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Fourth-grade children's dietary reporting accuracy by meal component: Results from a validation study that manipulated retention interval and prompts

Suzanne D. Baxter, PhD, RD, LD, FADA, FAND^{a,*} [Former Research Professor], David B. Hitchcock, PhD^b [Associate Professor], Julie A. Royer, MSPH^a [Former Statistician], Albert F. Smith, PhD, MS^c [Associate Professor], and Caroline H. Guinn, RD, LD^a [Former Research Dietitian]

^bDepartment of Statistics, University of South Carolina, Columbia, SC, 29208 USA

^cDepartment of Psychology, Cleveland State University, Cleveland, OH, 44114 USA

Abstract

We examined reporting accuracy by meal component (beverage, bread, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, vegetable) with validation-study data on 455 fourth-grade children (mean age = 9.92 ± 0.41 years) observed eating school meals and randomized to one of eight dietary recall conditions (two retention intervals [short, long] crossed with four prompts [forward, meal-name, open, reverse]). Accuracy category (match [observed and reported], omission [observed but unreported], intrusion [unobserved but reported]) was a polytomous nominal item response variable. We fit a multilevel cumulative logit model with item variables meal component and serving period (breakfast, lunch) and child variables retention interval, prompt and sex. Significant accuracy category predictors were meal component ($p < 0.0003$), retention interval ($p < 0.0003$), meal-component $\times$ serving-period ($p < 0.0003$) and meal-component $\times$ retention-interval ($p = 0.001$). The relationship of meal component and accuracy

*Corresponding/reprint author: 109 Autumn Oaks Lane, Lexington, SC 29073, phone 803-808-6264.

^aFormerly at: Institute for Families in Society, College of Social Work, University of South Carolina, 1600 Hampton Street, Suite 507, Columbia, SC, 29208 USA. (Note: SD Baxter resigned her fulltime Research Professor position on December 31, 2016 due to a health condition; as CH Guinn and JA Royer were part-time members of her team, their positions ended with Dr. Baxter's resignation. Currently, all three retain email addresses with the University.)

Transparency Declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

Declaration of Interest

The authors have no conflicts of interest.

Authorship

SDB designed the study and obtained funding, coordinated and provided oversight for all aspects of the study, participated in recruitment of schools, and drafted the manuscript. DBH and JAR designed analyses. JAR performed data programming and statistical analyses. DBH provided statistical oversight. AFS helped design the study, helped obtain funding, and helped draft the manuscript. CHG conducted interview quality control, participated in data coding, created the nutrient data base, and conducted the literature review. All authors were involved in interpreting the data and critically reviewing the manuscript's content. All authors approved the final version submitted for publication.

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category was much stronger for lunch than breakfast. For *lunch*, *beverages* were matches more often, omissions much less often and intrusions more often than expected under independence; *fruits* and *desserts* were omissions more often. For the meal-component $\times$ retention-interval interaction, for the *short retention interval*, *beverages* were intrusions much more often but *combination entrées* and *condiments* were intrusions less often; for the *long retention interval*, *beverages* were matches more often and omissions less often but *fruits* were matches less often. Accuracy for each meal component appeared better with the short than long retention interval. For *lunch* and for the *short retention interval*, children's reporting was most accurate for *entrée* and *combination entrée* meal components, whereas it was least accurate for *vegetable* and *fruit* meal components. Results have implications for conclusions of studies and interventions assessed with dietary recalls obtained from children.

Keywords

Children; Dietary recall; Reporting accuracy; Meal component; School meals

1. Introduction

The relationship between diet and disease is a critical one in public health, but dietary assessment is challenging, especially in children. Parents often report the dietary intake of their elementary school children, but studies (Burrows et al., 2013; Byers et al., 1993; Emmons & Hayes, 1973; Hunsberger et al., 2013) raise concerns about accuracy. For many national surveys, parents assist their elementary school children with 24-hour dietary recalls (24hDR) of children's intake. For example, since 2002, for children aged 6–11 years, the National Health and Nutrition Examination Survey (NHANES) has used joint recalls, with the child's age determining who the primary respondent is and who assists (National Health and Nutrition Examination Survey, 2002a, 2002b, 2004; National Health and Nutrition Examination Survey (NHANES), 2005, 2006, 2008a, 2008b, 2010a, 2010b, 2012a, 2012b, 2012c, 2013, 2014): Specifically, for children aged 6–8 years, the parent is the primary respondent and the child assists; for children aged 9–11 years, the child is the primary respondent and the parent assists; for children aged less than 6, proxy interviews (usually of a parent) are used; children aged 12 and older are interviewed alone (National Health and Nutrition Examination Survey, 2002a, 2002b, 2004; National Health and Nutrition Examination Survey (NHANES), 2005, 2006, 2008a, 2008b, 2010a, 2010b, 2012a, 2012b, 2012c, 2013, 2014). However, because parents lack first-hand knowledge of their children's intake at school, elementary school children must often self-report this information. For many years, elementary school children have provided dietary recalls for studies (Burghardt, Ensor, Hutchinson, Weiss, & Spencer, 1993; Fenton et al., 2015; Field et al., 1999; Moore et al., 2008; Ollberding et al., 2015; Ritchie et al., 2016; US Department of Agriculture, 2007; Wolfe & Campbell, 1993; Yuan et al., 2013) and interventions (Baranowski et al., 2003; Bartlett et al., 2013; Kitzman-Ulrich et al., 2011; Lindholm, Touliatos, & Wenberg, 1984; Luepker et al., 1996; McDonald, Brun, & Esserman, 1981; Receveur, Morou, Gray-Donald, & Macaulay, 2008; Reynolds et al., 2000; Wilson et al., 2015).

Conformance to nutritional guidelines is an indicator of diet quality; an example of a measure of diet quality is the Healthy Eating Index (HEI). The HEI is a measure of how well dietary intake conforms to the Dietary Guidelines for Americans. The HEI-2010 (Guenther et al., 2013), the latest version of the HEI, has 12 components, including nine adequacy and three moderation components. For purposes of the current article, some of the nine adequacy components (e.g., total fruit, total vegetables, dairy, total protein foods) of the HEI-2010 are similar to food groups or meal components. Most studies of diet quality use intake data that is self-reported, and/or jointly or proxy reported if for children. Banfield and colleagues (Banfield, Lui, Davis, Chang, & Frazier-Wood, 2016) used the HEI-2010 and 24hDR data from NHANES 2005–2006, 2007–2008, and 2009–2010 to describe diet quality among youth. Krebs-Smith and colleagues (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010) used MyPyramid food groups and 24hDR data from NHANES 2001–2004 to determine what proportion of the USA population does not meet federal dietary recommendations. Lorson and colleagues (Lorson, Melgar-Quinonez, & Taylor, 2009) used MyPyramids food groups and 24hDR data from NHANES 1999–2002 to assess fruit and vegetable intake among youth. Thus, the accuracy of children's (and/or adults') 24hDRs by food group or meal component could have major implications for conclusions concerning children's diet quality or adherence to dietary recommendations.

