8 afternoon, 3 evening]).

There were two sets of food items for each meal. One set contained items observed eaten; the other set contained items reported eaten. Each item observed and/or reported eaten in any non-zero amount at a school meal was weighted by meal component (see Table 1, footnote b) as in other validation studies (20,23–25,36). The weighted number of items observed eaten, and the weighted number of items reported eaten, were summed for each interviewed child's two school meals.

Food items in the observed set and/or reported set were classified as matches, omissions, or intrusions. An item that was in both sets was a *match*. An item that was only in the reported set was an *intrusion*. An item that was only in the observed set was an *omission*. This classification system has been used in previous studies (19–25,27,32–34,36,46–55). Footnote e of Table 1 provides more details and examples.

The weighted matches, omissions, and intrusions for an interviewed child's two school meals were summed, and omission rates and intrusion rates for the child were calculated (see Figure 3, footnotes b and c). For both omission rates and intrusion rates, lower values indicate *better* reporting accuracy.

Accuracy for reporting amounts eaten was assessed using established procedures (20,23–25, 36). Amounts eaten were observed, reported, and scored in servings of standardized school-meal portions (see Table 1, footnote b). For *arithmetic amount difference per match* (see Table 1, footnote f), negative and positive values indicate average under- and over-reporting, respectively; however, a child's under- and over-reported amounts for matches can offset each other, so small averages may disguise large reporting errors balanced over the two directions. *Absolute amount difference per match* (see Table 1, footnote g) indicates the magnitude of error for amounts for matches, but not whether under-or over-reporting occurred. *Amount per omission* and *amount per intrusion* (see Table 1, footnotes h and i) indicate whether these errors involved small or large amounts; omissions necessarily involve under-reporting and intrusions necessarily involve over-reporting.

As in other validation studies (20,21,23–25,36), a single measure of *total inaccuracy* that combined reporting errors for food items and amounts was calculated for each interviewed child (see Figure 3, footnote d); lower values indicate *better* reporting accuracy. This measure does not indicate whether errors are due to omissions, intrusions, or incorrect amounts for matches.

For each of two descriptive measures (weighted number of items observed eaten, weighted number of items reported eaten) and for each of seven accuracy measures (omission rate, intrusion rate, total inaccuracy, arithmetic amount difference per match, absolute amount difference per match, amount per omission, amount per intrusion), an analysis of variance (ANOVA) was conducted with target period, interview time, their interaction, sex, interviewer, and school year in the model. (Race was not in any model because 96% of the children in the final sample were Black.) After fitting a full model, non-significant ($P > 0.05$) terms were removed. Omission and intrusion rates were analyzed separately because although related intrinsically (32,46), they have been found to be empirically independent (22,46).

Analyses used Stata (10.0, Stata, Inc., College Station, TX) and SAS (9.0, SAS Institute, Inc., Cary, NC). A one-sided significance criterion of 0.05 was used when predicted outcomes were directional (i.e., for target period); otherwise, a two-sided significance criterion of 0.05 was used (e.g., for sex and school year). When the target-period by interview-time interaction was significant, means for each of the 15 pairs of six conditions were compared using a Bonferroni-adjusted significance criterion of 0.0033 (0.05/15). For each outcome, our main interest was the target-period effect and the target-period by interview-time interaction.

RESULTS

Table 1 shows, for each target period and condition, information about weighted numbers of items observed eaten and reported eaten. For weighted number of items observed eaten, ANOVA showed no significant effects of target period, interview time, their interaction, or interviewer, but this measure was greater for boys (7.99) than girls (7.63) ($P = 0.029$), and for the second school year (8.07) than the third school year (7.33) ($P = 0.0029$; post hoc contrasts) [data not in Table 1]. For weighted number of items reported eaten, ANOVA showed no significant effects of target period, interview time, their interaction, sex, interviewer, or school year.

Figure 3 shows, for each target period, information about omission rates, intrusion rates, and total inaccuracy. There was a target-period effect on omission rates ($P < 0.0001$), intrusion rates ($P < 0.0001$), and total inaccuracy ($P < 0.0001$). Accuracy was better for prior-24-hour recalls than previous-day recalls.

Figure 3 also shows, for each condition, information about omission rates, intrusion rates, and total inaccuracy. There was a target-period by interview-time interaction on omission rates ($P = 0.001$), intrusion rates ($P < 0.0001$), and total inaccuracy ($P = 0.004$). Omission rates were better for prior-24-hour recalls in the afternoon and evening than previous-day recalls in the morning, afternoon, and evening (six P values < 0.00093). Intrusion rates were better for prior-24-hour recalls in the morning and evening than previous-day recalls in the afternoon and evening; for prior-24-hour recalls in the afternoon than previous-day recalls in the morning, afternoon, and evening; and for previous-day recalls in the morning than previous-day recalls in the afternoon and evening (nine P values < 0.0003). Total inaccuracy was better for prior-24-hour recalls in the morning than previous-day recalls in the afternoon and evening; for prior-24-hour recalls in the afternoon and evening than previous-day recalls in the morning, afternoon, and evening; and for previous-day recalls in the morning than previous-day recalls in the evening (nine P values < 0.0024).

