Report

An overview of USDA's Dietary Intake Data System

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Abstract

Automated methods for collecting and processing food intake data have been developed by the Food Surveys Research Group at USDA to increase the quality and efficiency of food intake surveys and other dietary research studies. These automated methods are part of a Dietary Intake Data System, which consists of three computer systems and an extensive food and nutrient database. Computer systems included are the Automated Multiple Pass Method (AMPM) for collecting food intakes, the Post-Interview Processing System (PIPS) for reformatting data and assigning food codes, and Survey Net for final coding, quality review, and nutrient analysis. Features addressing data quality were prominent in the design of each of these systems. Components of the database, the Food and Nutrient Database for Dietary Studies (FNDDS), include food descriptions, food portions and their weights, and nutrients. These systems are currently used for research projects conducted by the USDA's Agricultural Research Service and for the dietary component of the National Health and Nutrition Examination Survey beginning in 2002. The AMPM, translated into French and adapted to collect data for Canadian foods, will also be used in the next Canadian Community Health Survey.
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Keywords: Dietary Intake Data System; Food intake; 24-h dietary recall; Food consumption survey; Food database; Nutrient database; USDA

1. Introduction

The US Department of Agriculture (USDA) has conducted periodic nationwide surveys on the kinds and amounts of foods consumed by Americans, using the 24-h dietary recall method, since 1965. Collecting and processing data for these large and complex surveys are significant tasks. The Food Surveys Research Group at USDA has developed automated methods for these activities to

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facilitate survey operations, ensure the use of standardized survey procedures, and expedite availability of survey results. These methods have been incorporated into a Dietary Intake Data System, whose main components includes three separate computer systems and an extensive food and nutrient database. The systems are the Automated Multiple-Pass Method (AMPM) for collecting food intake information; the Post-Interview Processing System (PIPS) for reformatting the data and automating food coding; and Survey Net for final coding, editing, and nutritional analysis. Components of the database, the Food and Nutrient Database for Dietary Studies (FNDDS), include food descriptions, food portions and their weights, and nutrients.

The AMPM and other components of the Dietary Intake Data System are currently being used for the dietary interview portion of the National Health and Nutrition Examination Survey, conducted by the US Department of Health and Human Services in collaboration with USDA (McDowell, 2003). Dietary supplements are not collected as part of the AMPM. The system is also being used for other dietary research projects conducted by the USDA's Agricultural Research Service, one of which is a study of over 500 individuals for whom energy intakes, as determined by the Dietary Intake Data System, are compared with total energy expenditure using the doubly labeled water method (Moshfegh et al., 2003). In addition to these uses in the US, Statistics Canada and Health Canada have recently translated the AMPM into French and are planning to use it in an upcoming survey in their country. Survey Net was adapted for use in Australia (McLennan and Podger, 1997) and several components of the USDA Dietary Intake Data System served as a model for a system now used in Israel (Goldsmith et al., 2000). This paper provides an overview of the Dietary Intake Data System and discusses how features of the system's components contribute to high-quality food intake data.

2. Automated multiple-pass method (AMPM)

2.1. New recall method

USDA has a long history of methodology research related to dietary surveys (Pao et al., 1989; DeMaio et al., 1993; Casey et al., 1999; Tippett et al., 2000). Research during the late 1990s centered on the development of an improved 24-h dietary recall method and incorporation of the new multiple pass method into a computerized data collection instrument, resulting in the AMPM. An automated multiple pass method for a 24 h food recall was first successfully introduced in a national survey in 1988 in NHANES III (McDowell et al., 1989). In general, a multiple pass method guides the respondent through a 24 h reference period of food intake more than one time, providing different opportunities for the respondent to remember food details and also additional foods. USDA also used a multiple pass method in the Continuing Survey of Food Intakes by Individuals (CSFII) 1994–1998, using a paper questionnaire (Tippett and Cypel, 1998). Pass 1 was an uninterrupted listing of all foods and beverages consumed the previous day. Pass 2 asked specific questions about each item, in the order reported in Pass 1, to obtain complete descriptions of the foods and amounts consumed, as well as eating occasion names and times. The third pass was a chronological review of foods reported at each occasion, with questions to help in remembering additional foods the respondent may have consumed during or between eating