Some nutrition interventions are designed to change children's intake of specific food groups or meal components. For example, nutrition interventions have been conducted to increase children's consumption of milk and/or fruits and vegetables (Baranowski et al., 2003; Cohen, Richardson, Parker, Catalano, & Rimm, 2014; Cohen et al., 2012; Cullen, Lui, & Thompson, 2016; Day, Strange, McKay, & Naylor, 2008; Eriksen, Haraldsdottir, Pederson, & Flyger, 2003; Hanks, Just, & Wansink, 2014; Perry et al., 2004; Perry et al., 1998; Reynolds et al., 2000; Upton, Upton, & Taylor, 2013; Wengreen, Madden, Aguilar, Smits, & Jones, 2013). For some of these interventions, children provided 24hDRs via face-to-face interview (Perry et al., 1998; Reynolds et al., 2000), telephone interview (Cullen et al., 2016), computer (Baranowski et al., 2003), or questionnaire (Day et al., 2008; Eriksen et al., 2003) before and after the intervention to assess change in their intake of the specific food groups or meal components. Thus, the accuracy of children's 24hDRs by food group or meal component could have major implications for conclusions concerning the effectiveness of such nutrition interventions.

To our knowledge, research specifically concerning children's reporting accuracy by meal component is sparse. In a retrospective analysis, examination was conducted of fourth-grade children's reporting accuracy by meal component of recalls for school lunch only (Study 1; 148 children) and for the school lunch portion of 24hDRs (Study 2; 104 children); all recalls by children were obtained in the morning on the day after school lunch had been observed (Baxter & Thompson, 2002). For the two studies, food-item omission rate for a specific meal component was calculated as the number of omissions for that meal component divided by the number of omissions plus the number of matches for that meal component. Also, food-item intrusion rate for a specific meal component was calculated as the number of intrusions for that meal component divided by the number of intrusions plus the number of matches for that meal component. For Study 1, food-item omission rates were greatest (i.e., least accurate) for condiment at 64%, followed by vegetable, bread, and dessert at 45–

49%, then fruit at 31% and entrée at 22%, and smallest (i.e., most accurate) for beverage at 8%; food-item intrusion rates were greatest (i.e., least accurate) for bread, vegetable, entrée, condiment, dessert, and fruit at 15–18%, and smallest (i.e., most accurate) for beverage at 8%. For Study 2, food-item omission rates were greatest for fruit, condiment, vegetable, and dessert at 67–72%, followed by bread at 56%, then entrée at 46%, and smallest for beverage at 16%; food-item intrusion rates were greatest for dessert, condiment, entrée, fruit, and vegetable at 37–47%, and smallest for bread at 24% and beverage at 20% (Baxter & Thompson, 2002). Thus, for each of Studies 1 and 2, beverage was the meal component for which children's reporting was most accurate, and condiment and vegetable were the meal components for which children's reporting was least accurate.

The aim of the current article was to investigate children's reporting accuracy by meal component for school-meal intake obtained during 24hDRs using data from a cross-sectional validation study (Baxter, Smith, Hitchcock, et al., 2015). That validation study was designed to investigate the combined influence of retention interval (time between the to-be-reported meals and the recall) and prompts (questions used to obtain reports of intake during the first pass of a multiple-pass recall procedure) on fourth-grade children's dietary reporting accuracy; intake was validated with direct meal observations of school-provided breakfast and lunch. We investigated three hypotheses which were not examined previously.

Hypothesis 1 states that the accuracy with which children report food intake at school meals during 24hDRs will vary over meal component (i.e., beverage, bread, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, vegetable). Specifically, omissions (items observed eaten but not reported eaten) and intrusions (items not observed eaten but reported eaten) will vary over meal component. This hypothesis was based on results from the retrospective analysis (Baxter & Thompson, 2002) summarized earlier.

Hypothesis 2 states that the effect on children's reporting accuracy by meal component will differ by school-meal serving period (breakfast, lunch). Specifically, there will be more variation over meal components in reporting accuracy for lunch than for breakfast. This hypothesis was based on results from past studies on fourth-grade children, with one study on the same sample as the current article's investigation and the other study on two different samples, which found that children's food-item accuracy for reporting school-meal intake during 24hDRs was better for lunch than breakfast (Baxter et al., 2016; Baxter, Royer, Hardin, Guinn, & Smith, 2007).

Hypothesis 3 states that the effect on children's reporting accuracy by meal component will vary as a function of retention interval, prompts, or sex, separately or in interactions. Specifically, reporting accuracy by meal component will be better for the short than long retention interval. The retention interval part of this hypothesis was based on results from numerous studies among different samples of children in grades three, four, or five (Baxter et al., 2009; Baxter et al., 2013; Baxter et al., 2014; Baxter, Smith, Hitchcock, et al., 2015; Baxter et al., 2006; Baxter et al., 2004), and the sample of fourth-grade children from the validation study (Baxter, Smith, Hitchcock, et al., 2015) that provided data for the current article's analyses, which showed that children's food-item accuracy for reporting school-meal intake during 24DRs was better with the short than long retention interval. We

proposed no specific hypotheses for reporting accuracy by meal component as a function of prompts or sex.

2. Methods

2.1. Overview, consent, and assent

Another publication (Baxter, Smith, Hitchcock, et al., 2015) provides results from the validation study for accuracy overall (not by meal component) and details about the design, sample, data collection, and quality control; this section summarizes the latter details. The study was approved by the University of South Carolina Institutional Review Board. Written parental consent and child assent were obtained.

2.2. Sample and general design

Data collection occurred 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, a total of 1,780 children were invited to participate in the study, and a total of 1,208 children (67.9%) agreed by providing written child assent and parental consent. Each child selected was observed eating two consecutive school-provided meals (breakfast and lunch) on the same day, and then interviewed to obtain a 24hDR 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]). Another publication describes the rationale for the design (Baxter, Smith, Guinn, et al., 2015). 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). Three of the four prompts were from prominent 24hDR multiple-pass protocols. Specifically, forward prompts were from the Nutrition Data System for Research protocol (Regents of the University of Minnesota), meal-name prompts were from the Automated Self-Administered 24-hour recall (National Cancer Institute), and open prompts were from the Automated Multiple-Pass Method (US Department of Agriculture, 9/8/2016). Reverse prompts were from our 2003 study (Baxter, Thompson, Smith, et al., 2003) and our unpublished 2007 pilot study.

For each school year, consented children in the highest 2.5 percent and lowest 2.5 percent of the age distribution were neither observed nor interviewed because they could have repeated a grade or skipped a grade (Baxter, Smith, Hitchcock, et al., 2015). From each school year's pool of consented children within the central 95th percent of the age distribution, children were randomly selected subject to constraints imposed by the intended composition (by number and sex) of the eight interview conditions. The final composition of each condition was 60 children (half girls), for 480 children total. Children and school staff did not know in advance when observations and/or interviews would occur (Baxter, Smith, Hitchcock, et al., 2015).

Each of the four districts had implemented offer-versus-serve foodservice which meant that at each school, of the meal components available at each meal, children could refuse one at breakfast, and one or two at lunch, but had to select a fruit or vegetable at each meal (US Department of Agriculture, 2013). A standard breakfast included fruit, grains, and milk, whereas a standard lunch included meat or alternate, grains, fruit, vegetable, and milk (US Department of Agriculture, 2013). Within meal components, children had a choice of food items (e.g., fruit, juice, milk flavor, vegetable, entrée) at most meals in all four districts.