Table 1 shows, for each target period and condition, information about accuracy for reporting amounts. Although ANOVAs yielded no significant effects or interaction for arithmetic or absolute amount differences per match, or for amount per omission, a target-period by interview-time interaction was found for amount per intrusion ($P = 0.023$). As Table 1 shows, mean amounts per intrusion for prior-24-hour recalls were smallest (best) in the evening, but

for previous-day recalls, these mean amounts were smallest in the morning; however, for no pairwise comparison was $P < 0.0033$ (the Bonferroni-adjusted significance criterion).

Seven children (3 boys) had perfect omission rates of 0% and perfect intrusion rates of 0% (5 prior-24-hour recalls [3 afternoon, 2 evening]; 2 previous-day recalls [both morning]). Twenty-five children (6 boys) had the worst possible omission rates of 100% and the worst possible intrusion rates of 100% (4 prior-24-hour recalls [2 morning, 1 afternoon, 1 evening]; 21 previous-day recalls [3 morning, 8 afternoon, 10 evening]). Thus, when the retention interval was shorter (for prior-24-hour recalls compared to previous-day recalls), more recalls had both omission rates and intrusion rates of 0%, and fewer recalls had both omission rates and intrusion rates of 100%; also, fewer recalls failed to meet criteria for meals to be treated as referring to both school meals.

DISCUSSION

These results provide compelling evidence that the retention interval substantially influences children's accuracy for reporting school meals during 24-hour dietary recalls. Specifically, children's accuracy depends systematically on target period—with better accuracy for prior-24-hour recalls than previous-day recalls—and on the target-period by interview-time interaction—with accuracy best for prior-24-hour recalls in the afternoon and evening, and worst for previous-day recalls in the afternoon and evening. Omission rates were better by one-third, intrusion rates were better by one-half, and total inaccuracy was better by one-third for (a) prior-24-hour recalls compared to previous-day recalls, and (b) prior-24-hour recalls in the afternoon and evening compared to previous-day recalls in the afternoon and evening. Similar results for target period were found in the third study described in the Introduction, which had a comparable design but a smaller sample of fourth-grade children from another school district (20).

Two prominent 24-hour dietary recall protocols use the previous-day target period—NDSR (44,56,57) and the US Department of Agriculture's automated multiple-pass method (58,59). These protocols are used to collect recalls throughout the day, so it is likely that recall accuracy deteriorates as interviews are conducted later in the day. Furthermore, it is likely that more accurate recalls could be collected if these protocols used the prior-24-hour target period rather than the previous-day target period.

Concerning accuracy for reporting amounts, this study found that when items were reported correctly, children were fairly accurate in reporting amounts (i.e., averages of -0.065 and 0.26 servings for arithmetic and absolute amount differences per match, respectively). However, when children failed to report items observed eaten, the average amount per omission was almost a full serving (0.85). Furthermore, when children falsely reported items that were not observed eaten, the average amount per intrusion was almost a full serving (0.80). These results, which are similar to those from other validation studies conducted with fourth-grade children in another school district (23–25), suggest that efforts to improve children's accuracy should focus first on reporting food items because when children report matches, the amounts reported eaten are fairly accurate.

Concerning retention interval and accuracy for reporting amounts, this study found a significant effect on amount per intrusion. To our knowledge, only two other validation studies have investigated retention interval and children's accuracy for reporting amounts. For the second study (22), described in the Introduction, the retention-interval effect (i.e., lunch-only recalls within 90 minutes of eating, the next morning, or three mornings later) was not significant for either arithmetic or absolute amount differences per match. (That study did not assess amounts per serving for omissions or intrusions.) In another study (60), 108 children ages 4 to 14 years

were provided with known quantities of a total of 12 foods at several school meals (breakfasts, lunches) and school snacks, and asked to estimate amounts; interviews occurred with the food in view, just after eating, and the next day. Children's ability to estimate food portions (either as served or as eaten) did not depend significantly on retention interval.

One limitation of this study was the homogeneity in children's ages and races/ethnicities. Validation studies are needed to investigate retention interval and dietary recall accuracy in other populations and for other characteristics such as socioeconomic status and BMI. Another limitation was that qualitative terms were converted to quantitative terms for amounts of standardized school-meal servings; however, these processes were applied consistently to observed information and reported information for all six conditions.

This study had several strengths. Direct observation was used as the validation method (instead of comparing children's recalls to information reported by children with another method [e.g., food records] or by parents [who lack first-hand knowledge of children's school-meal intake]). Observations were conducted in a setting and manner that minimized reactivity and enhanced generalizability, because millions of children in the US eat school meals each school day (61). Furthermore, results from a previous study suggest that conclusions about 24-hour dietary recalls by fourth-grade children observed eating school meals in validation studies may be generalized to 24-hour dietary recalls by comparable children not observed in non-validation studies (62). More children were recruited than needed for data collection, and only usual school-meal eaters were observed and interviewed. Quality control for observations and interviews was assessed rigorously and regularly before and throughout data collection.

