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Food Intake Recording Software System, version 4 (FIRSSt4): A Self-Completed 24 Hour Dietary Recall for Children

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Abstract

The Food Intake Recording Software System, version 4(FIRSSt4), is a web-based 24 hour dietary recall (24hdr) self-administered by children based on the Automated Self-Administered 24-hour recall (ASA24) (a self-administered 24hdr for adults). The food choices in FIRSST4 are abbreviated to include only those reported by children in U.S. national surveys; and detailed food probe questions are simplified to exclude those that children could not be expected to answer (for example questions regarding food preparation and added fats). ASA24 and FIRSSt4 incorporate 10,000+ food images with up to eight images per food to assist in portion size estimation. This paper reviews the formative research conducted during the development of FIRSSt4. When completed, FIRSSt4 will be hosted and maintained for investigator use on the National Cancer Institute's ASA24 website.

Keywords

diet; assessment; children; web-based; recall

Background

Assessing dietary intake in children is important to better understand what children are eating, what correlates with intake and to evaluate dietary change intervention programs. Self-reported dietary assessment of dietary intake, however, is prone to error among adults (Thompson and Subar, 2008) and more so among children (Mc Pherson et al., 2000). Error may lead to erroneous conclusions about meeting nutrient requirements (Beaton, 1994) or relating intakes to health outcomes or other variables (Ledoux et al., 2012). Error tends to

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Authors Contributions: Tom Baranowski was Principal Investigator; he conceptualized and designed all studies and wrote the first draft of this paper; Noemi Islam and Deirdre Douglass modified the food list terms and probes, and Noemi was a leader in FIRSSt design, and quality control of dietary assessment in all studies; Hafza Dadabhoy took most of the food pictures and participated in dietary data collection; Alicia Beltran participated in dietary data collection, especially qualitative data; Janice Baranowski managed all the studies; Debbe Thompson and Karen W. Cullen were co-investigators for all the studies; Amy F. Subar was the Project Scientist on U01 CA130762 and participated in study design. All the authors reviewed and extensively edited multiple drafts of this paper.

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attenuate findings regarding relationships toward the null, making it more difficult to detect relationships between diet and outcomes (Beaton, 1994, Freedman et al., 2011, Kipnis et al., 2002), but can aggravate some associations (Heitmann and Frederiksen, 2007).

The three most common dietary assessment methods are food frequency questionnaires (FFQ), 24 hour dietary recalls (24hdr) and diet diaries/food records (Magarey et al., 2010, Willett, 1998). FFQs query frequency of food intake over long time intervals (e.g. past year or month) are, low cost, self-administered and total nutrient and food intakes estimate analyses are generally automated.(Magarey et al., 2010, Willett, 1998). However, they lack detail regarding food preparation, consist of finite food lists and are cognitively difficult because they require respondents to remember and average frequency of intakes over long intervals that include seasonal intakes (Domel et al., 1994a, Subar et al., 1995). FFQs have been shown to have significant measurement error with respect to absolute intakes of some nutrients compared to recovery biomarkers such as doubly labeled water (Kipnis et al., 2003, Neuhouser et al., 2008). Diet diaries, in theory, could be the most precise method of diet assessment (Thompson and Subar, 2008), but often are not completed in real time as intended, affect what people eat, and, for children, require considerable assistance and supervision to facilitate completion(Domel et al., 1994b). The 24hdr method is considered among the most precise methods of assessing diet. It avoids the long-term memory, averaging, and lack of detail associated with FFQs , and avoids the reactivity issues associated with diaries. However, recalls have limitations related to short term memory and, like food records, require multiple days of assessment along with statistical modeling to correct for day-to-day variability (Dodd et al., 2006). Recalls could be more generally used if they were less expensive to investigators and less burdensome to participants. A logical next step in the evolution of innovative technology in dietary assessment (Thompson et al., 2010) is a self-administered web-based 24hdr that has low administration and coding costs, and has animated guides to be more engaging.

The Food Intake Recording Software System (FIRSSt) was an early self -administered 24hdr designed primarily to assess fruit and vegetable intake among children (Baranowski et al., 2002). Based on qualitative data (Cullen et al., 1998), FIRSSt used a hierarchically organized four-level tree structure of progressively more specific food groups to enable children to find specific food items they had eaten. Artist-drawn pictures of foods in four portion sizes helped children specify portion size consumed, and minimal probing that specified add-ons primarily to fruit and vegetables reduced respondent burden (Baranowski et al., 2002). A validation study demonstrated that FIRSSt was somewhat less accurate in assessing fruit and vegetable intake than a 24hdr conducted by a trained dietitian, when both were compared against observationally recorded previous day consumption of school lunch. Two problems children encountered were finding foods in the hierarchically organized food categories and selecting accurate estimates of portion size (Baranowski et al., 2002).