2.3. Direct observations of school-provided meals

A total of three researchers observed school-provided meals using an established protocol (Baxter et al., 2009; Baxter et al., 2014; Baxter et al., 2004; Baxter, Thompson, Litaker, Frye, & Guinn, 2002; Baxter, Thompson, Litaker, et al., 2003; Baxter, Thompson, Smith, et al., 2003). Any researcher observed one to three children simultaneously during regular meal serving periods to record items and amounts eaten. Interobserver reliability was assessed weekly using established procedures (Baglio et al., 2004; Baxter et al., 2009; Baxter et al., 2014; Baxter et al., 2004; Baxter, Thompson, Litaker, et al., 2003; Baxter, Thompson, Smith, et al., 2003) before and throughout data collection. Across three school years, 287 assessments of interobserver reliability during data collection showed mean agreement of 98.8% between observers to within one-fourth of a serving on amounts eaten, which is considered excellent (Baranowski et al., 1986; Simons-Morton & Baranowski, 1991).

2.4. Dietary recall interviews

A total of four researchers conducted face-to-face interviews in private locations at schools after lunch for the short retention interval and after breakfast for the long retention interval. For any child, the researcher who conducted the interview was different from the researcher who had observed the child's meals. The multiple-pass protocols are described in detail elsewhere (Baxter, Smith, Hitchcock, et al., 2015). Each interview was audio-recorded and transcribed. A non-interviewing researcher used established procedures to conduct quality control on each interview (Baxter et al., 2009; Baxter et al., 2014; Baxter et al., 2004; Baxter, Thompson, Litaker, et al., 2003; Baxter, Thompson, Smith, et al., 2003; Shaffer et al., 2004). Eighteen interviews were replaced because they did not adhere to the assigned protocol. One additional 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 24hDRs because only school meals were observed. Using established procedures (Baxter et al., 2009; Baxter et al., 2014; Baxter et al., 2004; Baxter et al., 2002; Baxter, Thompson, Litaker, et al., 2003; Baxter, Thompson, Smith, et al., 2003), for reported items to be treated as reports about school meals, a child 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.

2.5. Measures

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

Every food item in the reference set and/or in the reported set was classified as one of nine meal components — beverage, bread, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, or vegetable. Examples of items in the *beverage* meal component are milk (plain, chocolate, strawberry, etc.) and fruit juice (e.g., orange, apple, grape). Examples of items in the *bread* meal component are biscuit, roll, hamburger bun, white rice, and ready-to-eat breakfast cereal (e.g., Rice Krispies). Examples of items in the *breakfast meat* meal component are egg and sausage. Examples of items in the *combination entrée* meal component are pepperoni pizza and spaghetti with meat sauce. Examples of items in the *condiment* meal component are mustard, ketchup, and French salad dressing. Examples of items in the *dessert* meal component are vanilla ice cream, oatmeal cookie, and chocolate cake. Examples of items in the *entrée* meal component are baked chicken, ham, and hamburger patty. Examples of items in the *fruit* meal component are apple, orange, grapes, peaches, and applesauce. Examples of items in the *vegetable* meal component are broccoli, green beans, corn, and fresh carrot sticks. Items that did not fit into any of the nine meal components (e.g., candy, chips) were originally assigned to a *miscellaneous* meal component; however, the miscellaneous meal component was not included in analyses due to the small number of items observed eaten or reported eaten that were classified this way.

Using established definitions (Baxter et al., 2009; Baxter et al., 2013; Baxter et al., 2014; Baxter et al., 2004; Baxter, Thompson, & Davis, 2000; Baxter et al., 2002; Baxter, Thompson, Litaker, et al., 2003; Baxter, Thompson, Smith, et al., 2003; Paxton, Baxter, Fleming, & Ammerman, 2011; Smith, 1991; Smith, Jobe, & Mingay, 1991; Warren et al., 2003), for each child, a food item in both the reference set and reported set was classified as a *match* (item observed eaten and reported eaten). A food item in the reference set but not in the reported set was classified as an *omission* (item observed eaten but not reported eaten). A food item in the reported set but not in the reference set was classified as an *intrusion* (item reported eaten but not observed eaten).

2.6. Analyses

A multilevel generalized model was fit in SAS/STAT® (9.4© 2002–12, SAS Institute Inc., Cary, NC) using SAS PROC GLIMMIX, with food-item accuracy category (match, omission, intrusion) of each food item modeled as a polytomous nominal response variable. The multilevel model is appropriate when the data have a hierarchical structure with explanatory variables on multiple levels: For these data, some explanatory variables were characteristics of food items, whereas others were child characteristics. Food-item level explanatory variables were meal component (beverage, bread, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, vegetable) and serving period (breakfast, lunch). Child-level explanatory variables were retention interval, prompt, and sex. Two-way interactions were included; after a preliminary fit, interactions with $p > 0.20$ were removed and the model re-fit. Wald Type III tests were used to judge significance of individual

predictors. Because multiple simultaneous tests were conducted, the Benjamini-Hochberg method (Benjamini & Hochberg, 1995) was used to adjust p values to control the false discovery rate at 0.05. Adjusted p values are provided.

3. Results

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

Twenty-five children (8 girls) did not meet the criteria for any reported meals to be classified as school meals (Baxter, Smith, Hitchcock, et al., 2015); these 25 children 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). These 25 children were not included in analyses because each had 0 matches, 0 intrusions, and all omissions. Therefore, analyses included 455 children; their mean age was 9.92 ± 0.41 years.

Over the two school-provided meals of these 455 children, a total of 4,177 items was observed and/or reported eaten; by food-item accuracy category, there were 1,941 matches, 1,573 omissions, and 663 intrusions. (In the *miscellaneous* meal component not included in analyses, there were an additional 13 matches, 34 omissions, and 4 intrusions.)

Meal component ($F(16, 3173) = 8.58, p < 0.0003$) and retention interval ($F(2, 3173) = 49.68, p < 0.0003$) and the meal-component $\times$ serving-period ($F(12, 3173) = 3.31, p < 0.0003$) and meal-component $\times$ retention-interval ($F(16, 3173) = 2.61, p = 0.001$) interactions were significant predictors of food item-accuracy category (i.e., whether an item was a match, intrusion, or omission). Not significant were serving period ($F(2, 3173) = 0.15, p = 0.87$), prompt ($F(6, 3173) = 1.38, p = 0.29$), and sex ($F(2, 3173) = 0.49, p = 0.70$).

Food-item accuracy category is a nominal variable; therefore, the individual and joint effects of the explanatory variables on food-item accuracy category are best interpreted via contingency tables that give counts of matches, omissions, and intrusions for each type of meal component. If meal component had no association with food-item accuracy category (i.e., if these classifications were *independent*), the expected count in each cell of the contingency table would be the product of that cell's corresponding row and column marginal totals, divided by the total count for the entire contingency table. The χ^2 statistic measures the association between meal component and food-item accuracy category; it sums, across all cells, the squared difference between the actual and expected cell counts, divided by the expected cell count. Each cell's contribution to this χ^2 statistic can be examined to see the nature of any association. When the food-item accuracy category occurred about as often as expected under independence, the contribution to χ^2 was small. When the food-item accuracy category occurred more or less often than expected under independence, the contribution to χ^2 was large. Note that the magnitude of a cell's contribution to the χ^2 statistic can only be meaningfully understood with the context of the size of the overall χ^2 statistic for that contingency table. Although there is no formal cutoff

defining a “large” contribution to χ^2 , a food-item accuracy category whose contribution accounted for a larger fraction of the overall χ^2 statistic would reflect that category accounting for a more severe departure from independence. Performing this χ^2 analysis for multiple contingency tables indexed by levels of another variable (e.g., serving period) would shed light on the interaction between meal component and that variable on food-item accuracy category.