CONCLUSIONS

These results, which illuminate the importance of retention interval for children's dietary recall accuracy, are applicable to the science and practice of nutrition and dietetics. Although dietary recall accuracy may never be perfect, these results provide compelling evidence that it can be improved significantly by decisions made by investigators and practitioners. Specifically, to enhance children's dietary recall accuracy, target periods and interview times that minimize the retention interval should be chosen—for example, by using prior-24-hour recalls and by conducting interviews in the afternoon or evening so they are on the same day as most meals in the 24-hour period. If recalls must concern the previous-day target period, then accuracy can be improved by conducting interviews in the morning. Furthermore, because of the profound influence of retention interval on dietary recall accuracy, details concerning target period and interview time should be described in publications of studies that utilize dietary recalls.

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References

- Burghardt, J.; Ensor, T.; Hutchinson, G.; Weiss, C.; Spencer, B. Contract No. 53-3198-0-16; MPR Reference No. 7937-140. Princeton, NJ: Princeton, NJ: Mathematica Policy Research, Inc; 1993 [Accessed October 5, 2008]. The School Nutrition Dietary Assessment Study: Data collection and sampling. <http://www.fns.usda.gov/oane/MENU/Published/CNP/FILES/SNDA-Datacol.pdf>
- US Department of Agriculture, Food and Nutrition Service, Office of Research, Nutrition, and Analysis. School Nutrition Dietary Assessment Study-III: Volume II: Student Participation and Dietary Intakes, by A Gordon, et al., Project Officer: P McKinney, Report No. CN-7-SNDA-III. Alexandria, VA: 2007 [Accessed October 5, 2008]. <http://www.fns.usda.gov/oane/menu/Published/CNP/FILES/SNDAlII-Vol2.pdf#xml=http://65.216.150.153/tehis/search/pdfhi.txt?query=SNDA+III&pr=FNS&order=r&cq=&id=48236e0811>
- Moore HJ, Ells LJ, McLure SA, Crooks S, Cumbor D, Summerbell CD, Batterham AM. The development and evaluation of a novel computer program to assess previous-day dietary and physical activity behaviours in school children: The Synchronised Nutrition and Activity ProgramTM (SNAPTM). *Br J Nutr* 2008;99:1266–1274. [PubMed: 18042307]
- Todd KS, Kretsch MJ. Accuracy of the self-reported dietary recall of new immigrant and refugee children. *Nutr Res* 1986;6:1031–1043.
- Perry CL, Bishop DB, Taylor G, Murray DM, Mays RW, Dudovitz BS, Smyth M, Story M. Changing fruit and vegetable consumption among children: The 5-A-Day Power Plus program in St. Paul, Minnesota. *Am J Public Health* 1998;88:603–609. [PubMed: 9551002]
- Lytle LA, Dixon LB, Cunningham-Sabo L, Evans M, Gittelsohn J, Hurley J, Snyder P, Stevens J, Weber J, Anliker J, Keller K, Story M. Dietary intakes of Native American children: Findings from the Pathways Feasibility Study. *J Am Diet Assoc* 2002;102:555–558. [PubMed: 11985417]
- Receveur O, Morou K, Gray-Donald K, Macaulay AC. Consumption of key food items is associated with excess weight among elementary-school-aged children in a Canadian First Nations Community. *J Am Diet Assoc* 2008;108:632–666.
- Luepker RV, Perry CL, McKinlay SM, Nader PR, Parcel GS, Stone EJ, Webber LS, Elder JP, Feldman HA, Johnson CC, Kelder SH, Wu M. Outcomes of a field trial to improve children's dietary patterns and physical activity: The Child and Adolescent Trial for Cardiovascular Health (CATCH). *JAMA* 1996;275:768–776. [PubMed: 8598593]
- Baranowski T, Baranowski J, Cullen KW, Marsh T, Islam N, Zakeri I, Honess-Morreale L, de Moor C. Squire's Quest! Dietary outcome evaluation of a multimedia game. *Am J Prev Med* 2003;24:52–61. [PubMed: 12554024]
- Field AE, Peterson KE, Gortmaker SL, Cheung L, Rockett H, Fox MK, Colditz GA. Reproducibility and validity of a food frequency questionnaire among fourth to seventh grade inner-city school children: Implications of age and day-to-day variation in dietary intake. *Public Health Nutr* 1999;2:293–300. [PubMed: 10512564]
- Rockett HR, Breitenbach M, Frazier AL, Witschi J, Wolf AM, Field AE, Colditz GA. Validation of a youth/adolescent food frequency questionnaire. *Prev Med* 1997;26:808–816. [PubMed: 9388792]
- Wong SS, Boushey CJ, Novotny R, Gustafson DR. Evaluation of a computerized food frequency questionnaire to estimate calcium intake of Asian, Hispanic, and Non-Hispanic white youth. *J Am Diet Assoc* 2008;108:539–543. [PubMed: 18313437]
- Buzzard, M. 24-hour dietary recall and food record methods. In: Willett, W., editor. *Nutritional Epidemiology*. Vol. 2. New York, NY: Oxford University Press; 1998. p. 50-73.
- Willett, WC. *Nutritional Epidemiology*. Vol. 2. New York, NY: Oxford University Press; 1998.
- Baranowski T, Smith M, Baranowski J, Wang DT, Doyle C, Lin LS, Davis Hearn M, Resnicow K. Low validity of a seven-item fruit and vegetable food frequency questionnaire among third-grade students. *J Am Diet Assoc* 1997;97:66–68. [PubMed: 8990421]

