Computer-assisted self-interviewing: a multimedia approach to dietary assessment

Lenore Kohlmeier, Michelle Mendez, Jennifer McDuffie, and Mary Miller

ABSTRACT Currently available dietary assessment tools have limited ability to obtain valid data within the resource constraints of large-scale studies. Many obstacles to gathering data can be overcome with computer-assisted self-interviewing (CASI). Computers can conduct personalized, in-depth interviews without interviewers; provide standardized data collection with appropriate levels of probing; automate data entry; encourage subjects to review and correct inconsistent data; and ensure that responses are complete. Interactive multimedia tools can motivate subjects and improve participation. Visual and aural cues may stimulate recall and improve data quality. CASI is appropriate for use in populations in which literacy is low and in multiple ethnic groups. A prototype CASI diet-history program was developed for use in the United States. The diet-history approach was selected to improve cognitive support and capture information on usual diet. Scripts were based on recorded interviews with dietitians and interviewers from the National Health and Nutrition Examination Survey. At the end of the interview, participants are given information on how their reported nutrient intakes compare with current recommendations for their age and sex. The prototype was tested in focus groups of mixed age, sex, ethnicity, and education, with encouraging results. The development of multimedia-based dietary assessment tools seems a logical next step in improving dietary assessment methods. Am J Clin Nutr 1997;65(suppl):1275S–81S.

KEY WORDS Computer, self-interviewing, dietary assessment, epidemiology, nutrition, diet history, CASI

INTRODUCTION Dietary assessment in epidemiologic studies is based on either the responses of individuals to questions about their diet (1) or the measurement of biochemical markers of exposure to food-borne substances (2). The aims of these efforts are to quantify individual or group intakes and to rank individuals with respect to their consumption histories. Both these goals depend on data quality (validity and accuracy), logistic and monetary resources, and the time available for study.

Current dietary assessment tools are limited in their ability to meet resource and data-quality requirements. Because measuring biochemical markers of dietary intake is generally expensive and invasive, the use of these markers in a study restricts the size and scope of its population. In addition, many biochemical markers are difficult to interpret as indicators of long-compared with short-term diet or as markers of dietary intakes compared with physiologic status (3). As a result, most large-scale epidemiologic studies must rely on self-reported intake data, which are obtained with tools such as 24-h recalls, food-frequency questionnaires, and 3- to 14-d diet records to capture the typical or usual diet of individuals (1). There are, however, substantial concerns about the validity and practicality of each of these tools (Table 1).

Available computer technology may make it possible to address several of the concerns that undermine the effectiveness of methods for collecting self-reported dietary information. Computers offer the opportunity to conduct personalized, in-depth interviews without the costs involved in providing interviewers; to obtain standardized data collection with appropriate levels of probing; to provide instant data entry; to give immediate feedback to respondents; to encourage subjects to review and correct inconsistent data; to ensure that all responses are complete; and to provide visual and aural cues to stimulate recall. In this article we review some of the shortcomings of current dietary assessment methods. We then discuss the potential of multimedia technology and computer-based interviewing to improve dietary assessment and describe a prototype computer-assisted self-interviewing (CASI) system.

VALIDITY The validity of methods used for dietary data collection is a major concern of nutritional epidemiologists, who want to know how well the information collected with these techniques reflects the true intake of the individual (or group) during the time period of interest. Typically, validity is assessed by comparing dietary intake data with information collected by means of an accepted standard method. However, it is almost impossible to assess the true validity of a dietary assessment instrument because of the lack of gold standards that accurately measure habitual intake of free-living individuals (4).

Determination of an assessment method’s validity is also constrained by the selection process involved in recruiting

Addendum

1 From the Department of Nutrition and Epidemiology, School of Public Health, University of North Carolina at Chapel Hill, and Interactive Design and Development, Blacksburg, VA.
2 Funding for the demonstration model was provided in part by a grant from the Institute of Nutrition at the University of North Carolina.
3 Address reprint requests to L Kohlmeier, Department of Nutrition, School of Public Health, CB #7400, McGavran-Greenberg Hall, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7400. E-mail: lenorek@unc.edu.
subjects willing to participate in demanding or invasive procedures for determining usual intake. This process limits the generalizability of a tool’s validity for studying populations of different ages and ethnic groups. Validation is further complicated by the substantial variations in food intakes in the American diet. Because of the high within-person variance, methods that capture diet for only a short period (eg, 24-h recalls) have limited ability to assess habitual diet. On the other hand, techniques that attempt to measure long-term intakes may be subject to a “recency” effect, a bias that occurs when reported intakes reflect recent consumption patterns (5).