Table 1
Automated multiple pass method

Step	Pass	Purpose
1	Quick list	To collect a list of foods consumed the previous day.
2	Forgotten foods list	To collect foods that may have been forgotten during the Quick List. Questions probe for foods by categories: nonalcoholic beverages; alcoholic beverages; sweets; savory snacks; fruits, vegetables, cheese; breads and rolls; other foods.
3	Time and occasion	To collect time and name of eating occasion for each food. Used to sort foods chronologically and group into eating occasions.
4	Detail and review	To collect a detailed description of each food consumed, including amount eaten and additions to the food. Also, to review eating occasions and times between occasions to elicit forgotten foods.
5	Final review	To collect additional foods not remembered earlier.

occasions. This early 3-pass method provided a basis for the development of the current 5-pass AMPM.

The objective in revising the CSFII method was to develop new approaches to help keep respondents interested and engaged in the interview process, and to help them remember all foods they had consumed. This was undertaken out of concern for under-reporting in 24-h recalls (Briefel et al., 1995; Kiesges et al., 1995), which has implications for the interpretation of dietary data. Trying different techniques, such as varying the order of questions, with a panel of 46 individuals showed that increasing the number of passes helped to improve the recall of foods and did not increase respondent frustration. The results were used to revise and expand the number and order of passes in the interview, adding memory cues and increasing the opportunities for respondents to remember and report additional foods. The resulting method is a five-step interview, as detailed in Table 1. The new method was tested in a nationwide pilot study of 800 individuals. Average calorie intakes and the number of foods reported were higher in the pilot study than in the 1996 CSFII (Moshfegh et al., 2001).

2.2. Automation of the interview

Automation of the new method began with the development of specifications, by nutritionists, that were later used to program the instrument. Specifications, documented in a Microsoft® Access database (Microsoft® Access, 2000), included all questions, a list of possible response options for each question, routing instructions for each possible response, edit checks, and special instructions to both interviewers and programmers. Special instructions to interviewers were incorporated into the program to appear on the screen at the appropriate times, while instructions to programmers brought to their attention the nutritionists' ideas or concerns about presentation and content. Specifications for step 4, the Detail and Review step, were the most complex, since they included all the questions necessary to elicit details and amounts about all types of food items. The beginning point for writing step 4 specifications was the USDA Food Instruction Booklet which included the questions used by interviewers to obtain the information in the CSFII

(USDA, 1997). Foods were grouped into 132 food categories and then appropriate specifications were written for each group.

Documenting the specifications in a database has simplified the task of updating the food detail questions to reflect new foods, or changes, in the marketplace. Before revisions are made to the AMPM, nutritionists revise the specifications database, which is then used by programmers to effect the changes. After an update, the specifications are also used as the model for testing all changes in the instrument.

Because of the large number and the diversity of foods in the US, many different questions, along with a very large number of possible responses, are included in the AMPM. Each response is programmed to go to the next appropriate question. The AMPM includes about 2400 questions and over 21,000 response options, with approximately 500,000 possible pathways within the instrument. The AMPM was written using the Blaise® (Blaise® 4.5, 2001) programming language, an off-the-shelf program used widely in North America and Europe for authoring data collection instruments. Using Blaise® simplified the programming task because many functions were pre-programmed in the software.

2.3. Collecting foods and their details

2.3.1. Recording foods

Foods reported by respondents are selected from a file called the Main Food List (MFL) and recorded in a table called the Respondent Food List. The MFL contains about 2600 foods. Frequency data from earlier surveys were used to identify commonly eaten foods to place on the MFL. Each food on the MFL is assigned to one of the 132 food categories. A category code attached to each food on the list signals to the program the appropriate set of questions to ask for a food.

Foods are listed in ways that respondents will likely report them. Brand name foods are listed if they are commonly used as part of the name. Brand names are included for candy bars, ready-to-eat cereals, soft drinks, fast foods, frozen main dishes and meals, and snack cakes. Many specific ethnic foods, particularly Mexican and Chinese, are included. Generic food names, such as "milk," "bread," "juice," "soup," etc. are included for use when a specific food is not listed. "Unknown food" is listed for use when an unfamiliar food cannot be classified into a generic food category. At step 4, a list of questions is provided to help identify "Unknown foods."