Table 1 shows, for each serving period, the meal component $\times$ serving period $\times$ food-item accuracy category contingency tables that were used to clarify the meal-component $\times$ serving-period interaction. The association between meal component and food-item accuracy category was modest for both breakfast (Cramer’s $V=0.13$) and lunch (Cramer’s $V=0.16$). For the meal-component $\times$ serving-period interaction, for example, conclusions are based on χ^2 cell contributions which measured the association between meal component and food-item accuracy category, separately by serving period.

In Table 1, for *breakfast*, cell counts overall were mostly as expected under independence. For most of the meal components, matches, omissions, and intrusions were as expected under independence. (For example, as shown the left contingency table or “panel” for breakfast, for *beverages*, for matches, 276 occurred, 262 were expected, and the χ^2 cell contribution was 0.8; for omissions, 237 occurred, 270 were expected, and the χ^2 cell contribution was 4.0; and for intrusions, 159 occurred, 140 were expected, and the χ^2 cell contribution was 2.5.) The only meal components with cell contributions at least one-tenth of the overall χ^2 statistic of 53.9 for the left panel for breakfast were *desserts* being intrusions more often than expected (χ^2 cell contribution of 9.0) and *fruits* being matches less often than expected (χ^2 cell contribution of 6.9).

In Table 1, for *lunch*, *beverages* were matches more often, omissions much less often, and intrusions more often than expected under independence. (For example, as shown in the right panel for lunch, for *beverages*, for matches, 328 occurred, 267 were expected, and the χ^2 cell contribution was 13.7; for omissions, 100 occurred, 190 were expected, and the χ^2 cell contribution was 42.5; and for intrusions, 97 occurred, 68 were expected, and the χ^2 cell contribution was 12.6. All of these contributions were fairly large relative to the overall χ^2 statistic of 142.8 for the right panel for lunch.) *Desserts* were omissions more often than expected, but were matches and intrusions as expected under independence. *Fruits* were matches less often and omissions more often than expected, but were intrusions as expected under independence. For five meal components — *bread*, *combination entrée*, *condiment*, *entrée*, *vegetable* — matches, omissions, and intrusions were as expected under independence. (*Breakfast meat* was not a meal component for lunch.) In summary, the relationship of meal component and food-item accuracy category was much more pronounced for lunch than for breakfast. In other words, for lunch more than for breakfast, reporting accuracy for particular meal components deviated from what would be expected were food-item accuracy category not associated with meal component.

Table 2 shows, for each retention interval, the meal-component $\times$ retention-interval $\times$ food-item accuracy category contingency tables that were used to clarify the meal-component $\times$ retention-interval interaction. (Note that the food items in Table 2 are the same as in Table 1,

but arranged in a different way.) The association between meal component and food-item accuracy category was modest for both the short retention interval (Cramer's $V = 0.16$) and long retention interval (Cramer's $V = 0.14$). Specific conclusions are again based on cell contributions to the χ^2 association statistic. When the retention interval was short, *beverages* were omissions less often and intrusions much more often than expected, but were matches as expected under independence. (For example, as shown in the left panel, under independence, of the 590 *beverages* observed and/or reported eaten at the short retention interval, 343 would have been matches, 177 would have been omissions, and 69 would have been intrusions. The numbers that occurred were 335, 140, and 115, respectively, yielding χ^2 contributions of 0.2, 7.0, and 30.1, respectively, relative to an overall χ^2 statistic of 100.93 for the left panel for the short retention interval.) *Combination entrées* were intrusions less often than expected, but were matches and omissions as expected under independence. *Condiments* were intrusions less often than expected, but were matches and omissions as expected under independence. For six meal components — *bread, breakfast meat, dessert, entrée, fruit, vegetable* — matches, omissions, and intrusions were as expected under independence.

In Table 2, when the retention interval was long, *beverages* were matches more often but omissions much less often and intrusions as expected under independence. (For example, as shown in the right panel, under independence, of the 607 *beverages* observed and/or reported eaten at the long retention interval, 217 would have been matches, 271 would have been omissions, and 119 would have been intrusions. The numbers that occurred were 269, 197, and 141, respectively, yielding χ^2 contributions of 12.7, 20.2, and 3.9, respectively, relative to an overall χ^2 statistic of 86.14 for the right panel for the long retention interval.) *Fruits* were matches less often than expected, but were omissions and intrusions as expected under independence. For seven meal components — *bread, breakfast meat, combination entrée, condiment, dessert, entrée, vegetable* — matches, omissions, and intrusions were as expected under independence.

Note, also, that in Table 2, for each of the nine meal components, counts in the column for “occur” for matches were greater, and counts in the columns for “occur” for omissions and intrusions were smaller, when the retention interval was short compared to when the retention interval was long (with one exception — for intrusions, the count for “occur” for the *dessert* meal component was the same for the short retention interval and long retention interval). In other words, accuracy for each meal component appeared better with the short retention interval than with the long retention interval.

4. Discussion

Multilevel models were used to address three hypotheses about fourth-grade children's reporting accuracy by meal component with data from a validation study in which we had manipulated retention interval and prompts. These multilevel models permitted answers to hypotheses about both item-level variables such as meal component and serving period (breakfast, lunch) and child-level variables such as retention interval, prompt, and sex. Because the multilevel models reflect the data structure, they are the optimal way to address the hypothesis articulated.

Hypothesis 1 — that children's omissions and intrusions vary over meal component — was supported. There was variation over meal component in accuracy: *Beverage* was the meal component for which food-item accuracy category deviated the most from what was expected under independence. Specifically, for lunch, *beverages* were matches more often, omissions much less often, and intrusions more often than expected under independence. With the short retention interval, *beverages* were intrusions much more often than expected under independence. With the long retention interval, *beverages* were matches more often and omissions less often than expected under independence. *Fruit*, *dessert*, *condiment*, and *combination entrée* had some deviation in food-item accuracy category from what was expected under independence. Specifically, *fruits* and *desserts* were omissions more often than expected under independence. With the short retention interval, *combination entrées* and *condiments* were intrusions less often than expected under independence. With the long retention interval, *fruits* were matches less often than expected under independence. *Bread* was the meal component with the least deviation in food-item accuracy category. For the *bread* meal component, matches, omissions, and intrusions were as expected under independence for breakfast and lunch, and for the short and long retention intervals.

Hypothesis 2 — that children's reporting accuracy by meal component differs by school-meal serving period (breakfast, lunch) — was supported. The meal component effect on food-item accuracy category was much more pronounced for lunch than for breakfast. Specifically, for breakfast, accuracy categories by meal component overall were mostly as expected. For lunch, *beverages* were matches more often, omissions much less often, and intrusions more often than expected under independence, whereas *fruits* and *desserts* were omissions more often than expected under independence.