16. Domel SB, Baranowski T, Davis HC, Leonard SB, Riley P, Baranowski J. Fruit and vegetable food frequencies by fourth and fifth grade students: Validity and reliability. *J Am Coll Nutr* 1994;13:33–39. [PubMed: 8157851]
17. Rockett HR, Berkey CS, Colditz GA. Evaluation of dietary assessment instruments in adolescents. *Current Opinion in Clinical Nutrition and Metabolic Care* 2003;6:557–562. [PubMed: 12913673]
18. Smith AF. Concerning the suitability of recordkeeping for validating and generalizing about reports of health-related information. *Review of General Psychology* 1999;3:133–150.
19. 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;102:380–385. [PubMed: 11902371]
20. 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;14:385–390. [PubMed: 15246326]
21. Baxter SD, Thompson WO, Davis HC. Prompting methods affect the accuracy of children's school lunch recalls. *J Am Diet Assoc* 2000;100:911–918. [PubMed: 10955049]
22. Baxter SD, Thompson WO, Davis HC, Johnson MH. Impact of gender, ethnicity, meal component, and time interval between eating and reporting on accuracy of fourth-graders' self-reports of school lunch. *J Am Diet Assoc* 1997;97:1293–1298. [PubMed: 9366868]
23. 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;102:386–395. [PubMed: 11905461]
24. 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;35:124–134. [PubMed: 12773283]
25. 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;36:601–614. [PubMed: 12689806]
26. 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;94:626–630. [PubMed: 8195550]
27. Domel SB, Thompson WO, Baranowski T, Smith AF. How children remember what they have eaten. *J Am Diet Assoc* 1994;94:1267–1272. [PubMed: 7963170]
28. Emmons L, Hayes M. Accuracy of 24-hr. recalls of young children. *J Am Diet Assoc* 1973;62:409–415. [PubMed: 4691953]
29. 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;27:749–751. [PubMed: 14880399]
30. Crowder, RG. The Interference Theory of Forgetting in Long-Term Memory (Chapter 8, pgs 217–263) in *Principles of Learning and Memory*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1976.
31. Jobe JB, Tourangeau R, Smith AF. Contributions of survey research to the understanding of memory. *Appl Cognit Psychol* 1993;7:567–584.
32. Smith AF, Jobe JB, Mingay DJ. Retrieval from memory of dietary information. *Appl Cognit Psychol* 1991;5:269–296.
33. Baxter SD, Thompson WO. Accuracy by meal component of fourth-graders' school lunch recalls is less when obtained during a 24-hour recall than as a single meal. *Nutr Res* 2002;22:679–684.
34. 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;106:1656–1662. [PubMed: 17000199]
35. US Department of Agriculture, Food and Nutrition Service. Road to SMI Success - A Guide for School Foodservice Directors. 2007 [Accessed October 5, 2008]. Available at: <http://www.fns.usda.gov/tn/Resources/roadtosuccess.html>
36. Baxter SD, Smith AF, Guinn CH, Thompson WO, Litaker MS, Baglio ML, Shaffer NM, Frye FHA. Interview format influences the accuracy of children's dietary recalls validated with observations. *Nutr Res* 2003;23:1537–1546. [PubMed: 16724161]

37. Simons-Morton BG, Forthofer R, Huang IW, Baranowski T, Reed DB, Fleishman R. Reliability of direct observation of schoolchildren's consumption of bag lunches. *J Am Diet Assoc* 1992;92:219–221. [PubMed: 1737906]
38. Baxter SD, Thompson WO, Davis HC. Trading of food during school lunch by first- and fourth-grade children. *Nutr Res* 2001;21:499–503.
39. Domel SB, Baranowski T, Leonard SB, Davis H, Riley P, Baranowski J. Accuracy of fourth- and fifth-grade students' food records compared with school-lunch observations. *Am J Clin Nutr* 1994;59 (Suppl):218S–220S. [PubMed: 8279428]
40. Reger C, O'Neil CE, Nicklas TA, Myers L, Berenson GS. Plate waste of school lunches served to children in a low-socioeconomic elementary school in south Louisiana. *Sch Food Service Res Rev* 1996;20(Suppl):13–19.
41. Simons-Morton BG, Baranowski T. Observation in assessment of children's dietary practices. *J Sch Health* 1991;61:204–207. [PubMed: 1943043]
42. 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;104:1385–1393. [PubMed: 15354155]
43. 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;86:1381–1385. [PubMed: 3760429]
44. Regents of the University of Minnesota. NDSR Nutrition Data System for Research 2007. Minneapolis, MN:
45. 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;104:1577–1585. [PubMed: 15389417]
46. Smith, AF. Cognitive Processes in Long-term Dietary Recall. Vol. 4. Hyattsville, MD: National Center for Health Statistics, Vital and Health Statistics, Series 6; 1991. Series 6, No. 4
47. 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;6:41–47. [PubMed: 12581464]
48. Baxter SD, Smith AF, Nichols MN, Guinn CH, Hardin JW. Children's dietary reporting accuracy over multiple 24-hour recalls varies by body mass index category. *Nutr Res* 2006;26:241–248. [PubMed: 17541449]
49. 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;39:126–133. [PubMed: 17493562]
50. 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;107:595–604. [PubMed: 17383265]
51. 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;44:34–41. [PubMed: 16959308]
52. Baxter SD, Thompson WO, Davis HC. Accuracy of children's school lunch recalls according to how they remembered what they ate. *Top Clin Nutr* 1998;14:58–66.
53. Baxter SD, Thompson WO, Davis HC, Johnson MH. "How do you remember you ate ____?": A Delphi technique study to identify retrieval categories from fourth-grade children. *J Am Diet Assoc* 1997;97:31–36. [PubMed: 8990414]
54. Baxter SD, Thompson WO, Davis HC, Litaker MS. Children's dietary recalls: The salience of entree and liking for foods on accuracy and order of reporting. *Nutrition* 1999;15:848–853. [PubMed: 10575659]
55. 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;10:1247–1256. [PubMed: 17381899]