Correlated errors between imperfect assessment methods make it impossible to assess the true error in either of the two methods being compared (6). These correlations arise when respondents make the same reporting errors with both measurement instruments. For example, overweight subjects may consistently overestimate energy intake and overweight subjects may generally underestimate intake, regardless of the type of dietary assessment method used. This might artificially inflate agreement between two methods.

Given the many possible sources of error and bias, it is not surprising that validation studies usually show poor correlations between test and reference methods (3). Correlations of 0.2–0.6 are typical for crude (ie, non-energy-adjusted) nutrients, with a substantial loss in power resulting from low repeatability coefficients for many methods (7).

Because of its difficulty, method “validation” usually involves a comparison of data collected with two methods in a selected group of individuals over a relatively short period and subsequent extrapolation of the findings from the selected group to the population of interest. The reliability of this information depends on the following assumptions: use of the dietary assessment method has not induced a change in habitual diet, the respondents do not differ substantially from nonparticipants, the dietary components of interest are not greatly subject to correlated errors in measurement, and the time period of interest is reasonably captured. These assumptions are violated if participation rates are low or responses are incomplete or biased.

CASI can address two of these validation issues by ensuring that questionnaires are completed and enhancing participation rates in broader populations. The use of visual and aural cues in CASI may strengthen cognitive support and thus aid accurate recall of usual diet. CASI should also eliminate interviewer bias and decrease response bias. Interviewer bias cannot be present because the computer follows a predetermined decision tree in standardized probing responses and is not influenced by the physical characteristics of the subject. Response bias may be reduced because the perceived confidentiality of the computer-subject interface diminishes the tendency to give answers that will please the interviewer.

DEPTH OF INFORMATION

The depth of information required in dietary assessment depends on the exposure measure of interest. Interest may focus on foods or food groups, nutrients, nonnutrients in foods, specific food items, substances added to foods, food-preparation processes, or brand-name food consumption (8). The most common factors of interest are whether specific foods are consumed, how often they are eaten, and how much is normally consumed. Information about patterns of food intake may also be sought. The ideal dietary data-collection tool should deliver the necessary level of detail, with minimal measurement error, in assessing all foods and nutrients of interest.

A substantial investment of time by both subject and interviewer is needed to capture in-depth information. Simplified assessment tools cannot adequately capture details such as food-preparation methods or portion sizes. In addition, the number of questions and groupings of foods on questionnaires can affect response behavior (9). The use of a list prevents collection of meal-pattern information. CASI systems, however, like in-person interviews, collect meal-based data and can skip questions, thus supporting the level of branching needed to acquire details on foods consumed without burdening subjects by inquiring about items not eaten. CASI tools can also be tailored to provide the level of detail appropriate for a specific study.

COGNITIVE SUPPORT AND SUBJECT BURDEN

The ability of subjects to provide accurate data in response to a dietary assessment tool is an important determinant of the validity of the information collected with that tool. Because of the interest in reducing costs and simplifying data collection and entry, the cognitive burden on subjects has been given relatively little weight in evaluating instruments used to collect dietary data. Consequently, many tools rely on lists of foods or food groups, even though cognitive research has shown that recall of previous food intake is enhanced when a subject is prompted to remember certain meals consumed in context, instead of being given a list of foods from which items eaten can be chosen (10).
The use of visual cues (pictures of food), such as those provided by CASI systems, helps a respondent identify food items and amounts correctly, thereby minimizing misunderstandings, and overcomes literacy problems. It also enhances recall. Pictures have been found to be more memorable than words and are therefore useful when information must be remembered (11). In addition, images help to relieve boredom and improve the motivation of subjects, thereby increasing participation and completion rates and perhaps enhancing the accuracy of responses. Cognitive advantages of CASI systems are summarized in Table 2.