2.3.2. Questions and responses

Questions are designed to collect information about foods that allow them to be matched later with food descriptions and corresponding codes in the database. For example, Table 2 contains examples of responses to questions asked for "juice."

The program pre-fills the response for some descriptive questions, based on the food chosen from the MFL. Pre-filling answers reduces interviewer and respondent burden by reducing the number of questions asked. "Pre-fills" are based on the descriptive detail implied in the food name. In the example for juice, when a respondent reports consuming "juice" during step 1, the question "What kind was it?" is asked during step 4. However, if "orange juice" is reported during step 1, the answer to the question "What kind was it?" is pre-filled with "Orange" and that question is not asked.

Table 2
Questions in step 4 for juice

Question	Response example
What kind of juice was it?	Orange
Did the label say 100% juice?	Yes
Was the juice calcium fortified?	No
Was it made from frozen concentrate or powder, or was it in a carton, bottle, can or something else?	Carton

Table 3
Descriptive questions for fast food hamburger

Question	Response example
Was this from a fast food place?	Yes
What is the name of the fast food place?	McDonalds
What is the name of the sandwich?	Big Mac

Generic foods, like hamburger, have no pre-filled answers. However, the AMPM pre-fills all the food detail questions when fast food hamburgers, such as a McDonald's Big Mac®, is reported during step 1, as shown in Table 3.

Most questions require only one response but some allow more than one. For example, a question about the type of potato chip allows more than one answer from the following list of possible responses: baked, fat free, light, reduced fat, reduced sodium, regular, and unsalted. Questions about ingredients and their amounts in sandwiches and salads also allow multiple responses.

Possible answers are listed either on one screen or in a lookup table. When the number of possible answers exceed the limits of one screen, lookup tables are used to store them to eliminate scrolling from screen to screen. Ninety-three lookup tables are included in the program. The largest include possible answers for kinds of candy (361), frozen meals (353), cakes (335), cereals (315) and soups (292). ''Don't know'' and ''Refused'' are also allowed for all questions, and an ''other specify'' response allows the recording of an answer that is not listed as an option.

Responses to questions on food quantities provide a link to the food weights in the database. Quantities are recorded in two separate fields: *amount* and *unit*. For example, 1/2 cup of the orange juice described earlier is recorded as: *amount*=1/2; *unit* = cup. This weight will be calculated in processing based on the weight of a cup of orange juice in the database.

Units for estimating the amount of food eaten vary with the type of food. Answer options may include the following:

- Volume measures: tablespoon, cup, fluid ounce, quart, milliliter, liter, etc.
- Weight measures: ounce, gram, pound, etc.
- Dimensions: length, width, height, diameter

- General measures: relative sizes (small, medium, large), container units (bottle, can, carton, juice box).
- Specific measures for brand name foods.
- Food model measures.

USDA has developed a Food Model Booklet of two-dimensional drawings to help respondents estimate amounts of foods consumed. The booklet includes drawings of various sizes of glasses, mugs, bowls, mounds, circles, pat and spread sizes, a grid, two wedges and thickness blocks. When one of the drawings is used to estimate an amount, a symbol representing the specific model is selected as the "unit." These models are also linked to weights for specific foods in the database.

2.4. Quality control

One of the main advantages of an automated interview is the consistency maintained across all interviews. Questions and the potential responses are identified and are the same for all interviews. The interviewer reads a question as presented on the screen and the program automatically skips to the next appropriate question based on the answer received. While information about a food may be incomplete because a respondent does not know the answer to a question, it is never incomplete because an interviewer failed to ask the right questions.

Various types of edit checks are included throughout the AMPM instrument to improve the quality and consistency of the data. Some examples are:

- An "eating occasion edit" does not allow the reporting of two different eating occasions at the same time.
- "Impossible combination checks" do not allow illogical response combinations when multiple responses are allowed. For example, for the question about the type of potato chip, edits do not allow certain combinations of responses, such as fat free and regular.
- Missing data edits remind the interviewer that certain information must be entered before going to the next question. For example, if a respondent reports eating a green salad but no leafy green vegetable (lettuce, spinach, etc.) is entered as an ingredient, an edit prompts the interviewer for a "greens" entry.