56. Dennis B, Ernst N, Hjortland M, Tillotson J, Grambsch V. The NHLBI Nutrition Data System. *J Am Diet Assoc* 1980;77:641–647. [PubMed: 6893713]
57. NDSR Nutrition Data System for Research. Nutrition Coordinating Center - Mission and History. [Accessed October 5, 2008]. Available at: <http://www.ncc.umn.edu/about/missionandhistory.html>
58. Dwyer J, Picciano MF, Raiten DJ. Future Directions for What We Eat in America--NHANES: The Integrated CSFII-NHANES. *J Nutr* 2003;133(Suppl):576S–581S. [PubMed: 12566506]
59. US Department of Agriculture, Agricultural Research Center. USDA Automated Multiple-Pass Method. [Accessed October 5, 2008]. Available at: <http://www.ars.usda.gov/Services/docs.htm?docid=7710>
60. 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;99:185–190. [PubMed: 17651522]
61. US Department of Agriculture, Economic Research Service. The Food Assistance Landscape, FY 2007 Annual Report. Economic Information Bulletin No. 6-5. 2008 [Accessed October 5, 2008]. Available at: <http://www.ers.usda.gov/Publications/EIB6-5>
62. Smith AF, Baxter SD, Hardin JW, Guinn CH, Royer JA, Litaker MS. Validation-study conclusions from dietary reports by fourth-grade children observed eating school meals are generalisable to dietary reports by comparable children not observed. *Public Health Nutr* 2007;10:1057–1066. [PubMed: 17381934]

Condition	Target Period	Interview Time	midnight	6 a.m.	noon	6 p.m.	midnight	6 a.m.	noon	6 p.m.
1	Prior 24 hours	Morning	——— L ——— D ———— B – Int							
2	Prior 24 hours	Afternoon	——— D ———— B ——— L – Int							
3	Prior 24 hours	Evening	——— B ——— L ——— D – Int							
4	Previous day	Morning	——— B ——— L ——— D ———	xB Int						
5	Previous day	Afternoon	——— B ——— L ——— D ———	xB		xL		Int		
6	Previous day	Evening	——— B ——— L ——— D ———	xB		xL		xD		Int

Figure 1. Illustration of intake covered in a 24-hour dietary recall using each of six conditions defined by crossing two target periods with three interview times

The *prior-24-hour target period* consists of the 24 hours immediately preceding the interview time. The *previous-day target period* is midnight to midnight of the day before the interview. In this figure:

the solid line inside cells indicates intake to be covered in that 24-hour dietary recall,
 “B” indicates when a breakfast that is to be reported eaten in the 24-hour dietary recall is eaten,
 “L” indicates when a lunch that is to be reported eaten in the 24-hour dietary recall is eaten,
 “D” indicates when a dinner that is to be reported eaten in the 24-hour dietary recall is eaten,
 “xB” indicates when an intervening breakfast occurs between the to-be-reported breakfast and the interview,
 “xL” indicates when an intervening lunch occurs between the to-be-reported lunch and the interview,
 “xD” indicates when an intervening dinner occurs between the to-be-reported dinner and the interview, and
 “Int” indicates when an interview to obtain a 24-hour dietary recall is conducted.

Pass	Description
Prior-24-hour target period adaptation (20,34)	
1 st pass	<p>Quick list: <i>“Let’s start by talking about what you ate or drank today. After you got up this morning, what was the first time you had something to eat or drink? What did you eat or drink at that time? Did you eat or drink anything else at that time? What was the next time today that you had something to eat or drink? What did you eat or drink at that time? Did you eat or drink anything else at that time?”</i> The interviewer repeated this process to cover today’s intake in chronological order. <i>“Now that we have talked about what you ate or drank today, let’s talk about what you ate or drank yesterday. Let’s start with this time yesterday. After (interview start time) yesterday, what was the first time you had something to eat or drink? What did you eat or drink at that time? Did you eat or drink anything else at that time? What was the next time yesterday that you had something to eat or drink? What did you eat or drink at that time? Did you eat or drink anything else at that time?”</i> The interviewer repeated this process to cover yesterday’s intake in chronological order until the child indicated s/he went to bed and got up this morning to complete the prior-24-hour period. Then, the child was asked <i>“Can you remember any other times since (interview start time) yesterday through right now that you had something to eat or drink?”</i></p>