Subar and colleagues took this idea to a new level in developing the the Automated Self Administered (ASA24) 24 hour dietary recall for use with adults (Subar et al., 2007, Subar et al., 2010, Zimmerman et al., 2009). ASA24™ adapted the US Department of Agriculture's (USDA) Automated Multiple Pass Method (AMPM), which included five requests, or passes, for intake data across a 24hdr period (Blanton et al., 2006). In ASA24™, respondents are first asked to report a meal and time consumed. Next, they search (typing in the name of the food) or browse through hierarchically organized categories to find foods consumed at that meal. After all meals and foods are identified, the ASA24™ presents questions, referred to as probes, that the respondent must answer about each food. This includes portion size estimation questions that include 10,000 pictures of foods in multiple portion sizes per food to enable the respondent to match their memory of the amount consumed with the image that comes closest in size. Respondents are asked whether foods

or drinks were consumed between eating occasions that are 3 or more hours apart, are queried about forgotten foods, and are asked to review their recall before finishing. An animated avatar guides respondents throughout the recall, and participants are able to modify and edit their recall throughout. The resulting information is used to assign a food code and portion size to each food reported, which is then used to obtain nutrient and food group estimates from USDA's Food and Nutrient Database for Dietary Studies (FNDDS (USDA, 2010) and My Pyramid Equivalents Database (MPED) (Bowman et al., 2008)).

FIRSSt version 4 (FIRSSt4) builds upon the ASA24™. This paper reports on formative research conducted to contribute to its design features and describes how FIRSSt4 operates. Because the specific age at which children can reasonably accurately report their own dietary intake is unclear, assessing the component skills by age became one focus of the research.

Formative Research

Focus group discussions with 337 third to fifth grade students (i.e. approximately 9–11 years old) revealed that common triggers for recalling foods included preference for the food, habit in intake, behavior chaining (remembering one food which was linked to another food in memory), and memory of the food (Cullen et al., 1998). They reported difficulties in using measuring cups and spoons as aids in reporting portions consumed, and wanted the instrument to be "gamified", i.e. incorporate video game procedures to make it fun so as to encourage their participation (Bunchball, 2010). Four formative studies were conducted to explore design approaches that would facilitate finding or reporting foods, reporting portion size, and assessing challenges in doing on-line dietary assessment.

Finding foods in hierarchically organized categories

Because children had difficulties finding foods by "browsing" through a hierarchically organized set of progressively more specific food categories (Baranowski et al., 2002), we hypothesized that child-specific categories for foods might increase accuracy and speed of report, thereby minimizing burden. To identify child-friendly categories for organizing foods, 150 children were asked to sort cards with names and pictures of foods into categories that made sense to them. Five collections of cards were used: 62 diverse foods (to establish general categories), 48 food mixtures (e.g., lasagna, pepperoni pizza), 67 fruit, 64 vegetables, and 71 grain-based foods (Beltran et al., 2008a, Beltran et al., 2008c, Beltran et al., 2008b, Knight Sepulveda et al., 2008). Clustering analyses revealed that the identified food categories captured 89% or more of the variance in the categorization of the foods, suggesting that the categories were common across children. However, the children provided an enormous number of category names, suggesting that it would be difficult to use any one label that would enable all children to find a right food in each category (Beltran et al., 2008a, Beltran et al., 2008c, Beltran et al., 2008b, Knight Sepulveda et al., 2008). We therefore organized the food groups identified in these initial studies into a three-level hierarchical system for a second study.

In the second study, we compared the child-identified food categories against professionally-defined food categories to determine whether the child-specific categories enhanced the accuracy of child browsing to find foods they consumed. Two types of graphic presentations for food groups and subgroups also were explored to determine an optimal method based on usability testing and preferences of children. The first was called "coverflow," adapted from iTunes. Like music album covers, food groups were presented as graphically appealing covers with pictures of foods within that category. When selected, the cover flipped to reveal food subcategories. The second was a "tree view" structure, a more common computer graphic display that lists categories with subcategories indented

underneath. Child- versus adult-generated categories were tested with 120 children ages 8 to 13 years using both methods of browsing (Baranowski et al., 2010b). Neither of these methods led to more accurate categorization of foods, but the tree view with child categories was completed more quickly. Children ages 8 or 9 years tended to have lower accuracy and slower completion times to accomplish categorization than did older children (Baranowski et al., 2010b). Since neither hierarchical procedure enhanced accuracy, searching was emphasized over browsing in the ensuing studies.

Pictures for portion size estimation

A third study tested optimal methods for graphically displaying portion size images (Baranowski et al., 2010a) compared to accuracy against known portion sizes. We created over 14,000 images of foods in progressively larger portions (from half a serving to four servings) on a common plate. One graphic interface allowed users to use an arrow screen control to move among eight different sequentially-sized portion images displayed one at a time in full screen view. The second interface displayed all eight images on the screen at once in sequential order from smallest to largest. Another factor tested was the presence or absence of additional cues: in one interface the portions were presented on plates placed on a standard checkered tablecloth with a fork, knife and spoon; the second display also presented portions on plates but with a grey background only. The average percentage of correctly classified foods was 60.3%, with no differences by either design factor, separately or combined. However, when multiple small pictures appeared on the screen at once, children were able to estimate portion size twice as fast compared to larger pictures one at a time. Further, children tended toward more portion overestimation with the larger pictures. There were no age-related differences in accuracy or speed, suggesting the images minimized age differences in the errors of estimating portion sizes. As a result, FIRSSt4 will employ multiple small pictures on the screen at a time.

