United States
Department of
Agriculture

Human
Nutrition
Information
Service

Administrative
Report No. 382

RESEARCH ON SURVEY METHODOLOGY

Proceedings of a symposium held at the 71st annual meeting of the Federation of American Societies for Experimental Biology, April 1, 1987

May 1987

The research papers presented in this report were delivered at a symposium held on April 1, 1987, at the 71st Annual Meeting of the Federation of American Societies for Experimental Biology. The U.S. Department of Agriculture's Human Nutrition Information Service sponsored the symposium. HNIS staff members Dr. Robert L. Rizek and Dr. Eleanor M. Pao served as chairpersons, and Dr. Susan Welsh organized the symposium.

The Human Nutrition Information Service conducts periodic nationwide surveys of food consumption by households and by individuals. The research on survey methodology presented in these papers was sponsored by HNIS in order to improve the accuracy and efficiency of those surveys.

CONTENTS

DIETARY INTAKE MEASUREMENT IN USDA NATIONWIDE FOOD CONSUMPTION SURVEYS, 1977-1987

Patricia M. Guenther and Eleanor M. Pao
Human Nutrition Information Service

The U.S. Department of Agriculture began measuring dietary intakes by individuals in 1965 as an adjunct to the Household Food Consumption Survey (HFCS) because information on the dietary status of individuals in the United States was needed. Prior to that time, only household food use data had been collected. The results of a pilot test had indicated that most household respondents were willing and able to provide 1-day food recalls for their family members after they had completed the interview about food used by the household. In the first quarter of the 1965 survey, one household respondent provided recalls of food eaten during the preceding day for all members of the household, except that data were collected for only one-half of the adults 20 to 64 years of age. In 1965, food recalls were obtained for about 14,500 people.

During the Nationwide Food Consumption Survey 1977-78 (NFCS 77-78), the individual intake component was expanded. Individuals reported 3 consecutive days of dietary information for themselves, and this information was collected during all four quarters of the survey. In the first quarter, all household members were interviewed; in the last three quarters, one-half of those 19 years of age and older were questioned. Dietary data were collected from about 30,700 individuals in the basic sample.

The 1987 NFCS is about to begin. The data collection methods are basically the same as in 1977-78. A new procedure will be used to record the data about the household and its food use. The interviewer will enter the responses into a lap-top computer rather than record them on a paper form. The paper-and-pencil recording procedure will still be used for the individual intakes.

The individual dietary intake data are being collected from all household members regardless of age. About 15,000 individuals are expected to participate in the basic sample.

For the NFCS 77-78, the selection of the dietary data collection method was based, in part, on the experience gained during the 1965 survey. Also considered were some new survey objectives added to accommodate new users of the data and, of course, time and budget constraints.

In 1975, USDA had commissioned a special methodology study which was carried out by a private research firm--Response Analysis Corporation. This study systematically tested a number of variations in methods and procedures for dietary recalls and records in order to find out which ones would minimize both method-induced and respondent-induced errors. The investigators recommended that after completing the household food use interview, the interviewer obtain 1-day recalls and 2-day records from each household member.

This combination of recall and record methods was used in the NFCS 77-78. Household members were interviewed individually for the 1-day recall. The interviewer then trained each person in keeping the 2-day record and assisted the respondents in completing their records up to the time of the interview so that the second day was actually a combination of recall and record. The household respondent answered for children under 12 years of age and for any others who were unable to answer for themselves. The interviewer later returned to the home to pick up and review the completed records. Each household was given a set of measuring cups and spoons and a ruler to use when estimating portion sizes and a booklet which explained how to describe the foods eaten.

The 3-consecutive-day method used in the NFCS has several advantages over other possible methods. It places a minimum demand on the respondent's memory and record-keeping ability by starting in the middle of the reporting period.

The method also maintains respondents' cooperation. They are less likely to tire, to become bored, or to move to a different location during the reporting period than they would be in a survey that requires repeated interviews several times during a year-long period, for example.

Another advantage is that the 3 days are more representative of an individual's intake than 1 day would be. Also, 3 days enable the publishing of distributions of food and nutrient intakes by individuals.

Of course, no method is perfect. The disadvantages of the 3-day method include a possible method effect. The first day tends to be higher, on the average, than the second and third days in food energy and in the number of food items reported. Also, the variety of foods consumed by an individual is not captured as well by 3 consecutive days as it would be by 3 days that were nonconsecutive.

In 1977, USDA commissioned another private firm, Survey Design, Incorporated, to identify and recommend means for validating survey data. They recommended a combination of evaluation techniques because no single technique is without problems. Recommendations included publishing information about the quality of the survey's coverage, sampling problems, response rates, follow-up efforts, and measures of interviewer efforts, including variation in their response rates. They called for complete disclosure of changes made during editing and as a result of imputations and for an evaluation of the quality of the coded food descriptions and amounts. In general, they suggested that all information that could be useful in evaluating the data quality be published. They also recommended that respondents and interviewers be debriefed in order to get their assessment of the accuracy of the information reported.

National Analysts was the contractor who carried out the NFCS 77-78. In response to the recommendations from Survey Design, they developed a study to provide information on the quality and validity of the data derived from the NFCS 77-78. Most interviewers believed that the respondents were at least moderately accurate in reporting the number, quantities, and descriptions of the foods they had eaten.

About three-quarters of the respondents judged their listing of the number of foods eaten and the food descriptions on their 1-day recall to be very accurate; while only one-half considered the amounts reported to be very accurate. The greatest confidence in accuracy of reporting was expressed by young, well-educated respondents who lived in two-person households; and the least confidence was expressed by older, less-educated, low-income respondents who lived alone.

In the NFCS 87, the individual dietary intake data will again be collected using a 1-day recall and 2-day record. Unlike the NFCS 77-78, the 1987 survey will include all household members in all four quarters.

Several questions related to health issues have been added. For example, there are questions about the use of salt in cooking and salt added at the table and about the types of fat used in cooking and at the table. Respondents are asked if they have diabetes, high blood pressure, heart disease, cancer, or osteoporosis and if they follow a special diet, such as low-calorie, weight loss, low-fat, low-cholesterol, low-salt, low-sugar, or diabetic. They are asked if they have any chewing problems and the reasons for them. Questions have also been added about activity level during leisure time, regular exercise, and cigarette smoking.