Subjects' perception of the burden of data collection may be reduced by providing feedback on their diet. When information is relevant to respondents and feedback to their responses is delivered immediately, subjects are highly motivated to participate in the effort (15). Programs tailored to multiple target populations can be a major advantage in population-based research. Interactive patient-education strategies using telephone communication, videotapes, and computers are increasingly being used to meet specific patient needs. These programs are developed by taking into account variables such as the sex, language, literacy level, ethnic background, socioeconomic status, and medical history of the target audience (16). The response to these tools has been positive; for example, 90% of a group of patients using an interactive program on breast cancer surgery indicated that they were glad they saw it, that they would watch it again, and that they would recommend it to others (16). CASI provides the means by which tailored interviews can be developed and immediate feedback given to subjects.

COSTS AND LOGISTICS

Methods used in epidemiologic studies must be able to be used successfully in large populations at a reasonable cost. Although interviewers enhance the value of a study, the costs involved in recruiting, training, and compensating them preclude their participation in large studies (12). Thus, to limit data-collection costs, dietary information is typically acquired from mailed, preformatted, paper-and-pencil questionnaires that permit little or no inclusion of foods not appearing on an itemized list. CASI, however, saves money by eliminating or reducing the need for interviewers and data-entry personnel, data review and correction procedures, and the printing and mailing of questionnaires. The use of portable computers for running CASI programs, as well as new forms of technology such as interactive television, can provide opportunities to conduct studies in large populations for less money and time than is required in investigations that use traditional methods.

The success of an administration of a questionnaire depends on how many members of the target population comply with the request for information and how many of those complying answer all the questions asked. Experience with food-frequency questionnaires has shown that many people are unwilling to invest the time required to answer them and that most of those who do respond do not answer all the questions posed. Kushi et al (13), for example, found that only 41.9% of the women to whom they sent a 127-item questionnaire actually responded to it, despite repeated contacts. Among those who did respond, 5.8% left ≥ 30 of the questions unanswered; the answers of another 0.7% had to be excluded because the energy intakes reported on the questionnaire were excessively high (21 000 kJ) or low (< 2500 kJ). Willett et al (14) found that in a group of women willing to participate in a validation trial, 10.8% left ≥ 10 items on the 99-item food-frequency questionnaire blank. CASI methods can increase participation and completion rates by providing a stimulating, interactive, multimedia environment.

**COMPUTERS IN DIETARY ASSESSMENT**

In the past 20 y, computers have become an integral part of everyday life as they have gotten faster, more versatile, more reliable, and more user-friendly. Today's user-focused computers talk, show movies, correct mistakes, and check electronic mail automatically. The spread of computers from the scientist's laboratory to the family room, workplace, bank, and public library has been dramatic. Many applications now being developed require citizens to deal with a computer to file records or obtain permits. Because of these changes, the feasibility of using computer-based interactive programs in the population at large is no longer an issue.

In dietary assessment, computers have long been used extensively to simplify the tedious task of analyzing intake data. They were first used to calculate nutrient intakes from data on the types and amounts of foods eaten. In this role, they replaced a dietitian with an adding machine, who needed 7 h to analyze the intake of 12 essential nutrients in each dietary record from one person (17). Computers were next used to code dietary data. A decade ago, food coders were employed to look up appropriate food codes in books and write them on paper forms for subsequent computerized food-to-nutrient conversion. Key punchers entered the data from the paper forms into the computers. Since then, optically readable forms have been developed to allow automated and direct coding of dietary data obtained by means of standard sequences of questions, such as those on food-frequency questionnaires. In a few instances, computers have been involved in guiding the wording, sequence, and depth of questions asked by interviewers (18) but they have not yet replaced interviewers in expressing dietary assessment questions.

Currently available technology, however, can support computer-assisted interviews with use of interactive software that applies multimedia tools (digital video, color graphics, written text, and sound) during the interview process. Such tools can provide cognitive advantages over traditional dietary assessment methods and have the potential to address several data-

---

**TABLE 2**

Cognitive advantages of computer-assisted self-interviewing

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aural instead of written questions</td>
</tr>
<tr>
<td>2</td>
<td>Meal cues instead of total diet recall</td>
</tr>
<tr>
<td>3</td>
<td>Communication enhanced by pictures</td>
</tr>
<tr>
<td>4</td>
<td>Ability to respond to delays</td>
</tr>
<tr>
<td>5</td>
<td>Higher level of concentration maintained</td>
</tr>
<tr>
<td>6</td>
<td>Neutral environment</td>
</tr>
<tr>
<td>7</td>
<td>Unbiased amounts and frequencies</td>
</tr>
<tr>
<td>8</td>
<td>Portion sizes visualized</td>
</tr>
</tbody>
</table>
quality concerns (Table 3). The design and structure of a prototype CASI dietary assessment instrument is described below.