3. Post-interview processing system (PIPS)

The PIPS is the next step for food intake data once they have been collected. This system extracts the data from the AMPM, assigns food codes where coding pathways have been established, and arranges the data into formats suitable for loading into Survey Net for final editing and review. A coding pathway leads to a specific food code through the responses that have been provided for the questions asked about a food. For example, the sample responses in Table 2 to the questions about "juice," lead to the food code "Orange juice; canned, bottled, or in a carton; unsweetened" in the database. Assigning food codes automatically not only saves time, it also increases data quality by eliminating coding inconsistencies. However, because numerous

coding pathways are possible within the AMPM that may seldom be used in an actual food recall, coding pathways are being developed based on data that have actually been collected in the AMPM and coded using Survey Net, described below.

4. Survey net

Survey Net is the computer-assisted food coding and data processing system developed for and used with CSFII 1994–96, 1998. Survey Net played a significant role in reducing survey processing time when it was introduced in 1994 and continues to be an important component of the current automated Dietary Intake Data System. Although originally designed for coding data collected by paper and pencil, it has been modified to accept data electronically as collected in the AMPM.

Survey Net operates on a computer network with multiple users accessing the food and nutrient database described later. Survey Net is used for food coding, assigning weights, reviewing and editing data, and calculating the nutritional composition of foods consumed. It has three access levels. Coders enter data at the basic level. Supervisors review and approve the data at the intermediate level. An advanced level is for review and approval by a nutritionist, if needed, and for calculating nutrient intakes. During the CSFII, levels 1 and 2 were used by the contractor responsible for survey operations and then transferred electronically to USDA at periodic intervals. Level 3 was used by USDA nutritionists to resolve difficult coding situations, and to conduct data quality assurance.

4.1. Coding foods

Even though most food codes will eventually be assigned by PIPS, a small proportion of foods (primarily new foods) will continue to be coded within Survey Net. Food descriptions and quantity data collected for each food in the AMPM are imported into a text box in Survey Net. Coders view this information as they select food codes and quantities in Survey Net to match the AMPM food intake data. Using descriptive information collected for each food, partial or complete food terms are entered into the Survey Net food search feature. Survey Net then displays all food descriptions in the database that contain matching terms.

4.2. Unknown foods

If a new or unusual food is not found in the database or a food cannot be matched exactly, Survey Net allows the food to be entered into a central file of unknown foods. Each food is automatically assigned a temporary food code number, which is used for coding the food if it is reported in subsequent intakes. USDA nutritionists research these "unknowns", decide how each is handled and make changes to intake records containing the unknowns. "Unknowns" are resolved by selecting a similar existing item from the database, by modifying a recipe, or by adding a new item to the database if the food is new to the marketplace. Additions to the database may prompt additions to the AMPM Main Food List or revisions to current questions and response options if they cannot adequately characterize the added food item.

4.3. Recipe modification

A recipe modification feature allows coders to view the pre-defined recipes listing ingredients and their amounts for all food codes in the database. Recipes can be modified to match more closely the food eaten by the respondent by substituting ingredients. For example, recipes for vegetables, eggs, and rice are modified to reflect the type of fat (oil, margarine, margarine spreads or butter) used in cooking. Modified recipes are retained in the database for future use in coding.

4.4. Food combinations

Survey Net provides the ability to link foods that were eaten in combination, although combination codes representing these links are now placed on the records by the AMPM. A combination code identifies foods that were consumed as one item. Individual foods in the combination are coded with their own separate food codes and amounts. Combinations include one food added to another, such as sugar to coffee, and foods with separate ingredients, such as salads and sandwiches.

4.5. Other features

A copy feature allows the coder to copy foods when the same food or foods are reported more than once within the same intake or by another person within a household. A notepad is available for communication between coders and data reviewers. Food records may be flagged by coders to alert nutritionists that an unusual coding situation exists that they should review. Records that require review are highlighted in Survey Net's summary screens and can be identified quickly. Once data have been through their final review, an analysis feature calculates the nutritional composition of each 24-h recall.

4.6. Quality control

An automatic check is performed each time a portion size weight is entered for a food. If the gram weight is above or below a pre-established range for each food, a message notifies the coder to check the entry. If the quantity remains as entered, Survey Net marks the record with a flag to prompt review by supervisors. Logic checks related to codes for eating occasion, time of day and foods eaten in combination are included as well, although some of these checks are now performed during data collection within the AMPM.