One major difference between the 1977-78 and the 1987 surveys does not involve data collection: The nutrient data base has been expanded from 15 to 30 food components. In 1977-78 it included food energy, protein, total fat, carbohydrate, vitamin A (measured in International Units), ascorbic acid, thiamin, riboflavin, preformed niacin, vitamin B-6, vitamin B-12, calcium, phosphorus, magnesium, and iron. Starting with the Continuing Survey of Food Intakes by Individuals in 1985, we added saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, dietary fiber, vitamin A (in retinol equivalents), carotenes, vitamin E, folacin, zinc, copper, sodium, potassium, water, and alcohol.

In summary, while some improvements have been made in the NFCS between 1977-78 and 1987, the experience gained during the last decade has confirmed the choice of the 3-consecutive-day dietary data collection method.

VALIDATION OF FOOD INTAKE REPORTING BY MEN

Eleanor M. Pao
Human Nutrition Information Service

The study "Validation of Food Intake Reports by Men" was an extramural study for HNIS carried out by Dr. M.A. Caliendo while she was a faculty member at the University of Maryland.

In this experimental study the validity of food recall information was evaluated. Specifically, the study was conducted to determine --

1. ability of men to recall and estimate food intake on the day prior to an interview.
2. effectiveness of two types of measurement aids -- measuring utensils and models -- in helping respondents estimate portion sizes of foods and beverages ingested.
3. some problem foods and errors in reporting them.
4. agreement between recalls of men's food intake by the men and by knowledgeable family members as surrogate respondents.

METHODOLOGY

Subjects were 193 male volunteers from firms in the Washington, D.C., area. The men were between 18 and 60 years of age; most were well-educated and had middle- or high-level incomes. Each man had a family member familiar with his food intake who could be interviewed separately.

Subjects were recruited in the workplace cafeteria at the cashier's station after they selected and paid for lunch items. If an employee agreed to participate, an unobtrusive observer recorded food items and portion sizes on forms listing the day's menu. After lunch, his tray was taken to the kitchen where leftovers were weighed and recorded. An appointment was made with each man for an interview the next day during work hours in a private room provided by the firm. A separate interview was arranged with a close family member, usually a wife, either at home or at another designated place.

During the interview, a 1-day dietary recall was taken for the male volunteer. The interviewer also traveled to the place specified by the household member, who was asked to recall the man's same 1-day intake.

The men were divided randomly into two equal groups based on the type of measurement aid used to help in estimation of portion sizes during the interview. One group was interviewed using a set of standard measuring utensils -- measuring cups, measuring spoons, and a ruler. The other group was interviewed using a set of models -- dishware including glasses, cup, bowl, and spoons; shapes including disks, squares, rectangles, and wedges; and food models. Each man and his family member were interviewed using the same measurement aid. Interviewers were students in nutrition and were trained to use both types of measurement aid. For the analysis, food items were grouped into

22 categories based mainly on appropriate ways of measuring portions -- such as by volume, by piece, by dimensions, or by weight.

RESULTS

Comparison of lunch items actually eaten with those reported by the men revealed that the men recalled about 85 percent (86-87) of the food and beverage items actually eaten. Just under 15 percent (13-14) of the items actually eaten were omitted. About 6 percent (5-7) of the items recalled were not observed to have been eaten. Thus, errors of omission appeared to be more serious than errors in the form of fictitious additions. Differences between measurement aid groups were not significant, as would be expected (Table 1).

Table 1.--Enumeration of Lunch Items Eaten and Recalled by Men

	Measures Group	Models Group
	------percent------	
Eaten and recalled	86	87
Eaten but omitted	14	13
Not eaten but added	5	7

Foods most frequently omitted were: (1) accompaniments such as condiments, cream, sugar, butter, catsup; (2) vegetables; (3) gravies and sauces; (4) crackers and salty snacks; (5) irregularly shaped breads, such as rolls and muffins; and (6) cheese. Foods most frequently added that were not eaten included accompaniments and vegetables.

The accuracy of portion amounts reported by the men on their lunch recalls was compared with portion amounts actually eaten (Table 2).

The frequency of overestimation was greater than the frequency of underestimation or frequency of accurate recall of food items. About one-half of the portions were overestimated, about one-fourth were underestimated, and about one-fourth were accurate. Frequencies of over- and underestimation of portion sizes between the two measurement aid groups were not significantly different.

The degree of error in reporting portion amounts was based on the difference between recalled and actual weight for each matched item. The mean differences in quantity indicated that

Table 2.--Accuracy of Portion Amounts on Lunch Recall by Men

	Measures Group	Models Group
	-----percent-----	
Percent of portion amounts--		
--Overestimated	52	47
--Underestimated	23	27
--Accurately recalled	25	26
	------grams------	
Quantity estimation errors*:		
Overestimation errors	82±97	54±60
Underestimation errors	26±26	25±24

*Mean difference ± S.D., in grams; difference equals actual minus recalled weight.

underestimation errors were similar for both measurement aid groups. However, men using the measuring utensils, on average, overestimated portion sizes to a greater degree than men using models; and moreover, the difference was statistically significant ($p < 0.05$). The large standard errors indicate great variation in the ability of men to estimate portion sizes.

The degree of error on the side of overestimation (determined by mean difference between actual and recalled weight in grams) was significantly greater in the measures group than in the models group for three food categories: main dishes, vegetables by volume, and beverages. Underestimation error tended to be greater in the models group than in the measures group, but differences were not significant (data not given).

Models appeared to produce closer estimates of portion sizes than measuring utensils in representing volumetric contents. Estimates of food portions in terms of dimensions were similar for the measures group and the models group. Foods measured by dimensions included meats, breads, sweet baked goods, and fruits and vegetables by the piece. About 30 percent of the items were estimated without reference to a model.

When the interviewers asked a family member to report the lunch eaten away from home by the male volunteer, only one-third of the family members attempted to recall the men's lunches; the others said they lacked information. On average, less than half of the items reported by the men were also reported by the family members who did answer. Obviously, this approach had serious shortcomings.

Although family members had trouble reporting the men's lunches away from home, the recalls of the morning and evening meals were expected to show greater agreement, especially if the men ate with family members.