THE CASI DIET-HISTORY INTERVIEW

A CASI diet history that uses the structure of a meal to guide the interview process has been developed and tested (19). The presentation format in the prototype model is lively and colorful, with images displayed throughout the program to help the user remember foods, preparation processes, and serving sizes. The hundreds of realistic images aid recall of both dietary habits (generic memory) and casual encounters (episodic memory) with foods (20). The aural component gives depth to the interview environment by providing background sounds that help respondents recall daily activities. The simultaneous use of text, sound, and images provides a congruent presentation and allows participation by nonliterate and deaf subjects. The stimulation provided by this multimedia environment facilitates recall to a much greater extent than do written tools and maintains interest in the interview, thereby improving concentration and the likelihood that recall will be accurate.

With the prototype CASI system, subjects who have agreed to give a diet history are provided with a portable color computer that can be used in the setting of their choice. As soon as the system is turned on, welcoming music plays and a series of images from the most recent season of the year shows people in many different settings enjoying a variety of foods. These initial interactions with users are intended to orient them to recalling their eating patterns or their mental organization of past experiences. Users are then told that they will be asked to provide information about their usual eating habits. The users interact with the program by using a pointing device. No technical expertise is required to operate the system and users set their own pace, which helps to optimize motivation (23). Before the interview begins, they are invited to “meet” four possible “interviewers” and select the one who will conduct the interview. The interviewers all have their own histories and their introduction quickly gives the program a personal tone. Choosing an interviewer should stimulate users’ interest in the program and engage them in the process (21, 22).

The CASI program follows the general sequence shown in Figure 1. First, basic demographic and anthropometric information, including height, weight, and age, is collected. At the start of the dietary assessment, the program ascertains exactly how often each meal is eaten, when a snack is substituted for a meal, and how consumption on weekends differs from that on weekdays. After the general eating pattern of the interviewee has been elicited, it is used as the framework within which the program asks about the categories and types of food eaten. The respondent is trained to interpret and use frequency and quantity question screens that have a uniform format throughout the program. The training is done by means of a tutorial sequence containing specific examples. Repeat users can bypass this sequence.

The program centers on a main menu that lists general categories of foods. Detailed information on usual meal and snack consumption in a selected time frame is elicited. Respondents select the categories of foods they usually consume at each meal or snack. The program explores 20 types of food, including breads, salads, and a variety of other dishes. Interviewees select the food types they usually eat; all others are then bypassed for the remainder of the food category. A frequency of consumption for each food eaten in the food group is then ascertained. If the answers (eg, rye bread, 4 times/wk, plus wheat bread, 5 times/wk) do not logically match the frequency given for the entire category (eg, some type of bread, 7 times/wk), the program will probe further, requesting clarification. After all questions pertaining to a meal are answered, a summary of responses is provided for the interviewee to review and, if necessary, correct.

The quantity of each of the individual foods typically consumed per eating episode is also ascertained. When answering questions about portion size, users are shown pictures of different portions and given aural cues that identify the sizes of the reference dishes. Various servings of food items are illus-

---

**TABLE 3**

Advantages of computer-assisted self-interviewing

1) Immediate results
2) Standardized question sequences
3) Automatic range checking
4) Completed questionnaires
5) Low cost
6) No data entry, editing, or correction
7) Immediate feedback to participants

---

**FIGURE 1.** Sequence of computer-assisted self-interviewing dietary assessment program.
trated, and respondents select the most appropriate visual representations of the servings they have eaten. The focus is on visual cues rather than size terminology. Similarly, information on food preparation is collected with use of images of such items as cooking oils, salad dressings, and mayonnaise. For example, a subject who reports eating mayonnaise on sandwiches is shown several pictures of mayonnaise being spread on a piece of bread and asked to identify which image most closely represents his or her usual eating behavior.