Hypothesis 3 — that children's reporting accuracy by meal component varies as a function of retention interval, prompts, or sex, separately or in interactions — was supported but only for retention interval. With the short retention interval, *beverages* were intrusions much more often while *combination entrées* and *condiments* were intrusions less often than expected under independence. With the long retention interval, *beverages* were matches more often and omissions less often, whereas *fruits* were matches less often than expected under independence. Accuracy for each meal component was better with the short than long retention interval, as shown in Table 2. This is consistent with findings from our past studies (Baxter et al., 2009; Baxter et al., 2013; Baxter et al., 2014; Baxter et al., 2006; Baxter et al., 2004) among samples of third-, fourth-, or fifth-grade children about the effect of retention interval on food-item reporting accuracy, as well as the sample of fourth-grade children from the validation study (Baxter, Smith, Hitchcock, et al., 2015) that provided data for the current article's analyses. This Hypothesis 3 finding on retention interval is likely related to the Hypothesis 2 finding that item accuracy by meal component was more pronounced for lunch than breakfast: With the short retention interval (for an afternoon interview about the prior-24-hours' intake), the 24hDR was obtained about 5 hours after the to-be-reported school breakfast and 1 hour after the to-be-reported school lunch, whereas with the long retention interval (for a morning interview about the previous-day's intake), the times were about 25 and 21 hours, respectively. Thus, the average time between eating school breakfast and the 24hDR was 15 hours, whereas for school lunch it was 11 hours.

The Introduction provided food-item omission rates and food-item intrusion rates by meal component for a retrospective analysis (Baxter & Thompson, 2002) of fourth-grade children's recalls from two studies. For the current article, such food-item omission rates and food-item intrusion rates by meal component were not calculated because multilevel models were used due to the item-level and child-level variables. However, one can calculate such rates using counts in the columns for "occur" for match, omission, and intrusion within each panel in each of Tables 1 and 2. For example, using counts in Table 1, for lunch, food-item omission rate was greatest for *dessert* (for which counts were low) at 58%, *fruit* at 52%, and *vegetable* at 51%, and smallest for *combination entrée* at 33%, *entrée* at 33%, and *beverage* at 23%. Also, for lunch, food-item intrusion rate was greatest for *vegetable* at 27%, *fruit* at 25%, *beverage* at 23%, and *dessert* (for which counts were low) at 22%, and smallest for *condiment* at 16%, *entrée* at 16%, and *combination entrée* at 14%. Thus, for lunch, *entrée* and *combination entrée* were the meal components for which children's reporting was most accurate, whereas *vegetable* and *fruit* were the meal components for which children's reporting was least accurate. Using counts in Table 2, for the short retention interval, food-item omission rate was greatest for *dessert* (for which counts were low) at 46%, *breakfast meat* (for which counts were low) at 45%, *fruit* at 41%, *vegetable* at 38%, and *condiment* at 38%, and smallest for *combination entrée* at 23% and *entrée* at 22%. Also, for the short retention interval, food-item intrusion rate was greatest for *beverage* at 26%, *vegetable* at 20%, *breakfast meat* (for which counts were low) at 18%, and *fruit* at 17%, and smallest for *entrée* at 7%, *combination entrée* at 4%, and *condiment* at 4%. Thus, as with lunch, for the short retention interval, *entrée* and *combination entrée* were the meal components for which children's reporting was most accurate, whereas *vegetable* and *fruit* were the meal components for which children's reporting was least accurate.

In some publications, authors have mentioned accuracy by meal component but not provided specific results. For example, for a validation study (Domel, Thompson, Baranowski, & Smith, 1994) with 24 fourth-grade children who were observed eating school lunch, the authors mentioned that the items most frequently omitted were condiments, followed by side dishes (e.g., bread items).

The current article's investigation was limited by the design of the validation study that was the source of the data for the current article. As described in the discussion, serving period and retention interval were somewhat confounded, because for each retention interval, the lunch to be reported was more recent than the breakfast to be reported. Direct meal observations included only school-provided breakfast and lunch rather than intake for an entire 24 hours per child due to budgetary constraints. Dietary recalls were obtained from children via face-to-face interviews; thus, the study design could not address potential biases in reporting accuracy from other administration modes such as via telephone, computer, or paper questionnaire. Although the sample of children was from a total of 10 schools in four school districts, it included only fourth-grade children. Another publication (Smith et al., 2016) provides results concerning the relationship of reporting accuracy to child-respondent characteristics — cognitive ability, social desirability, body mass index (BMI) percentile, and socioeconomic status (SES) — for the validation study that provided data for the sample analyzed for the current article. We assessed children's reporting accuracy for school meals for four outcome variables, two at the food-item level (omission rate; intrusion rate) and two

at the energy level (correspondence rate; inflation ratio). Controlling for manipulated variables and other measured respondent characteristics, for one or more of the outcome variables, reporting accuracy increased with cognitive ability (omission rate, intrusion rate, correspondence rate), decreased with social desirability (correspondence rate), decreased with BMI percentile (correspondence rate), and was better by higher than by lower SES children (intrusion rate); some of these effects were moderated by interactions with retention interval and sex (Smith et al., 2016). Thus, even when a study limits the sample of children to a single grade level, there is variation in cognitive ability, social desirability, BMI percentile, and SES, as well as in reporting accuracy.

Strengths of the current article's investigation include aspects of the validation study that was the source of the data for the current article. Specifically, validation of recalls used direct meal observations of school-provided breakfast and lunch. The meal observation setting was free-choice as children had choices of items and determined the amount eaten of the standard portion provided for each item. The meal observation setting offers maximum generalizability as millions of children eat school-provided meals each school day (Oliveira, 2016) and minimum reactivity as children typically eat in large groups with oversight by adults (Baxter, Thompson, Litaker, et al., 2003; Simons-Morton & Baranowski, 1991). We implemented rigorous quality control procedures throughout data collection for meal observations and interviews.

5. Conclusions

Examination of reporting accuracy by meal component is an important yet understudied aspect of dietary-reporting validation studies. As explained in the introduction, the accuracy of children's 24hDRs by food group or meal component could have major implications a) for conclusions concerning diet quality or adherence to dietary recommendations or b) for conclusions concerning the effectiveness of nutrition interventions conducted to change intake of specific food groups or meal components such as milk and/or fruits and vegetables. Our findings showed that food-item accuracy category varied by meal component, was much more pronounced for lunch than breakfast, and varied as a function of retention interval. However, as mentioned as a limitation, serving period and retention interval were somewhat confounded, because for each retention interval, the to-be-reported lunch was more recent than the to-be-reported breakfast. Our findings could help contextualize findings from *non-validation* studies, for example, on the relationship of reported intake for a specific meal component or category (e.g., dairy, vegetables) and BMI. Because accuracy for each meal component appeared better with the short than the long retention interval, to improve overall accuracy of dietary recalls, we encourage investigators to design studies to obtain dietary recalls using a short rather than long retention interval, and we encourage practitioners to obtain dietary recalls that use a short rather than long retention interval. For example, obtain recalls in the afternoon or evening that concern the prior-24-hours' intake rather than the previous-day's intake. If recalls must concern the previous day's intake, obtain recalls in the morning rather than afternoon or evening. Our results and conclusions are from 24hDRs obtained using prompts in prominent 24hDR multiple-pass protocols that included no prompt that referred specifically to any meal component. Thus, our results and conclusions are not applicable to recalls of single meal component, such as 24hDRs of only vegetables

eaten on the previous day as used in a study with children aged 9–12 years (Mangunkusumo, Brug, de Koning, van der Lei, & Raat, 2007). We encourage investigators of dietary-reporting validation studies to examine food-item accuracy category (match, omission, intrusion) by meal component. These food-item accuracy categories provide a standard and easily understood way to examine validation-study data concerning reporting accuracy by meal component, yet publications with such results are sparse. Although examination of reporting accuracy by meal component is especially applicable to studies that use school-meal observations to validate accuracy, it may be less practical and more complex to examine reporting accuracy by meal component for complete 24-hour intakes of children who do not consume school meals because school meals must abide by strict rules concerning their content (US Department of Agriculture, 2013). The idea of examining reporting accuracy by meal component or category may help investigators of non-school-based studies to create similar options for use. When examining validation-study data for the relationship of reporting accuracy by meal component, we encourage investigators to use the multilevel models which reflect the data structure by accounting for the food-item level and child-level explanatory variables.