Of the 193 pairs, 58 percent reported men's breakfasts. Of the men who ate breakfast, 74 percent said they ate alone. The men reported more items and usually larger portion sizes for nearly all food groups than did the family members. The percentage of items recalled by both members of a pair was highest for milk, cheese, breads, and grains. However, amounts reported by the two members of a pair agreed 25 percent or less of the time, except for meat and sliced bread.

The evening meal was reported by 89 percent of the 193 pairs. A larger proportion of the men ate this meal with family members. Similarity between number of items and percentage of matches reported by men and by family members was greater for the evening meal than for breakfast. In contrast with breakfast, evening meal portion sizes tended to be larger on recalls by family members than on recalls by the men for 12 of the 22 food groups. Few portion sizes were of equal size on recalls by pairs.

CONCLUSIONS

This study indicates that food intake recalls are in closer agreement if both the man and the family member reporting the man's intake have eaten the meal together rather than apart. Results of the study concerning measurement aids suggest that users of both types overestimate and underestimate with about the same frequency, but that use of measuring utensils lead to greater error in overestimations than did use of food models.

Important implications of this study are that the two types of measuring aid are used differently: They are not interchangeable. For recalls taken away from home, models helped estimate volumetric measure more closely than measuring cups and spoons. For food recalls and food records administered in the home, the measuring utensils should be more helpful than models, assuming that the measuring utensils are used consistently as directed to convey the volume content of servings in tableware as used by the respondent. Measuring utensils cannot double as models. The NFCS 1987 contains a new question to learn how often and for what purpose measuring utensils are used during interviews.

RESULTS OF AN EXPLORATORY STUDY OF LONGITUDINAL MEASURES OF INDIVIDUAL FOOD INTAKE

Lucy B. Wilson and Beth B. Rothschild
National Analysts

BACKGROUND

In the late '70s and early '80s, a strong message was delivered by the nutrition research community -- it was a call for a national nutrition monitoring system. The Surgeon General, the National Academy of Sciences, and other leaders recommended that a national nutrition surveillance system be established to help study and understand health and the impact of diet on well-being.

Among some of the features of such an ongoing monitoring system were the following:

- It was to be based on a statistically valid sample of the total population from which sound samples of target populations (such as high-risk women) could be drawn.
- It was to provide adequate baseline information about the population under investigation. In addition to intake data, detailed information about the individual consumer and factors that might be related to patterns of consumption were to be captured.
- It was to yield valid and reliable data that users would feel confident in analyzing and using to plan programs or make policy recommendations.
- It was to allow the timely reporting and dissemination of data. The system needed to be efficient in data collection and data reduction/manipulation procedures so that results could be publicly shared promptly.
- It was to be capable of detecting and predicting trends.
- And, finally, it was to be cost-effective.

The USDA and, more specifically, the Human Nutrition Information Service took up the challenge to create a national monitoring system by building on its prior experience with such information-gathering research efforts. The approach the researchers in the Human Nutrition Information Service selected was a panel design in which participants would be inducted into the monitoring sample for a period of 1 year. At different times throughout that 12-month period, panel members would be recontacted and would report on the foods and beverages they ate during a specified timeframe. These respondent-reported data would be translated into nutrients and calories and the results analyzed for programmatic and other purposes. Every 12 months, the then-current set of panelists would be released and a new monitoring group or set of groups convened.

Conceptually, the model was a good one, but two questions loomed large about its implementational feasibility:

1. Was it "doable"? Could such a longitudinal nutritional survey, in fact, be created? Would it be judged successful by objective research standards?

2. Which data collection methods were best designed to capture panel nutritional data?

The National Analysts Division of Booz Allen & Hamilton, under contract, assisted the Human Nutrition Information Service, USDA, in answering these questions in a project we called "An Exploratory Study of Longitudinal Measures of Individual Food Intake."

DATA COLLECTION METHODS TESTED

USDA asked us to consider eight different approaches to collecting panel data over the course of a year. A brief description of each of the data collection approaches is as follows:

<u>Method #1</u>

In-person contact in the first quarter to gather 3 consecutive days of food intake reporting. Follow-up contacts in the second, third, and fourth quarters, also in person, to collect 3 days of intake each time.

Total contacts = 4 Total days of reporting = 12

<u>Method #2</u>

In-person contact in Quarter #1, spread across three separate occasions -- once a month for the first 3 months -- 1 day of intake gathered. Follow-up contacts in Quarters #2, #3, and #4 also in person, but limited to one contact per quarter; 1 day of intake reporting each contact.

Total contacts = 6 Total days of reporting = 6

<u>Method #3</u>

Same as Method #2 in terms of number and types of contact. Differed in the use of a semistructured instrument to report food consumption.

Total contacts = 6 Total days of reporting = 6

<u>Method #4</u>

In-person contact in Quarter #1 to gather 3 consecutive days of food intake information. In subsequent quarters, panelists were mailed 2-day intake diaries for completion and return.

Total contacts = 4 Total days of reporting = 9

<u>Method #5</u>

All-mail contact. In each of the four quarters, a 2-day intake diary mailed to panelists for completion and return.

Total contacts = 4 Total days of reporting = 8

Method #6 — In-person contact in first quarter to gather 1 day of intake. Follow-up contacts in subsequent quarters switched to telephone and 1-day recall of intake.

Total contacts = 4 — Total days of reporting = 4

Method #7 — All-telephone contact. In each of four quarters, 1 day of intake reported by telephone.

Total contacts = 4 — Total days of reporting = 4

Method #8 — Modified all-telephone contacts. In each of four quarters, 1-day diary mailed to panelists. Telephone contact made to aid respondent in completing the diary and to urge its return.

Total contacts = 4 — Total days of reporting = 4

A ninth method was employed in the research design to serve as a control group. In the second, third, and fourth quarters, the standard National Food Consumption Survey approach was used to gather intake. A new group was contacted each quarter in person and asked to supply 3 consecutive days of food consumption data. The results for this method served as the standard against which to judge the results from other methods for that quarter.

CRITERIA

We set up several criteria by which to judge the results from each of these experimental treatment methods. These measures include indicators of data quality, costs, and sample integrity.

Completion Rates

1. Some cooperation: percentage of panelists providing data for at least part of the possible contacts.

2. Full cooperation: percentage of panelists providing data at all contacts.

Data Quality

3. Intake days covered: percentage of panelists reporting on a different day of the week each quarter.

4. Food codings reported per intake day: mean number of food or beverage items reported daily by panelists. Typically, the more extreme the number of items reported -- either high or low -- the greater the overreporting or underreporting of actual consumption.