Bias is reduced by the provision of a neutral environment that removes judgments about quantities consumed. By asking users to select the image that best represents their eating behavior, the CASI program does not have to use words such as small or large to obtain the necessary information. The lack of judgmental terms increases the likelihood that more accurate reports of dietary intake will be given. Therefore, helping users recall information is only part of the CASI process; providing an environment in which users can honestly and accurately disclose their eating habits is equally important. CASI programs can also be designed to provide users with a perception of control, thereby reducing stress associated with responding to questions (24, 25).

Throughout the CASI interview, the system evaluates users’ input immediately and prompts subjects to confirm unusual behaviors, complete unfinished responses, and correct any inconsistent information. Before the interview ends, respondents are given a detailed evaluation of their reported diet in the form of a personalized notebook that summarizes the results of the interview. This notebook informs participants how their reported nutrient intakes compare with current recommendations for their age and sex.

DEVELOPMENT OF CASI PROGRAMS

The development of computerized multimedia approaches for dietary assessment will present nutritionists with many new challenges. The designs for such programs must match system capabilities with the needs of end users. Each presentation in the program is similar to a presentation on a stage in that it involves characters, scripts, and stage directions. The components of a multimedia production include onscreen text, speech, music, artist-generated images, computer-generated images, movies, and animation. The colors of graphic elements, animation speeds, compression algorithms for video clips, and bit rates for sound components all require attention.

We designed program specifications for a computerized, multimedia diet-history instrument that performs a meal-by-meal assessment of the habitual diet of Americans. Its content is similar in structure to a program previously developed, validated, and used in Germany (18). The dietary characteristics it is intended to survey include the specific foods (not food groups) consumed, meal by meal; the amounts eaten; the frequency of consumption; and the food-preparation methods used.

The design effort faced several initial obstacles, including the complex nature of the American diet (what is consumed and when, where, and how it is eaten), the heterogeneity of American culture (ethnic variations in food choices and eating habits), and the many different settings and literacy levels in which a CASI system must be applicable. The steps undertaken to address these obstacles and create the flow chart for the program are described below.

To incorporate into the CASI system the best features of dietary assessments conducted by experienced interviewers, interviewers from the National Health and Nutrition Examination Survey (NHANES), as well as local dietitians, were tape-recorded performing 24-h recalls and diet-history interviews (26). The transcripts of these sessions furnished the framework for the question sequence in the CASI program. The interviews also provided insight into the amount of flexibility the program would need to accommodate the variety in American eating patterns.

A review of the interviews allowed sorting and categorization of the questions. Specific aspects considered were the optimal organizational approach (meal by meal or according to food category), the order of probing that flowed best (ie, whether the sequence of questions should initially solicit detail on a specific food or should first ascertain frequency and quantity for a group of foods and then capture specific information), and identification of the most neutral wording that would still allow interviewees to feel comfortable. We observed a considerable range of interviewer styles, compared them, and chose approaches and wordings from each style to create a standardized, nonleading (unbiased), logical interview for the CASI program.

Once the “Americanized” framework for the CASI system was established, we compared the decision-tree branches and prompts of the American interviewer-driven version and the German computer-driven version of the diet history by examining all essential programming subroutines and branches that might be presented to interviewees. The resulting framework was compared with the protocol of the Minnesota Nutrition Data System (27) and the interviewer’s instruction manual from NHANES III (26) to ensure completeness of the food categories. The depth of probing was also compared with that in the Nutrition Data System and NHANES protocols. Use of these two sources helped to standardize the format so that a predictable order of probing could be achieved.

The results of these comparisons produced a draft of the screens for the program that was distributed to dietary assessment professionals, a research dietitian, a literacy expert, and a health behaviorist for review and comment. Revisions in the order in which screens appear and the wording of questions were made in response to the feedback provided by these reviewers. The final draft (240 screens) and a flow chart for the new, American version of the program (Figure 1) were then prepared.

FOCUS GROUP TESTING OF CASI PROGRAM

Design is a critical aspect of a multimedia program. Although it is valuable to have many capabilities available during the design process, it is an additional challenge to use them properly. Decisions concerning users are best made with input from users. In the development of our prototype CASI program, end-user input about its design was obtained through focus group testing to evaluate menu structure, whether the images used conveyed the intended concepts, and whether the program logic was appropriate and understandable.