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References

- 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. *Journal of the American Dietetic Association*. 2004; 104(9):1385–1393. [PubMed: 15354155]
- Banfield EC, Lui Y, Davis JS, Chang S, Frazier-Wood AC. Poor adherence to US dietary guidelines for children and adolescents in the National Health and Nutrition Examination Survey Population. *Journal of the Academy of Nutrition and Dietetics*. 2016; 116(1):21–27. [PubMed: 26391469]
- Baranowski T, Baranowski J, Cullen KW, Marsh T, Islam N, Zakeri I, et al. Squire's Quest! Dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine*. 2003; 24(1): 52–61. [PubMed: 12554024]
- Baranowski T, Dworkin R, Henske JC, Clearman DR, Dunn JK, Nader PR, et al. The accuracy of children's self-reports of diet: Family Health Project. *Journal of the American Dietetic Association*. 1986; 86(10):1381–1385. [PubMed: 3760429]
- Bartlett, S., Olsho, L., Klerman, J., Patlan, KL., Blocklin, M., Connor, P. Evaluation of the Fresh Fruit and Vegetable Program (FFVP): Final evaluation report. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service; Project Officers: Karen Castellanos-Brown and Allison Magness; 2013. Prepared by Abt Associates under Contract No. AG-3198-D-09-0053

- Baxter SD, Guinn CH, Smith AF, Hitchcock DB, Royer JA, Puryear MP, et 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. *British Journal of Nutrition*. 2016; 115(7):1301–1315. [PubMed: 26865356]
- 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). *Journal of the American Dietetic Association*. 2009; 109(5):846–856. [PubMed: 19394471]
- Baxter SD, Hitchcock DB, Guinn CH, Royer JA, Wilson DK, Pate RR, et al. A pilot study of the effects of interview content, retention interval, and grade on accuracy of dietary information from children. *Journal of Nutrition Education and Behavior*. 2013; 45(4):368–373. [PubMed: 23562487]
- Baxter SD, Hitchcock DB, Guinn CH, Vaadi KK, Puryear MP, Royer JA, et al. A validation study concerning the effects of interview content, retention interval, and grade on children's recall accuracy for dietary and/or physical activity. *Journal of the Academy of Nutrition and Dietetics*. 2014; 114(12):1902–1914. [PubMed: 24767807]
- 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. *Journal of Nutrition Education and Behavior*. 2007; 39(3):126–133. [PubMed: 17493562]
- Baxter SD, Smith AF, Guinn CH, Hitchcock DB, Puryear MP, Vaadi KK, et al. Retention interval and prompts: Creation and cross-sectional pilot-testing of eight interview protocols to obtain 24-hour dietary recalls from fourth-grade children. *Journal of the Academy of Nutrition and Dietetics*. 2015; 15(8):1291–1298.
- Baxter SD, Smith AF, Hitchcock DB, Guinn CH, Royer JA, Collins KL, et al. Effectiveness of prompts on fourth-grade children's dietary recall accuracy depends on retention interval and varies by gender. *Journal of Nutrition*. 2015; 145(9):2185–2192. [PubMed: 26224752]
- Baxter SD, Smith AF, Litaker MS, Guinn CH, Nichols MN, Miller PH, et al. Body mass index, sex, interview protocol, and children's accuracy for reporting kilocalories observed eaten at school meals. *Journal of the American Dietetic Association*. 2006; 106(10):1656–1662. [PubMed: 17000199]
- Baxter SD, Smith AF, Litaker MS, Guinn CH, Shaffer NM, Baglio ML, et al. Recency affects reporting accuracy of children's dietary recalls. *Annals of Epidemiology*. 2004; 14(6):385–390. [PubMed: 15246326]
- 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. *Nutrition Research*. 2002; 22(6):679–684.
- Baxter SD, Thompson WO, Davis HC. Prompting methods affect the accuracy of children's school lunch recalls. *Journal of the American Dietetic Association*. 2000; 100(8):911–918. [PubMed: 10955049]
- Baxter SD, Thompson WO, Litaker MS, Frye FHA, Guinn CH. Low accuracy and low consistency of fourth-graders' school breakfast and school lunch recalls. *Journal of the American Dietetic Association*. 2002; 102(3):386–395. [PubMed: 11905461]
- Baxter SD, Thompson WO, Litaker MS, Guinn CH, Frye FHA, Baglio ML, et al. Accuracy of fourth-graders' dietary recalls of school breakfast and school lunch validated with observations: In-person versus telephone interviews. *Journal of Nutrition Education and Behavior*. 2003; 35(3):124–134. [PubMed: 12773283]
- Baxter SD, Thompson WO, Smith AF, Litaker MS, Yin Z, Frye FHA, et al. Reverse versus forward order reporting and the accuracy of fourth-graders' recalls of school breakfast and school lunch. *Preventive Medicine*. 2003; 36(5):601–614. [PubMed: 12689806]
- Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society, Series B (Methodological)*. 1995; 57(1):289–300.
- Burghardt, J., Ensor, T., Hutchinson, G., Weiss, C., Spencer, B. The School Nutrition Dietary Assessment Study: Data collection and sampling. Berenson, L., editor. Princeton, NJ: Mathematica Policy Research, Inc; 1993. Contract No. 53-3198-0-16; MPR Reference No. 7937-140