5. Incomplete food descriptions: mean number of default food codings per day. When the reported foods or beverages were not described clearly enough or in enough detail to use the full power of the USDA code structure, we were forced to use a less specific default code. This meant a loss of accuracy in the individual's consumption patterns.

6. Incomplete portion sizes: mean number of default quantity codings per day. When the reported amounts of foods were not described fully or imprecise measures were used, we were forced to use a default "standardized" portion code. The more often the default quantity code was used, the greater the challenge to the validity of the reporting for the given individual.

7. Kilocalorie reporting: average total calories consumed per day as determined by the food and beverage items coded. Again, any method associated with the upper or lower extremes of consumption was suspect. Independently valid data were hard to come by here.

Respondent Burden

8. Respondent burden: mean number of minutes required of each panelist every quarter.

Process Measures

9. Recontacts: percentage of panelists requiring recontacts or callbacks to correct, clarify, or further prepare the data for analyses.

10. Data preparation time: mean number of minutes required to translate respondent-provided data into analyst-oriented codes. Obviously, this has implications for costs as well as data quality impacts.

THE RESEARCH

To test the eight different data collection approaches, we conducted a field experiment in four communities: Philadelphia, PA; Baltimore, MD; Wilmington, DE; and Vineland, NJ. We identified as potential panelists the "average homemaker"/"typical meal planner/preparer." This was a woman between the ages of 20 and 69 living in a household with income between $10,000 and $35,000. In addition, eligible households resided in an experimental community, had two or more persons, did not receive Food Stamps, and did not plan to move for at least 12 months.

Each of the women was randomly assigned to one of the eight treatment conditions or the control group. Each group began the year-long experiment with approximately 155 women assigned to it. Sociodemographic and dietary characteristics of the participants are shown in Table 1.

We examined the make-up of the panels and ran tests of significance (one-way ANOVAs) on key demographic characteristics for panel members at the beginning of the experiment and for those who were still participating at the end.

Table 1.--Sociodemographic and Dietary Characteristics of Experimental Panel Participants

Characteristics	Initial sample panelists	Fully cooperative panelists
	-----------percent-----------	
Age:		
20 to 29 years	23	21
30 to 39 years	30	30
40 to 49 years	19	20
50 to 69 years	28	29
Mean	40.7 years	41.1 years
Race:		
White	91	92
Nonwhite	9	7
Ethnicity:		
Hispanic	4	4
Non-hispanic	96	96
Educational level:		
High school or less	70	70
College or beyond	30	30
Employment status:		
Working	60	58
Nonworking	40	42
Dietary Status:		
Dieting	14	14
Not dieting	86	86
Household size	3.5 people	3.4 people
Household income	$24,900	$25,000

Several important factors emerge from these analyses. First, there were no significant differences among the nine groups for any of these key sociodemographic variables at the onset of the experiment. Second, when we looked at these data again for those who remained part of the intact panels, the data showed no differences across panel conditions for these key sociodemographic variables. In fact, comparison between the characteristics of the full set of panelists at the onset and the subgroup of those who cooperated fully show that the latter are very representative of the total. We are confident, therefore, that any differences noted among the panels in the criterion measures are likely to be a function of the differences in data collection methods and not due to panel composition differences or panel-by-method interactions.

RESULTS

Let us now turn our attention to the results for each of the eight data-collection approaches for each of the criteria. (These differences were tested using ANOVA and Duncan's range tests, and the strength of association was measured by omega-squared. Because of the many significance tests run and the interrelationships among many of the outcome measures, we used statistical significance as a guide, rather than as the sole determinant of method selection.) The results are summarized in Table 2.

Table 2.--Results for Eight Experimental Data-Collection Approaches

Criterion	Method							
	1	2	3	4	5	6	7	8
Some cooperation (percent)	88	81	83	83	53	88	87	56
Full cooperation (percent)	63	61	67	24	19	64	67	25
Intake day coverage (percent)	64	83	68	31	28	39	43	42
Daily food items reported (mean)	15.1	15.6	16.7	16.6	16.8	17.0	16.6	17.7
Incomplete food descriptions (mean)	1.6	1.7	2.5	1.6	1.7	1.9	1.9	2.4
Incomplete portion size (mean)	.3	.2	.4	.4	.7	.5	.6	.5
Kilocalories (mean)	1,432	1,579	1,579	1,508	1,527	1,490	1,494	1,583
Survey time (min.)	147	188	237	199	225	108	112	186
Respondent recontacts (percent)	88	81	72	97	97	54	50	92
Data preparation time (min.)	45	60	91	47	48	56	57	57

Method #1

All in-person contacts; 3 clustered intake days on four separate occasions

- Had the highest rate of cooperation of any approach; 88 percent cooperated at least some in spite of having the largest amount of work to do (i.e., 12 days of reportings).
- Had good full cooperation rate (63 percent).
- Did medium-well in getting the different days of the week represented in intake reporting; 64 percent of those who cooperated fully reported for a new day of the week each quarter.
- Low in the average number of food codings at about 15 per intake day. May be underreporting intake.
- Good results in both measures of incomplete descriptive and amount reporting. Among the lowest of all the approaches.
- Lowest kilocalorie reporting (1,432 kcal), which, again, may not be good.
- In spite of the large number of days of reporting each quarter, the respondent burden was moderate at 147 minutes a quarter.
- This approach required high levels of recontacts to adjust the data for missing, incomplete, or uncodable responses (88 percent of all respondents recalled for information).
- The document handling time extremely modest at 45 minutes per day of intake reporting.

Method #2

All in-person; 3 unclustered intake days first quarter, 1 intake day each of the following quarters

- Good cooperation rates for full (61 percent) and some (81 percent).
- Very good spread of contacts across weekdays, the best of any group at 83 percent.
- On the low side in number of food codings.
- But also modest in incomplete description and quantity reportings (1.74 and 0.24).
- Higher kilocalorie reporting (1,579 kcal).
- Respondent burden (188 minutes per quarter) was especially disappointing given fewer days of reporting than for Method #1 (12 days versus 6 days).
- Significant level of follow-up with respondents was required to "make whole" the data (81 percent).
- Moderate amount of time to prepare the data (60.4 minutes).