2 nd pass	Review: The interviewer reviewed by repeating back everything the child reported at each time, and asking “ <i>Can you think of anything else you ate at that time?</i> ” and “ <i>Can you think of anything else you drank at that time?</i> ” The interviewer began with the earliest time today and repeated this process in chronological order to review today’s intake, and then reviewed yesterday’s intake in chronological order to complete the prior-24-hour period.
3 rd pass	Details: The interviewer asked the child to name each eating occasion (response options: school breakfast, breakfast, school lunch, lunch, dinner, supper, snack), identify the location of each meal (response options: home, school, somewhere else), provide details about each item, indicate additions to items, and indicate amounts consumed for each item. The interviewer began with the earliest time today and continued in chronological order until the time the interview started, and then reviewed yesterday’s intake in chronological order to complete the prior-24-hour period.
4 th pass	Final review: Each eating occasion was reviewed with the child for correctness. The interviewer began with the earliest time today and repeated this process in chronological order until the time the interview started before reviewing yesterday’s intake in chronological order to complete the prior-24-hour period. Then, the child was asked one final time “ <i>Can you remember any other times since (interview start time) yesterday through right now that you had something to eat or drink?</i> ”
Previous-day target period (44)	

1 st pass	Quick list: <i>"We'll be talking about what you ate or drank yesterday. After you got up yesterday morning, what was the first time you had something to eat or drink? What did you eat or drink at that time? Did you eat or drink anything else at that time? What was the next time yesterday that you had something to eat or drink? What did you eat or drink...?"</i> The interviewer repeated this process to cover yesterday's intake in chronological order. Then, the child was asked <i>"Can you remember any other times yesterday that you had something to eat or drink?"</i>
2 nd pass	Review: The interviewer repeated back everything the child reported at each time, and asked <i>"Can you think of anything else you ate at that time?"</i> and <i>"Can you think of anything else you drank at that time?"</i> (The interviewer repeated this process for yesterday's intake in chronological order.)
3 rd pass	Details: The interviewer asked the child to name each eating occasion (response options: school breakfast, breakfast, school lunch, lunch, dinner, supper, snack), identify the location of each meal (response options: home, school, somewhere else), provide details about each item, indicate additions to items, and indicate amounts consumed for each item. The interviewer began with the earliest time yesterday morning and continued in chronological order to cover yesterday's intake.
4 th pass	Final review: Each eating occasion was reviewed with the child for correctness. The interviewer began with the earliest time yesterday morning and repeated this process in chronological order to cover yesterday's intake. Then, the child was asked one final time <i>"Can you remember any other times yesterday that you had something to eat or drink?"</i>

Figure 2.

Multiple-pass interview protocols patterned after the Nutrition Data System for Research (44) and used to obtain 24-hour dietary recalls from fourth-grade children during the 2004–05, 2005–06, and 2006–07 school years in (city), (state)

Omission Rates (in %)

Intrusion Rates (in %)

Figure 3. Information, by two target periods and six conditions,^a about omission rates,^b intrusion rates,^c and total inaccuracy^d for the school-meal (breakfast and lunch) parts of fourth-grade children's 24-hour dietary recalls validated with school-meal observations during the 2004–05, 2005–06, and 2006–07 school years in (city), (state)

^a The six conditions created by crossing two target periods (prior 24 hours, previous day) with three interview times (morning, afternoon, evening) are defined and illustrated in Figure 1. Each section of this figure shows the mean and standard deviation above the bar for each target period and each condition; each sample size is shown in parentheses below the label for each bar. Accuracy was assessed for only the school-meal parts of 24-hour dietary recalls because only school meals were observed. Each item observed eaten and/or reported eaten at a school meal was weighted by meal component (see Table 1, footnote b) and scored as a match, omission, or intrusion (see Table 1, footnote e).

^b Omission rate is the percentage of items observed eaten that was not reported eaten. For an interviewed child, omission rate = (sum of weighted omissions/[sum of weighted omissions + sum of weighted matches]) × 100%. Values may range from 0% (indicating no omissions) to 100% (indicating that no items observed eaten were reported eaten). *Lower* omission rates indicate *better* reporting accuracy. Fifteen children (6 boys) had perfect omission rates of 0% (12 prior-24-hour recalls [1 morning, 4 afternoon, 7 evening]; 3 previous-day recalls [all morning]). Analysis of variance (ANOVA) showed an effect of target period on omission rates ($P < 0.0001$), which were better for prior-24-hour recalls than previous-day recalls. Also, ANOVA showed a target-period by interview-time interaction on omission rates ($P = 0.001$); pairwise comparisons showed that omission rates were better for prior-24-hour recalls in the afternoon and evening than previous-day recalls in the morning, afternoon, and evening (six P values < 0.00093).