The food and nutrient database used in Survey Net, described below, is continually updated by USDA. Updated versions are inserted periodically into Survey Net so that the food data can be processed with the most recent information.

5. USDA Food and Nutrient Database for Dietary Studies (FNDDS)

The following FNDDS components are necessary for collecting, processing and analyzing food intake data using the USDA Dietary Intake Data System. The data files are multi-year; that is,

they may contain different entries for different years to reflect changes that have occurred in foods. The database is designed to aid in the analysis of trends in intakes in the US (Anderson et al., 2001). Database entries representing the current year are accessed directly by Survey Net. An updated version of the database is released biannually and can be found at the following website address: 〈http://www.barc.usda.gov/bhnrc/foodsurvey〉

The *Food Descriptions Component* contains names and descriptions for about 7000 generic or "main" survey foods. A generic description often represents one or more similar foods. Over 6500 additional specific descriptions are associated with the generic food; over half of the additional descriptions are brand name items. A unique code is assigned to each generic food description and this code is linked to the other databases in the intake system. Foods recorded in the AMPM intake are matched to food descriptions and their codes during processing in either PIPS or Survey Net.

The *Food Portions and Weights Component* contains about 30,000 weights for common portions for each food in the database. These are used to convert amounts of foods reported by respondents into gram weights which, along with the nutrient file, are used to calculate the nutrient content of each food amount by the Survey Net analysis feature. Generally, each food has multiple entries. For example, weights are included for 1 cup scrambled eggs, as well as small, medium, large, extra large and jumbo size scrambled eggs. Separate entries are included for different brand names of a food when their package sizes are unique. For example, weights for chocolate cupcakes include 19 brand name entries, such as Hostess Cupcakes[®], Little Debbie Snak Cakes[®], etc.

The *Nutrients Component* includes values for 61 nutrients and food components for each food in the database. The source of nutrient values is the USDA Nutrient Database for Standard Reference (USDA, 2002). Links between the database and the SR are included. The retention factor recipe calculation method (Powers and Hoover, 1989) is used for database items representing mixtures when there is no direct link with the SR. Before final processing for each national survey, nutrient values are updated with food composition values from the most recent SR. With each update, revised values are assigned as either a "data improvement" or "food change". Data improvements replace older values and are due to either improved analytical methods for determining the values, or better sampling of foods. Data improvements are used retroactively for recalculating past survey results. Food changes occur because foods have been reformulated. When a food has changed, multiple sets of values are found in the database for the food.

6. Conclusion

Dietary research methods have been enhanced through the USDA automated systems described in this article. The AMPM for data collection has several advantages over previous data collection methodologies. Standardized questions are presented in logical sequence, with their flow designed to keep respondents interested and engaged in the process. Questions probing for additional foods have been placed at optimal locations within the interview to help respondents to remember all foods consumed. The PIPS will eliminate much of the need for manually selecting food codes, which will reduce coding time and potential errors. Survey Net will continue to

provide opportunity to review new or unusual foods that are reported and to link the data with appropriate entries on the database for data analysis. Extensive research is conducted each year to keep the information current.

An assessment of the accuracy of the AMPM is ongoing. A validation study has been conducted comparing energy expenditure by the doubly labeled water technique with energy intake from the new method. Results from this study will provide baseline data on the accuracy of the 24-h recall method and will be used to adjust the method to improve its accuracy.

The AMPM and other components of the USDA Dietary Intake Data System are used in the dietary component of the National Health and Nutrition Examination Survey, which each year includes two 24-h recalls on a sample of approximately 5000 people of all ages. In addition, the Food Surveys Research Group uses the system in collaboration with other organizations to conduct dietary research, and various components of the system, especially the Food and Nutrient Database, are also used by other researchers. As mentioned in the introduction, both the AMPM, and Survey Net have been adapted by other countries for nutrition surveys.

Research organizations interested in collaborating with the Food Surveys Research Group to use the Dietary Intake Data System in research studies should contact Alanna Moshfegh at Amoshfegh@rbhnrc.usda.gov

7. Disclaimer

Mention of commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA over others not mentioned.

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