Is a FIRSSt4 needed?

To get a clearer idea of how best to modify ASA24™ to meet the needs of children, 120 children were asked to complete a 24hdr twice, once by self-administration of a Beta version of ASA24™ and once by interviewer administration using the Nutrient Data System for Research system (Feskanich et al., 1989) (Baranowski et al., 2012). Children were randomly assigned to do the ASA24™ or NDSR first, and then completed the other. A dietitian observed children completing ASA24™ and interviewed them afterward about what they liked and disliked. In the absence of true intake, the interviewer-administered recall was used as the reference instrument. Children ages 8 or 9 years had more errors of report on the ASA24™ in comparison to the interviewer-administered 24hdr, and based on usability issues identified by observation, a substantial number of modifications were proposed to enhance ASA24™'s ease of use by children, such as using a phonetic spell checker to minimize misspelling and using an avatar to stimulate continued interest (Baranowski et al., 2010a).

FIRSSt4

FIRSSt4 will be designed as a child-friendly adaptation of ASA24™ (Zimmerman et al., 2009). ASA24™ requires detailed information on the nature of the component foods and methods of preparation (e.g., 18 probe questions are triggered when a home-prepared hamburger on bun is reported). This detailed approach may result in more precise nutrient estimates, but it also may overburden respondents, especially children, if they do not know the answer to the questions. As a result, two dietitians (NI, DD) with expertise in dietary assessment with children led our team of dietitians in reviewing the 6804 food list terms (FLTs) organized into 123 categories in the ASA24™ system. The team deleted 45% of the

FLTs, based primarily on children not having reported consuming those items in national dietary surveillance studies, and simplified the wording of others (e.g., changing "carbonated water" to "bubbly water"). Similarly, they reviewed 413 detailed probes for FLTs and deleted 46%, primarily based on their accumulated experience that most children would not know the answer (e.g., low-sodium version or not, type of fat used in preparation). A preliminary analysis of data collected from the children using the Beta version of ASA24™ indicated that eliminating and modifying the FLTs and probes led to no meaningful differences in mean kilojoules consumed (7080 kilojoules from full system vs. 7130 kilojoules from modified system), nor in other commonly analyzed nutrients. This suggests that the modifications did not appreciably affect the mean nutrient estimates, as might be expected from removing queries children could not answer anyway.

Current Status and Future Plans

At this time the ASA24™'s graphic user interface is being reprogrammed to incorporate many of the proposed changes in earlier work, including a new, more interesting avatar, phonetic spell check and other modifications (e.g., updated nutrient database). A beta version of FIRSSt4 should be available in the fall of 2011, and a validity study is tentatively scheduled for the winter of 2012, which will include unobtrusive observation of a child's dietary intake at school breakfast and lunch on day 1, followed by FIRSSt4 and an interviewer-administered 24hdr on day 2. Because the new version of FIRSSt4 will have been modified to address many of the child-related usability issues of the adult-based Beta version of ASA24™, we will reassess whether children ages 8 or 9 years have the cognitive abilities to use FIRSSt4 accurately and quickly.

If demonstrated to be valid and feasible for children to self-administer, FIRSSt4 will be available for research free of charge on the National Cancer Institute's ASA24™ Researcher website. Analytic output for respondents will include total and food-specific nutrient and food groups. The FIRSSt4 will not be available for direct use by the general public.

Validation research, usability testing, response rates and experience, will inform future development. It may be that more attention will need to be paid to how to motivate and encourage children to complete FIRSSt4 on multiple occasions. More extensive and creative use of the avatar and wrapping a story around the dietary reporting task (e.g., design a narrative and interactivity about the avatar trying to solve the mystery of what the child ate) may focus the child's attention on the recall task and enhance motivation to use FIRSSt4, but research will need to verify that children enjoyed using it and there was no adverse effect on the accuracy of report (Lu et al., 2011).

Conclusion

In light of the difficulties experienced by 8 and 9 year olds in the formative research, FIRSSt4 is a 24hdr designed to be self-administered by children 10 years of age or older. We have taken the adult-based ASA24™, abbreviated the lists of foods to only those reported by children in national surveys, and simplified the probes to details that children could be expected to know. ASA24™ and FIRSSt4 each incorporate 10,000+ food images to quantify portion size estimation. FIRSSt4 will be available to researchers on the NCI web page. The NCI will maintain and periodically update ASA24™ and FIRSSt4 to incorporate new versions of the FNDDS and MPED data base.

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