^c Intrusion rate is the percentage of items reported eaten that was not observed eaten. For an interviewed child, intrusion rate = (sum of weighted intrusions/[sum of weighted intrusions + sum of weighted matches]) × 100%. Values were undefined for 39 children (21 boys) whose recalls failed to meet criteria for both school breakfast and school lunch (see Table 1, footnote b). Defined values for intrusion rate may range from 0% (indicating no intrusions) to 100% (indicating that no items reported eaten were observed eaten). *Lower* intrusion rates indicate *better* reporting accuracy. Forty-two children (23 boys) had perfect intrusion rates of 0% (33

prior-24-hour recalls [8 morning, 15 afternoon, 10 evening]; 9 previous-day recalls [3 morning, 2 afternoon, 4 evening]). ANOVA showed an effect of target period on intrusion rates ($P<0.0001$), which were better for prior-24-hour recalls than previous-day recalls. Also, ANOVA showed a target-period by interview-time interaction on intrusion rates ($P<0.0001$); pairwise comparisons showed that intrusion rates were better for prior-24-hour recalls in the morning and evening than previous-day recalls in the afternoon and evening; for prior-24-hour recalls in the afternoon than previous-day recalls in the morning, afternoon, and evening; and for previous-day recalls in the morning than previous-day recalls in the afternoon and evening (nine P values <0.0003).

^d Total inaccuracy, for an interviewed child, was the sum of three components: a) the sum, over matches, of the absolute difference between amounts observed eaten and reported eaten for each match times the weight; b) the sum, over intrusions, of each intruded amount times the weight; and c) the sum, over omissions, of each omitted amount times the weight. This single measure cumulates errors (in servings) for all food items whether they are matches, omissions, or intrusions. It provides a composite score for both food items and amounts, but does not indicate whether errors are due to omissions, intrusions, or incorrect amounts for matches. *Lower* total inaccuracy values indicate *better* reporting accuracy. ANOVA showed an effect of target period on total inaccuracy ($P<0.0001$) which was better for prior-24-hour recalls than previous-day recalls. Also, ANOVA showed a target-period by interview-time interaction on total inaccuracy ($P=0.004$); pairwise comparisons showed that total inaccuracy was better for prior-24-hour recalls in the morning than previous-day recalls in the afternoon and evening; for prior-24-hour recalls in the afternoon and evening than previous-day recalls in the morning, afternoon, and evening; and for previous-day recalls in the morning than previous-day recalls in the evening (nine P values <0.0024).

Table 1
Information about two descriptive measures and four accuracy measures for amounts, by two target periods and six conditions, ^a for the school-meal (breakfast and lunch) parts of fourth-grade children's 24-hour dietary recalls validated with school-meal observations during the 2004–05, 2005–06, and 2006–07 school years in (city), (state)

	Prior-24-Hour Target Period			Previous-Day Target Period				
	overall	morning	afternoon	evening	overall	morning	afternoon	evening
	----- Mean -----							
	----- (Standard Deviation) -----							
	----- number of children -----							
Weighted number of items observed eaten ^{b, c}	7.87	7.81	7.98	7.82	7.75	8.03	7.56	7.66
	(1.68)	(1.56)	(1.63)	(1.86)	(1.64)	(1.65)	(1.73)	(1.52)
	186	62	62	62	188	62	62	64
Weighted number of items reported eaten ^{b, d}	5.90	5.26	6.05	6.40	5.88	5.65	5.48	6.48
	(2.86)	(2.82)	(2.82)	(2.87)	(3.16)	(3.67)	(2.85)	(2.85)
	186	62	62	62	188	62	62	64
Arithmetic amount difference per match ^{b, e, f}	-0.06	-0.05	-0.07	-0.05	-0.07	-0.10	-0.08	-0.03
	(0.30)	(0.31)	(0.22)	(0.35)	(0.32)	(0.25)	(0.37)	(0.33)
	168	56	57	55	142	45	46	51
Absolute amount difference per match ^{b, e, g}	0.24	0.25	0.22	0.26	0.28	0.25	0.29	0.30
	(0.24)	(0.24)	(0.18)	(0.28)	(0.24)	(0.21)	(0.29)	(0.21)
	168	56	57	55	142	45	46	51
Amount per omission ^{b, h}	0.85	0.84	0.89	0.83	0.86	0.89	0.87	0.83

	Prior-24-Hour Target Period			Previous-Day Target Period				
	overall	morning	afternoon	evening	overall	morning	afternoon	evening
				Mean				
				(Standard Deviation)				
				number of children				
Amount per intrusion $b_{e,i}$	(0.27)	(0.22)	(0.30)	(0.28)	(0.23)	(0.27)	(0.18)	(0.24)
	174	61	58	55	185	59	62	64
	0.81	0.85	0.83	0.75	0.79	0.73	0.82	0.83
	(0.27)	(0.23)	(0.26)	(0.30)	(0.26)	(0.28)	(0.32)	(0.16)
	139	50	43	46	154	45	52	57

^aThe six conditions from crossing two target periods (prior 24 hours, previous day) with three interview times (morning, afternoon, evening) are defined and illustrated in Figure 1.