Method #3

All in-person; 3 unclustered intake days first quarter, 1 intake day, each of the following quarters; semistructured questionnaire

- Still good cooperation rates (83 percent and 67 percent).
- Reasonable spread across days (68 percent).
- Fuller reporting of food coding (16.68) per day.
- Unfortunately, higher number of incomplete/default codings for descriptions (2.52) and moderate for amounts (0.40).

- Kilocalories same as Method #2, which is interesting -- the unstructured and semistructured instruments netted the same.
- And, surprisingly, required the greatest amount of preparation time (91 minutes) to translate into scorable, machine-acceptable data.

<u>Method #4</u>

In-person/mail; 3 clustered intake days first quarter, 2 intake days by mail each of the following quarters

- Low full-cooperation rate (only one out of four persevered), although partial cooperation is good (83 percent), which can be attributed to the initial personal interviewer contact in the first quarter.
- Poor coverage across weekdays by full-cooperators (31 percent).
- Full reporting of food codings (16.6).
- Not bad in specificity of descriptions (1.62) and amounts.
- Kilocalories reported are midrange (1,508).
- Respondent burden is relatively great (198.6 minutes) per quarter.
- Required highest levels of recalls to adjust the data (97 percent).
- Among the easiest to code (47 minutes) and prepare for processing.

<u>Method #5</u>

All mail; 2 clustered intake days on four separate occasions

- Worst performance for cooperation (at 53 percent for some cooperation and 19 percent for full).
- Poor spread across reporting days (28 percent).
- Full reporting of intake was supplied by those who fully cooperated (16.80).
- Largest number of unspecific amount reported (0.71).
- Moderate amount of kilocalories (1,527).
- Very burdensome (225 minutes).
- Many callbacks to rectify the data (97 percent).
- However, low in coding/data preparation time (48 minutes).

<u>Method #6</u>

In-person initially; switched to telephone intake 1 day per quarter

- Good on almost all measures.
- Good cooperation rates (88 percent some; 64 percent full).
- Lower on spread across weekdays (39 percent).
- Second highest in number of food codings reported per day at 17.0.
- Medium in incomplete reportings for food descriptions (1.93) and amounts (0.5).
- In the midrange for kilocalories.
- The least burdensome (108 minutes) per quarter at one intake day each contact.

- Among the lowest in incomplete reportings (54 percent).
- Moderate in processing time requirement (56 minutes).

Method #7 — All telephone; 1 intake day per quarter

- Among highest cooperation rates (87 percent some, 67 percent full).
- Low to moderate spread across days of reporting (43 percent).
- Midlevel in food codings (16.57).
- Medium in unspecified descriptions and amounts.
- Midrange in kilocalories.
- Second lowest in burden (112.30 minutes).
- Required the least recontacts to adjust the data (50 percent).
- Midrange in preparation time (57 minutes).

Note: The two telephone methods track together in many ways.

Method #8 — Modified all-telephone; intake day per quarter mailed out with telephone assistance

- Among the lowest cooperation rates (more like the mail methods than telephone).
- Low to moderate spread across reporting days (42 percent).
- Highest number of food codings (17.7).
- High in incomplete food description (2.39).
- Highest amount of kilocalories reported (1,583).
- A lot of contact required with respondent. Burden is 186 minutes.
- Many respondents were recontacted to retrieve missing information or to adjust inadequate descriptions and amounts.
- Midrange in coding efforts (57 minutes).

CONCLUSIONS

To help summarize these results, we can use a simplified table (Table 3).

Looking down the columns, the data collection methods with poorest showing are the three approaches involving mail. Method #5, the all-mail approach, has the largest number of poor ratings. Method #8, the mail-with-telephone-assistance approach, is next in line with the added disadvantage of being high in food codings and kilocalorie reportings, which is likely to be indicative of overreporting. The final mail approach is Method #4, and there are enough holes in the performance criteria for this approach to be eliminated also.

The semistructured questionnaire administered in person in Method #3 has as many poor ratings as the previously dismissed mail approach; therefore, we narrowed the range of potential data collection approaches to the personal and the telephone

Table 3.--Ratings of the Eight Experimental Data-Collection Approaches

["1" signifies good performance; "2", acceptable performance; "3", poor performance; "L" indicates the lowest number; "H", the highest]

Criterion	Method							
	1	2	3	4	5	6	7	8
Cooperation	2	2	1	3	3	2	1	3
Intake day coverage	1	1	1	3	3	2	2	2
Number of daily food items reported	L	-	-	-	-	-	-	H
Incomplete food descriptions	1	2	3	1	2	2	2	3
Incomplete portion sizes	1	1	2	2	3	2	3	3
Kilocalories	L	-	-	-	-	-	-	H
Survey time	2	2	3	2	3	1	1	2
Respondent recontacts	2	2	2	3	3	1	1	3
Data preparation time	1	2	3	1	1	2	2	2

unstructured methods (#1, #2, #6, and #7). We chose to not recommend Method #1, the all-personal, 3-days-per-quarter approach, because it yielded the lowest food and beverage and kilocalorie reportings. We were suspicious that it may have been prone to underreporting actual consumption. This is not surprising, given that the respondent is asked to provide 3 days of intake reporting each quarter. The willingness to mention every food item consumed may have weakened by the second and third days of record keeping each time.

Each of the three remaining approaches appears viable as a data collection method for a national monitoring system when evaluated against only those measures used in this experimental project. We, therefore, turned to some external criteria to make our selection.

Returning to the previously mentioned recommendations for a national monitoring system, the approach was to be cost-effective. An all-in-person data collection approach, such as Method #2, will be more costly than an all-telephone (Method #7) or in-person-and-telephone combined approach (Method #6). As we have already acknowledged that the three remaining approaches are equally effective, we can eliminate Method #2 in terms of the cost-effectiveness criterion.

Referring again to the earlier recommendation that the research be carried out with a statistically valid sample of the total population, the all-telephone approach (Method #7) is not appropriate. While sound telephone samples can, of course, be devised, they exclude households without telephones. It is very likely that some of the critical, at-risk target populations which would be important to include in any national nutrition surveillance system would have a portion of their numbers residing in households without telephone service or without consistent service during the year-long observation period.