- Burrows TL, Truby H, Morgan PJ, Callister R, Davies PSW, Collins CE. A comparison and validation of child versus parent reporting of children's energy intake using food frequency questionnaires versus food records: Who's an accurate reporter? *Clinical Nutrition*. 2013; 32(4):613–618. [PubMed: 23206381]
- Byers T, Treiber F, Gunter E, Coates R, Sowell A, Leonard S, et al. The accuracy of parental reports of their children's intake of fruits and vegetables: Validation of a food frequency questionnaire with serum levels of carotenoids and vitamins C, A, and E. *Epidemiology*. 1993; 4(4):350–355. [PubMed: 8347746]
- Cohen JFW, Richardson S, Parker E, Catalano PJ, Rimm EB. Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *American Journal of Preventive Medicine*. 2014; 46(4):388–394. [PubMed: 24650841]
- Cohen JFW, Smit LA, Parker E, Austin SB, Frazier AL, Economos CD. Long-term impact of a chef on school lunch consumption: Findings from a 2-year pilot study in Boston middle schools. *Journal of the Academy of Nutrition and Dietetics*. 2012; 112(6):927–933. [PubMed: 22504283]
- Cullen KW, Lui Y, Thompson DI. Meal-specific dietary changes from Squires Quest! II: A serious video game intervention. *Journal of Nutrition Education and Behavior*. 2016; 48(5):326–330. [PubMed: 27169641]
- Day ME, Strange KS, McKay HA, Naylor PJ. Action Schools! BC - Healthy Eating: Effects of a whole-school model to modifying eating behaviours of elementary school children. *Canadian Journal of Public Health*. 2008; 99(4):328–331. [PubMed: 18767281]
- Domel SB, Thompson WO, Baranowski T, Smith AF. How children remember what they have eaten. *Journal of the American Dietetic Association*. 1994; 94(11):1267–1272. [PubMed: 7963170]
- Emmons L, Hayes M. Accuracy of 24-hr. recalls of young children. *Journal of the American Dietetic Association*. 1973; 62(4):409–415. [PubMed: 4691953]
- Eriksen K, Haraldsdottir J, Pederson R, Flyger HV. Effect of a fruit and vegetable subscription in Danish schools. *Public Health Nutrition*. 2003; 6(1):57–63. [PubMed: 12581466]
- Fenton K, Rosen NJ, Wakimoto P, Patterson T, Goldstein LH, Ritchie LD. Eat lunch first or play first? Inconsistent associations with fruit and vegetable consumption in elementary school. *Journal of the Academy of Nutrition and Dietetics*. 2015; 115(4):585–592. [PubMed: 25487854]
- Field AE, Peterson KE, Gortmaker SL, Cheung L, Rockett H, Fox MK, et al. 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 Nutrition*. 1999; 2(3):293–300. [PubMed: 10512564]
- Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HAB, Kuczyński KJ, et al. Update of the Healthy Eating Index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics*. 2013; 113(4):569–580. [PubMed: 23415502]
- Hanks AS, Just DR, Wansink B. Chocolate milk consequences: A pilot study evaluating the consequences of banning chocolate milk in school cafeterias. *PLoS ONE*. 2014; 9(4):e91022. [PubMed: 24740451]
- Hunsberger M, Pena P, Lissner L, Grafstrom L, Vanaelst B, Bornhorst C, et al. Validity of self-reported lunch recalls in Swedish school children aged 6–8 years. *Nutrition Journal*. 2013; 12:129. [PubMed: 24047239]
- Kitzman-Ulrich H, Wilson DK, St George SM, Segal M, Schneider E, Kugler K. A preliminary test of a motivational and parenting weight loss program targeting low-income and minority adolescents. *Childhood Obesity*. 2011; 7(5):379–384.
- Krebs-Smith SM, Guenther PM, Subar AF, Kirkpatrick SI, Dodd KW. Americans do not meet federal dietary recommendations. *Journal of Nutrition*. 2010; 140(10):1832–1838. [PubMed: 20702750]
- Lindholm BW, Touliatos J, Wenberg MF. Predicting changes in nutrition knowledge and dietary quality in ten- to thirteen-year-olds following a nutrition education program. *Adolescence*. 1984; 19(74):367–375.
- Lorson BA, Melgar-Quinonez HR, Taylor CA. Correlates of fruit and vegetable intakes in US children. *Journal of the American Dietetic Association*. 2009; 109(3):474–478. [PubMed: 19248865]

- Luepker RV, Perry CL, McKinlay SM, Nader PR, Parcel GS, Stone EJ, et al. 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(10):768–776. [PubMed: 8598593]
- Mangunkusumo RT, Brug J, de Koning HJ, van der Lei J, Raat H. School-based internet-tailored fruit and vegetable education combined with brief counselling increases children's awareness of intake levels. *Public Health Nutrition*. 2007; 10(3):273–279. [PubMed: 17288625]
- McDonald WF, Brun JK, Esserman J. In-home interviews measure positive effects of a school nutrition program. *Journal of Nutrition Education*. 1981; 13(4):140–144.
- Moore HJ, Ells LJ, McLure SA, Crooks S, Cumbor D, Summerbell CD, et al. 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 Program™ (SNAP™). *British Journal of Nutrition*. 2008; 99(6):1266–1274. [PubMed: 18042307]
- National Cancer Institute. ASA24 Automated Self-Administered 24-hour Recall. Retrieved from <http://epi.grants.cancer.gov/asa24/>
- National Health and Nutrition Examination Survey. MEC In-Person Dietary Interviewers Procedures Manual. 2002a. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_01_02/dietary_year_3.pdf
- National Health and Nutrition Examination Survey. Phone Follow-Up Dietary Interviewer Procedures Manual. 2002b. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_01_02/phone_followup_year_3.pdf
- National Health and Nutrition Examination Survey. Phone Follow-Up Dietary Interviewers Procedures Manual. 2004. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/DIETARY_PFU.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-Up Dietary Interviewer Procedures Manual. 2005. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_05_06/DIETARY_PFU.pdf
- National Health and Nutrition Examination Survey (NHANES). MEC In-Person Dietary Interviewers Procedures Manual. 2006. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_05_06/DIETARY_MEC.pdf
- National Health and Nutrition Examination Survey (NHANES). MEC In-Person Dietary Interviewers Procedures Manual. 2008a. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_dietarymec.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-Up Dietary Interviewer Procedures Manual. 2008b. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_dietarypfu.pdf
- National Health and Nutrition Examination Survey (NHANES). MEC In-Person Dietary Interviewers Procedures Manual. 2010a. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_09_10/mec_in_person_dietary_procedures_manual_mar_2010.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-Up Dietary Interviewer Procedures Manual. 2010b. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_09_10/phone_follow_up_dietary_procedures_manual_mar_2010.pdf
- National Health and Nutrition Examination Survey (NHANES). MEC In-Person Dietary Interviewers Procedures Manual. 2012a. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/mec_in_person_dietary_procedures_manual_jan_2012.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-up Dietary Interviewer Procedures Manual. 2012b. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Phone_Follow-up_Dietary_Procedures.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-Up Dietary Interviewer Procedures Manual. 2012c. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Phone_Follow-up_Dietary_Procedures.pdf
- National Health and Nutrition Examination Survey (NHANES). Phone Follow-Up Dietary Interviewer Procedures Manual. 2013. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/Phone_Follow-up_Dietary_Interviewers_Manual.pdf