^b Accuracy was assessed for only the school-meal parts of 24-hour dietary recalls because only school meals were observed. Meals in children's 24-hour dietary recalls were treated as referring to school meals if children identified *school* as the location, referred to breakfast as *school breakfast* or *breakfast*, referred to lunch as *school lunch* or *lunch*, and reported mealtimes to within one hour of observed mealtimes. Recalls from 39 (21 boys) of 374 children (10%) failed to meet these criteria for both school breakfast and school lunch (14 prior-24-hour recalls [4 morning, 4 afternoon, 6 evening]; 25 previous-day recalls [14 morning, 8 afternoon, 3 evening]). For food items observed eaten and/or reported eaten at school meals, a weight was assigned to each item according to meal component (beverage, bread/grain, breakfast meat, combination entrée, condiment, dessert, fruit, miscellaneous, vegetable) with combination entrée (e.g., hamburger on bun)=2, condiment (e.g., mustard, jelly)=0.33, and remaining meal components=1, so that errors for combination entrées counted more than errors for condiments and remaining meal components. Amounts eaten were observed, reported, and scored in servings of standardized school-meal portions as none=0.00, taste=0.1, little bit=0.25, half=0.50, most=0.75, all=1.00, and the actual number of servings if more than one serving was observed and/or reported eaten.

^cWeighted number of items observed eaten: For an interviewed child, this variable is the sum of the weighted numbers of items observed eaten in any non-zero amount. Analysis of variance (ANOVA) showed no significant effects of target period, interview time, their interaction, or interviewer. However, the weighted number of items observed eaten was greater for boys (7.99) than girls (7.63) ($P=0.0029$), and greater for the second school year (8.07) than the third school year (7.33) ($P=0.0029$; post hoc contrasts) [data not in this table].

d Weighted number of items reported eaten: For an interviewed child, this variable is the sum of the weighted numbers of items reported eaten in any non-zero amount. ANOVA showed no significant effects of target period, interview time, their interaction, sex, interviewer, or school year.

² There were two sets of food items for each meal. One set contained items observed eaten; the other set contained items reported eaten. An item that was in both sets was a *match*. An item that was only in the reported set was an *intrusion*. An item that was only in the observed set was an *omission*. Because children can report food items many ways, food items were scored as matches unless it was clear that the child's recall did not describe an observed food item. For example, *matches* included all types of pizza (e.g., cheese pizza observed, pepperoni pizza reported) and all types of white milk (e.g., whole milk observed, 1% milk reported). Juices, milk flavors, and vegetables that differed were not matched. For example, apple juice observed did not match orange juice reported, white milk observed did not match chocolate milk reported, and broccoli observed did not match green beans reported. Items for which a child could not provide any defining details (e.g., flavor, color) were not matched.

f Arithmetic amount difference per match: For an interviewed child, this variable = $\{\text{sum (amount reported - amount observed for each match)} \times \text{weight}\} / (\text{weighted number of matches})$. Values were undefined for 39 children (21 boys) whose recalls failed to meet criteria for school breakfast and school lunch (see footnote b) plus 25 children (6 boys) who had zero matches and thus the worst possible omission rates (defined in Figure 3, footnote b) of 100% and the worst possible intrusion rates (defined in Figure 3, footnote c) of 100% (4 prior-24-hour recalls [2 morning, 1 afternoon, 1 evening]; 21 previous-day recalls [3 morning, 8 afternoon, 10 evening]). For defined values, average under- and over-reporting are indicated by negative and positive values, respectively. Also, defined values close

to zero are interpreted as indicating better accuracy; however, a child's under- and over-reported amounts for matches can offset each other, so small averages may disguise large reporting errors balanced over the two directions. ANOVA yielded no significant effects for arithmetic amount difference per match.

^g Absolute amount difference per match: For an interviewed child, this variable = $\{ \text{sum} [(\text{absolute difference between amounts reported and observed for each match}) \times \text{weight}] / (\text{weighted number of matches}) \}$. Values were undefined for 39 children (21 boys) whose recalls failed to meet criteria for school breakfast and school lunch (see footnote b) plus 25 children (6 boys) who had zero matches (see footnote f). Defined values close to zero indicate better accuracy. This measure indicates the magnitude of error for amounts for matches, but not whether under- or over-reporting occurred. ANOVA yielded no significant effects for absolute amount difference per match.

^h Amount per omission: For an interviewed child, this variable = $\{ \text{sum} [(\text{amount observed but not reported for each omission}) \times \text{weight}] / (\text{weighted number of omissions}) \}$. Values were undefined for 15 children (6 boys) who had zero omissions and thus perfect omission rates of 0% (see Figure 3, footnote b). Defined values close to zero indicate that smaller amounts were unreported for omissions. ANOVA yielded no significant effects for amount per omission.

ⁱ Amount per intrusion: For an interviewed child, this variable = $\{ \text{sum} [(\text{amount not observed but reported for each intrusion}) \times \text{weight}] / (\text{weighted number of intrusions}) \}$. Values were undefined for 39 children (21 boys) whose recalls failed to meet criteria for school breakfast and school lunch (see footnote b) plus 42 children (23 boys) who had zero intrusions and thus perfect intrusion rates of 0% (see Figure 3, footnote c). Defined values close to zero indicate that smaller amounts were reported for intrusions. ANOVA showed a target-period by interview-time interaction for amount per intrusion ($P=0.023$). For prior-24-hour recalls, mean amounts per intrusion were smallest (best) in the evening, but for previous-day recalls, these mean amounts were smallest in the morning; however, for no pairwise comparison was $P<0.0033$ (the Bonferroni-adjusted significance criterion).