It is for these reasons that we recommended to our research sponsors at USDA that they use data collection Method #6 -- an initial in-person contact followed in subsequent waves by telephone contacts for households with telephones and in-person contacts for nontelephone households. One day of intake for each contact would be recorded. This is the approach which was incorporated into the Continuing Survey of Food Intake of Individuals.

PILOT STUDY OF MEASURES OF INDIVIDUAL FOOD INTAKES OF THE LOW-INCOME POPULATION

Robert B. Reese
Human Nutrition Information Service

INTRODUCTION

The 2-year Pilot Study of Measures of Individual Food Intakes of the Low-Income Population was carried out under contract for the Human Nutrition Information Service (HNIS) by Westat, Inc., of Rockville, Maryland, from 1983 to 1985.

The study was designed specifically to follow up on the "Exploratory Study of Longitudinal Measures of Individual Food Intakes," discussed by Dr. Lucy B. Wilson and Beth B. Rothschild. Results from the two studies were used in planning the Continuing Survey of Food Intakes by Individuals (CSFII), conducted in 1985 and 1986.

Two events late in 1981 affected the HNIS survey methodology program and studies of low-income surveys.

- In October, the Departments of Agriculture and Health and Human Services jointly forwarded to Congress a comprehensive plan for a National Nutrition Monitoring System (NNMS).

- Subsequently, in the Agriculture and Food Act of 1981, Congress directed the Secretary of Agriculture to implement pilot programs to test various means of measuring the nutritional status of the low-income population on a continuing basis. Special emphasis was to be given to people who are eligible for food stamps.

The primary objective of the Pilot Low-Income Study was to provide information needed in selecting the methodology for continuing national efforts to monitor the nutritional status of low-income populations. Our concerns included--

- adequacy of followup intake records taken using telephone interviews and mailed-in forms. We needed information on the completeness of reporting and accuracy of food identifications and descriptions of food quantities.
- response/nonresponse rates by wave of data collection and by sex and age of the respondent.
- data collection problems within the poverty-income population.

Tangentially, there was interest in the possibility of expanding USDA surveys to include clinical measures of height and weight of individuals.

The Pilot Low-Income Study included 11 separate panels of households covering a wide demographic range. Seven panels made up Phase I. Phase II further tested the telephone followup methodology among population groups in which special data collection difficulties might be anticipated, such as rural Mexican-Americans, American Indians, and the elderly.

Panels: Phase I	Number of Households
Black, northeast, central city	360
Black, south, rural	360
White, west, central city	360
White, north central rural	360
Mexican-American west, central city	180
Supplemental	
Black, south, rural (no telephones)	150
Black, south, rural (NFCS-3-day intakes)	120

The study plan involved development of matching groups of low-income households whose members were asked to recall and report 3 days of food and beverage intakes quarterly, for a total of 12 days over 1 year. After an initial personal interview and training session, one group provided followup interviews by telephone. The other group used mail-in records.

The overall response rate, by quarter, for the telephone method (Table 1) illustrates the need for limiting the number of household members under study. As household size increased, participation rates dropped over the four quarters. Also, Food Stamp recipients were more likely to participate in the study than nonrecipients were.

The overall individual response rates, by sex and age, for the first and fourth quarters (Table 2) illustrate the slightly greater difficulty in getting adult males to enter and continue with the study. The group most likely to cooperate were women over 50 years of age.

Table 3 shows the amount of time required to complete a 1-day food record. Time for the telephone method was relatively low and dropped from 7 minutes to 5 minutes. Respondent burden in the mail-in method was relatively high, ranging from 14 to almost 17 minutes.

Table 1.--Telephone Method: Overall Response Rate

Household Characteristics	Response rate: quarter No.			
	1	2	3	4
	-----------	percent	-----------	
Size:				
2 persons	79	67	57	51
3 persons	84	61	52	47
4 persons	80	61	50	47
5 or more persons	86	67	53	40
Food Stamps:				
Receiving	88	71	60	55
Not receiving	80	65	53	49

CONCLUSIONS

Results from the study indicated that it is too much to ask low-income people to report 3 days of intakes quarterly over a year for all household members, at least by means other than personal interviews.

The use of a personal interview and mail-in records was unsatisfactory on all counts. Response rates were very low. Only one-third of the households participated in the second quarter, and by the fourth quarter, the response rate approached 20 percent.

Comparisons of estimates and home measurements for height and weight of individuals were comparable with information from other studies. Difficulties were encountered in maintaining accuracy of portable scales and measuring height of babies and infants.

Response rates were highest for Mexican-Americans. People in rural areas were more responsive than central-city residents. The group of individuals with lowest response rate was adult males.

The method of personal interview with telephone followups, however, should be appropriate for continuing food intake surveys if the reporting burden is held down by limiting data collection to one or two household members and to 1 day at a time. Also, in-person interviews are needed where telephones are not available or service has been discontinued.

Table 2.--Telephone Method: Overall Individual Response Rate, by Sex and Age, First and Fourth Quarters

Sex and age	Response rate, quarter No. 1	Response rate, quarter No. 4
	----percent----	
Males:		
0- 5 years	69	45
6-12 years	76	45
13-19 years	67	38
20-50 years	60	41
Over 50 years	66	47
Females:		
0- 5 years	68	44
6-12 years	72	49
13-19 years	69	44
20-50 years	69	44
Over 50 years	86	52

Table 3.--Mean Time to Complete a 1-Day Food Record

Quarter	Method: Telephone	Method: Mail-in
	-------minutes------	
1	7.1*	14.0
2	5.9*	16.8
3	5.6*	15.1
4	4.9*	14.5

*Significantly different at $p < 0.05$.

SURVEY SAMPLE INTEGRITY: EXPERIENCE WITH THE PANEL APPROACH.

P. Peter Basiotis and Eleanor M. Pao
Human Nutrition Information Service

The 1985 USDA Continuing Survey of Food Intakes by Individuals (CSFII 85) was the first nationwide survey to collect dietary and other information on U.S. households and individuals within sample households year by year. The basic sample consisted of women 19 to 50 years old and their children 1 to 5. Dietary and other information was collected from each participating woman and child up to six times, about 2 months apart, from April 1985 to March 1986. The 24-hour recall method was used in all waves. The first interview was in person, while subsequent interviews were by telephone or in person if no telephone was available or if otherwise necessary. A panel of low-income women and their children and a cross section of males were also surveyed as part of the CSFII-85.