- National Health and Nutrition Examination Survey (NHANES). MEC In-Person Dietary Interviewers Procedures Manual. 2014. Retrieved from https://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/mec_in_person_dietary_procedures_manual_jan_2014.pdf
- Oliveira, V. The Food Assistance Landscape: FY 2015 Annual Report, EIB-150, March 2016. US Department of Agriculture, Economic Research Service; 2016. Retrieved from <http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib-150.aspx>
- Ollberding NJ, Gilsanz V, Lappe JM, Oberfield SE, Shepherd JA, Winer KK, et al. Reproducibility and intermethod reliability of a calcium food frequency questionnaire for use in Hispanic, non-Hispanic black, and non-Hispanic white youth. *Journal of the Academy of Nutrition and Dietetics*. 2015; 115(4):519–527. [PubMed: 25683819]
- 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. *Journal of the American Dietetic Association*. 2011; 111(3):419–424. [PubMed: 21338742]
- Perry CL, Bishop DB, Taylor GL, Davis M, Story M, Gray C, et al. A randomized school trial of environmental strategies to encourage fruit and vegetable consumption among children. *Health Education and Behavior*. 2004; 31(1):65–76. [PubMed: 14768658]
- Perry CL, Bishop DB, Taylor GL, Murray DM, Mays RW, Dudovitz BS, et al. Changing fruit and vegetable consumption among children: The 5-A-Day Power Plus program in St. Paul, Minnesota. *American Journal of Public Health*. 1998; 88(4):603–609. [PubMed: 9551002]
- 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. *Journal of the American Dietetic Association*. 2008; 108(2):362–366. [PubMed: 18237583]
- Regents of the University of Minnesota. NDSR User Manual. Retrieved from <http://www.ncc.umn.edu/products/ndsr-user-manual/>
- Reynolds KD, Franklin FA, Binkley D, Raczyński JM, Harrington KF, Kirk KA, et al. Increasing the fruit and vegetable consumption of fourth-graders: Results from the High 5 Project. *Preventive Medicine*. 2000; 30(4):309–319. [PubMed: 10731460]
- Ritchie LD, Rosen NJ, Fenton K, Au LE, Goldstein LH, Shimada T. School breakfast policy is associated with dietary intake of fourth- and fifth-grade students. *Journal of the Academy of Nutrition and Dietetics*. 2016; 116(3):449–457. [PubMed: 26433452]
- 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. *Journal of the American Dietetic Association*. 2004; 104(10):1577–1585. [PubMed: 15389417]
- Simons-Morton BG, Baranowski T. Observation in assessment of children's dietary practices. *Journal of School Health*. 1991; 61(5):204–207. [PubMed: 1943043]
- Smith, AF. Cognitive Processes in Long-term Dietary Recall. Hyattsville, MD: National Center for Health Statistics, Vital and Health Statistics; 1991. Series 61991. Retrieved from https://www.cdc.gov/nchs/data/series/sr_06/sr06_004.pdf
- Smith AF, Baxter SD, Hitchcock DB, Finney CJ, Royer JA, Guinn CH. Cognitive ability, social desirability, body mass index and socioeconomic status as correlates of fourth-grade children's dietary reporting accuracy. *European Journal of Clinical Nutrition*. 2016; 70(9):1028–1033. [PubMed: 27222153]
- Smith AF, Jobe JB, Mingay DJ. Retrieval from memory of dietary information. *Applied Cognitive Psychology*. 1991; 5(3):269–296.
- Upton D, Upton P, Taylor C. Increasing children's lunchtime consumption of fruit and vegetables: an evaluation of the Food Dudes programme. *Public Health Nutrition*. 2013; 16(6):1066–1072. [PubMed: 23067425]
- US Department of Agriculture, & Agricultural Research Center. USDA Automated Multiple-Pass Method. Sep 8. 2016 Retrieved from <http://www.ars.usda.gov/Services/docs.htm?docid=7710>
- US Department of Agriculture, & Food and Nutrition Service. Updated Offer versus Serve Guidance for the National School Lunch Program and School Breakfast Program in School Year 2013–2014 (Memo Code SP 45-2013). 2013. Retrieved from <http://www.fns.usda.gov/sites/default/files/SP45-2013os.pdf>

- US Department of Agriculture, Food and Nutrition Service, Office of Research, Nutrition, & Analysis. School Nutrition Dietary Assessment Study-III: Volume II: Student Participation and Dietary Intakes, Executive Summary, Report No. CN-07-SNDA-III. 2007. Retrieved from <http://www.fns.usda.gov/school-nutrition-dietary-assessment-study-iii>
- 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 Nutrition. 2003; 6(1):41–47. [PubMed: 12581464]
- Wengreen HJ, Madden GJ, Aguilar SS, Smits RR, Jones BA. Incentivizing children's fruit and vegetable consumption: Results of a United States Pilot Study of the Food Dudes Program. Journal of Nutrition Education and Behavior. 2013; 45(1):54–59. [PubMed: 23178042]
- Wilson DK, Kitzman-Ulrich H, Resnicow K, Van Horn ML, St George SM, Siceloff ER, et al. An overview of the Families Improving Together (FIT) for weight loss randomized controlled trial in African American families. Contemporary Clinical Trials. 2015; 42:145–157. [PubMed: 25835731]
- Wolfe WS, Campbell CC. Food pattern, diet quality, and related characteristics of schoolchildren in New York State. Journal of the American Dietetic Association. 1993; 93(11):1280–1284. [PubMed: 8227878]
- Yuan WL, Kakinami L, Gray-Donald K, Czernichow S, Lambert M, Paradis G. Influence of dairy product consumption on children's blood pressure: Results from the QUALITY cohort. Journal of the Academy of Nutrition and Dietetics. 2013; 113(7):936–941. [PubMed: 23684662]

Table 1
For 455 fourth-grade children, for meal component by serving period, items in each food-item accuracy category^a and expected^b, and cell χ^2 contribution

Food-item accuracy category	Serving Period: Breakfast						Serving Period: Lunch					
	Match			Omission			Match			Omission		
	n occur	n expect	χ^2 cell	n occur	n expect	χ^2 cell	n occur	n expect	χ^2 cell	n occur	n expect	χ^2 cell
Beverage	276	262	0.8	237	270	4.0	159	140	13.7	100	190	42.5
Bread	192	177	1.3	183	183	<0.1	79	95	0.3	117	101	2.5
Breakfast Meat	81	86	0.2	103	88	2.4	36	46	--	--	--	--
Combination Entrée	17	24	2.1	30	25	1.0	15	13	4.4	66	81	2.9
Condiment	20	21	<0.1	28	21	2.1	5	11	0.5	177	152	4.2
Dessert	0	1	1.2	0	1	1.2	3	1	9.0	52	50	8.9
Entrée	--	--	--	--	--	--	--	--	3.9	82	101	3.4
Fruit	18	33	6.9	40	34	1.0	27	18	7.0	175	140	8.8
Vegetable	0	1	1.2	3	1	2.7	0	1	6.3	161	134	5.2

^aEach item was classified by food-item accuracy category as a match (item observed eaten and reported eaten), an omission (item observed eaten but not reported eaten), or an intrusion (item reported eaten but not observed eaten).

^bFood-item accuracy category is a nominal variable; therefore, the individual and joint effects of the explanatory variables on food-item accuracy category are best interpreted via contingency tables that give counts of matches, omissions, and intrusions for each type of meal component. If meal component had no association with food-item accuracy category (i.e., if these classifications were *independent*), the expected count in each cell of each serving-period contingency table or “panel” would be the product of that cell’s corresponding row and column marginal totals, divided by the total count for that serving-period panel. The χ^2 statistic measures the association between meal component and food-item accuracy category, separately for each serving period; it sums, across all cells for the serving period, the squared difference between the actual and expected cell counts, divided by the expected cell count. Each cell’s contribution to this χ^2 statistic can be examined to see the nature of any association. Conclusions are based on χ^2 cell contributions which measure the association between meal component and food-item accuracy category for each serving period. When the category occurred about as often as expected under independence, the contribution to χ^2 was small. When the category occurred more or less often than expected under independence, the contribution to χ^2 was large. How large or small a cell’s contribution to the χ^2 statistic is can only be defined relative to the size of the overall χ^2 statistic for that contingency table. Although there is no formal cutoff defining a “large” contribution to χ^2 , a food-item accuracy category whose contribution accounted for a larger fraction of the overall χ^2 statistic would reflect that category accounting for a more severe departure from independence. The overall χ^2 statistic is 53.9 for the left panel (breakfast) and 142.8 for the right panel (lunch).