One major concern regarding computer-based tools is the extent to which they can be used in computer-shy and
computer-illiterate groups. However, recent reports on computer usage (28, 29), ongoing projects using computer-based applications in various study populations, and focus group testing of CASI in groups of mixed sex, age, ethnicity, and education have indicated that computerized tools are applicable in a broad range of target populations. Research on computer use by elderly persons, a population of particular concern, has shown that the most important factors in the acceptance and use of computers are age, level of education, previous exposure to computers, and the type and degree of existing physical impairments, including those affecting vision, motor skills, and attention span (30–32). Many elderly people are apparently willing and able to become computer literate, although ergonomic adaptations that facilitate their use of computer equipment are often necessary.

Our CASI system was tested in several focus groups, including one consisting of elderly persons, with encouraging results. In a focus group session in which CASI was demonstrated at a retirement community in North Carolina, the participants were flattered that they had been asked to use a “high-tech” approach and expressed support for the program and concept. Results from this session are shown in Figure 2. Overall, 8 of 12 participants responded positively to the program, 3 said they would have preferred an interviewer, and 1 subject had no interest. Only 1 of 12 respondents had previously had substantial interaction with computers, whereas 7 had limited exposure. Nevertheless, the entire group understood the basic demonstration program and four respondents ultimately expressed a preference for using CASI over in-person interviews or paper-and-pencil questionnaires. Five participants said they would feel comfortable completing the program alone and five felt they might be comfortable using it with more guidance or after modifications were done to alleviate difficulty seeing the screen or hearing the soundtrack. Except for the one subject with poor eyesight, all members of this focus group responded positively to the use of pictures, although they suggested changes such as larger typefaces, bigger cursors, and louder sound to increase their comfort with the program.

The CASI dietary assessment program was also tested in a focus group of 20 college-age adults and low-income African Americans (9 men and 11 women), all of whom used the demonstration program on their own. Overall, the response to the program was positive in that the group had no difficulty understanding or responding to the questions. The nine computer-literate subjects felt comfortable completing the program independently, but responded negatively to repetition within the program and the overall pace of the interview. They suggested that the program include an option for accelerating the process. The 11 computer-illiterate subjects were satisfied with the pace and only mildly concerned about using the program without an interviewer. This group also expressed interest in the printouts of personal results provided at the end of the interview.

A group of practicing dietitians also expressed support for the CASI system. They thought that their clients would not be intimidated by the computer and that the system offered advantages over traditional paper-and-pencil interviews. The dietitians believed that the degree of detail captured equaled or surpassed the information they were accustomed to collecting, that the pictures and language were adequate for assessment of portion size, and that the meal-based approach and ability to add new foods would aid collection of accurate information.

CONCLUSION

Dietary assessment will continue to rely largely on the subjective assessment of habitual diet but technological tools are now available to help nutritionists and epidemiologists overcome many of the weaknesses of dietary assessment methods (Table 4). Application of these tools should motivate the
subjects of studies and thereby improve participation and increase the quality of the information gathered. Generalized visual stimulation, video presentations, soundtracks with narration and music, and interactive components with immediate feedback are well received by respondents to dietary assessment interviews and enhance their interest and concentration. CASI technology can therefore help nutritional epidemiologists obtain more accurate and more detailed dietary information from diverse populations. Problems such as language interpretation, low literacy, incomplete questionnaires, and disinterest resulting in low participation rates caused by the tedious nature of traditional methods can be overcome. The cognitive advantages of this approach are self-evident. The potential gains from the use of CASI technology will be evaluated in validation studies once the prototype has been more fully developed. The next step is the active design of a variety of multimedia-based tools and their application in the population at large.

We thank the many persons who contributed to this effort, including Alice Ammerman, Marjorie Busby, and Margaret McDowell, who provided us with taped dietary assessments and commented on the CASI questions and their sequencing; members of the Twin Lakes Retirement Community and the housekeeping staff of the University of North Carolina at Chapel Hill, who participated in focus group testing; and Susan Hastings, who conducted part of the focus group testing.

REFERENCES