Panel surveys, such as the CSFII 85, obtain data from specific cross-sections of the population repeatedly over time. As such, they provide uniquely useful information for research purposes. However, the number of individuals who do not complete the survey is typically higher in panel surveys than in cross-sectional surveys.

In the CSFII 85, the number of adult respondents was 1,459 in the first wave of the survey and 902 in the sixth wave. The largest drop in participation occurred after the first and second waves. Six hundred and ninety-two women provided all 6 days of intake; 1,032 completed four or more waves of the survey.

CSFII 1985 Response Rates
Women 19-50 years

Wave	Unweighted Sample
1	1,459
2	1,221
3	1,042
4	995
5	910
6	902
Four or more	1,032
All six waves	692

Respondents were not followed if they moved out of their original area. During the survey year, 145 (10 percent of the sample) moved out of their respective areas.

An additional issue of concern with panel surveys is an observed change in data collected between the first interview and later interviews. This was observed in the food energy levels of diets reported in the CSFII. Between waves one and two of the survey, mean food energy intake for the women declined 10 percent. The average food energy intake for women completing all six waves was 1,544 kilocalories; for those completing four or more, it was 1,512 kilocalories.

Analysis of both the all-income and the low-income panel samples indicated that the switch from personal to telephone interview method was not responsible for the drop in food energy. Those households in wave 2 who were interviewed by personal interview reported a drop in calories similar to that reported by those interviewed by telephone.

As the data show, mean intakes in the sample differ by the number of waves completed.

Food energy intakes by women, by wave and by number of days completed:

	Food energy (kcal)
Wave 1 (N = 1,459)	1,665
Wave 2 (N = 1,221)	1,495
4 or more days (N = 1,032)	1,512
6 days (N = 692)	1,544

Thus, it may be useful to attempt to identify characteristics of respondents who drop out of the survey at various points in time. This information could be useful in interpreting research results and in future designs of dietary panel surveys.

The objectives of this study are to answer the following three questions:

1. What are the characteristics of respondents who dropped out of the survey after the initial interview?

2. What are the characteristics of respondents who completed all six waves of the survey?

3. What are the characteristics of respondents who completed at least 4 days of interviews? This group was studied because the sample of individuals completing at least four waves was chosen for HNIS final reports and for further in-house and extramural analysis. This sample was chosen because it allowed the inclusion of the maximum number of sample days while minimizing reduction of sample size.

Two methodologies were utilized to statistically identify characteristics of respondents participating in one, four, or all six waves. Initially, characteristics were statistically related to those outcomes using a linear probability regression model. The method of estimation was that of "feasible generalized least squares" to account for nonhomogeneous variances.

For the sake of confirming the results of the linear probability model, a statistically more sophisticated logistic regression model was estimated using the "maximum likelihood estimation" method. The software used was the Statistical Analysis System (SAS) "PROC LOGIST" procedure. The results obtained from the logistic regression estimation were in general agreement with those obtained from the linear probability regression estimation. Logistic regression results significant at the 0.01 and 0.10 levels are presented in this paper. Since the analysis was investigative, the estimated regression models simultaneously included about 40 available independent variables. Thus, even though the estimates remain unbiased for large samples like this, variances of the estimates are higher and tests of significance will tend to be conservative. That is, relationships found not to be significant might have been significant if fewer variables were included. On the other hand, relationships found to be significant are likely to remain so when some irrelevant variables are deleted.

The characteristics simultaneously included in the analysis were:

I. Household characteristics
   A. Socioeconomic
      1. Income (last year)
      2. Did not report income for last year (yes/no)
      3. Home ownership status:
         a) own
         b) rent
         c) occupy home without payment
      4. Household member owns or operates farm (yes/no)
      5. Number of individuals in households at wave 1
      6. Presence of child 1 to 5 years of age (yes/no)
      7. Male head present (yes/no)
   B. Demographic
      1. Geographic location (region):
         a) Northeast
         b) Central
         c) South
         d) West
      2. Urbanization status
         a) Central city
         b) Suburban
         c) Nonmetropolitan

C. Participation in government food assistance programs in any of 6 waves
   1. Food Stamp Program (yes/no)
   2. Women, Infants, and Children Program (yes/no)
D. Self evaluation of household food supply at wave 1
   1. Sufficient
   2. Not sufficient

II. Personal characteristics
   A. Physiological
      1. Body mass index (weight/height^2) (Heights and weights were self-reported.)
      2. Height
      3. Age
      4. Self-reported health
         a) "Excellent," "very good," or good
         b) Fair or poor
      5. Pregnant at any wave (yes/no)
      6. Breastfeeding at any wave (yes/no)
   B. Physical activity (self reported)
      1. At work or housework
         a) Heavy
         b) Moderate
         c) Light
      2. At leisure:
         a) Heavy
         b) Moderate
         c) Light
   C. Cigarette Smoking
      a) Smoked now
      b) Has quit
      c) Never smoked
   D. Dietary Habits
      1. Vegetarian (yes/no)
      2. On a special diet (yes/no at wave 1)
      3. Takes vitamin or mineral supplements regularly (yes/no at wave 1)
      4. Ratio of usual number of meals away from home to usual number of meals at home
   E. Employment and education
      1. Worked outside of home last week (yes/no)
      2. High school or more education (yes/no)
   F. Race and Ethnic Origin
      1. Race
         a) White
         b) Black
         c) Other
      2. Ethnic origin
         a) Non-Hispanic
         b) Hispanic

III. Survey methodology

1. In-person contact at any of waves 2-6 (yes/no)
2. Length of time of household portion of interview at wave 1
3. Length of time of individual portion of interview at wave 1

Simultaneous examination of these characteristics allowed us to determine the groups of respondents who are more likely or less likely to remain in the survey for various numbers of days. We have listed below characteristics that were significant at the 0.1 level. Characteristics that were significant at 0.01 are indicated in the lists.

Several characteristics were associated with the likelihood that a given respondent will remain in the survey after the first interview for at least one additional wave. Specifically, respondents had a higher likelihood of staying if they had some of the following characteristics (they obviously will not have them all):

- Higher income
- Household food supply reported not sufficient
- Higher body mass index for given height; that is, heavier for a given height
- Older (significant at 0.01)
- Pregnant (significant at 0.01)
- Household interview at wave 1 around 24 minutes or less (average was 19 minutes)

The opposites of these characteristics were associated with a lower likelihood of staying in the survey for more than one day. For example, respondents from lower income households and younger respondents had a lower likelihood of remaining in the survey after wave 1.

Respondents had a lower likelihood of remaining in the survey after the initial interview if they had some of the following characteristics:

- Did not report an income figure for last year (significant at 0.01)
- Larger household
- Occupied residence without payment (significant at 0.01)
- Taller for given body mass index
- Vegetarian
- Race other than white or black
- Individual interview at wave 1 more than the average of 30 minutes, especially at around 45 minutes

Again, note that respondents from smaller households, for example, had a higher chance of staying in the survey past wave 1.

We also examined the likelihood that a given respondent would complete all six waves of interviews. The estimated characteristics associated with the respondent completing all six waves were:

- Nonmetropolitan household
- Participation in Food Stamp Program
- Household food supply reported not sufficient
- Higher body mass index for given height, or heavier
- Older (significant at 0.01)
- "Excellent," "very good," or "good," self-reported health
- High school or more education

Conversely, the following characteristics were associated with a decreased likelihood of a respondent completing all six waves of the survey:

- Did not report an income figure for last year
- Larger household
- One or more children 1 to 5 years of age (significant at 0.01)
- No male head present (significant at 0.01)
- Higher ratio of meals away to meals at home
- Nonwhite race
- Smokes cigarettes
- Contacted in person in any of waves 2 to 6 (significant at 0.01)

At this point we would like to mention that most respondents who were contacted in person after the first wave did not have a telephone. Others refused to be interviewed by telephone and a personal contact followed.

The likelihood that a respondent would complete four or more waves of the CSFII 85 was estimated to increase with the following characteristics:

- Nonmetropolitan household (significant at 0.01)
- Participation in Food Stamp Program
- Participation in Women, Infants, and Children Program
- Household food supply reported not sufficient (significant at 0.01)
- Older (significant at 0.01)
- Hispanic ethnic origin
- Household interview at wave 1 around 27 minutes or less

The likelihood of a respondent completing four or more waves decreased with the following characteristics:

- Did not report an income figure for last year (significant at 0.01)
- One or more children 1 to 5 years of age
- No male head present (significant at 0.01)
- Physical activity at work reported as light
- Race other than white or black
- Smokes cigarettes
- Contacted in person in any of waves 2 to 6 (significant at 0.01)

In conclusion, these results suggest that the response rate in the CSFII 85 was at least partly associated with the respondent characteristics studied. The estimated regression models included about 40 variables, and about one third of them were statistically significant at the 0.10 level.

Based on these results it appears that, in general, respondents who tended to participate in more waves had some of the following characteristics:

- Reported a figure for last year's income
- Nonmetropolitan household
- Participated in government good assistance programs
- Household food supply reported not sufficient
- Higher body mass index for given height, or heavier for a given height
- Older
- "Excellent," "very good," or "good" health
- Pregnant
- All contacts subsequent to first wave by telephone
- Household interview at wave 1 around 24 minutes or less

Respondents who tended to participate in fewer waves had some of these characteristics:

- Did not report a figure for last year's income
- Occupied residence without payment (but did not own)
- Larger households
- One or more children 1 to 5 years of age
- No male head present
- Race other than white or black
- Smokes cigarettes
- Contacted in person in any of waves 2 to 6

These results may be useful in interpreting research findings and in designing of future dietary intake surveys.

VARIETY OF FOOD INTAKES: ANALYSIS OF DATA FOR 12 DAYS

Karen J. Morgan, Stanley R. Johnson, and Basil Goungetas
Nabisco Brands, Inc.; Iowa State University; and the University of Hawaii

There are important questions about the reliability of estimated mean daily intake levels of food energy and nutrients. One issue of concern is the number of days of intake data required to estimate, with a given reliability level, mean daily intake per individual. Results from analyses of 1- and 3-day survey data have shown substantial day-to-day variation in intakes for a number of the nutrients.

The purpose of this study was to evaluate individual intake data for day-to-day patterns and relate these patterns to the reliability with which mean daily energy and nutrient intakes can be estimated.

The data for this investigation were from the Exploratory Study of Longitudinal Measures of Individual Food Intake conducted in 1982 under the auspices of the Nutrition Monitoring Division of Human Nutrition Information Service, U.S. Department of Agriculture. This "methodology study" was designed to evaluate effects of different numbers of daily intake records and different methods of recording intake on estimated intake levels.

The present analysis used only the data from the methodology study for the Nationwide Food Consumption Survey (NFCS) standard 3-day intake method replicated in four quarters. These data included 12 observations of daily intake per subject.

The subjects of the survey were female homemakers between the ages of 19 and 70 years. Thus, the study was not designed to evaluate intake levels of all household members. For the NFCS standard method, 100 of the 150 females in the sample completed the survey in each of the quarters; thus, the sample size for the present analysis was 100.

Clearly, if observations from the different days were independent, standard statistical methods could be used to relate numbers of days to the reliability of mean intake estimates. The standard deviation of the mean in this case would be calculated from the estimated variance of the underlying distribution and the sample size. There is, however, a question about the applicability of this simple statistic for estimating reliability of mean daily intakes. Specifically, a cursory examination of the available results from the methodology study showed that the variances of estimated mean daily intakes did not decrease with increased sample size as rapidly as they should have if the observations had been independent. Therefore, the distributions of intakes were not constant, or there were patterns in individual intakes across days.

The estimators for this investigation were modified to reflect the fact that individuals' daily intake records may exhibit day-to-day correlations. Specifically, estimators were modified to reflect persistence in consumption behavior. Generally, this persistence means, other things equal, that a greater number of days are required to achieve a particular reliability level for the estimate of mean daily intake.

A regression analysis framework is convenient for generating expressions for the estimators incorporating persistence. Assume that the reported intake for the i-th day is equal to the mean intake plus an error. The 12 observations per individual can be written:

$$\underline{y} = \underline{x}\mu + \underline{\varepsilon}$$

The day-to-day pattern in intakes or the relationship among the elements of $\underline{\varepsilon}$ can take different forms. For the present analysis, it is initially assumed that the elements of $\underline{\varepsilon}$ are related to each other by a first-order autoregression process:

$$\underline{\varepsilon} = \rho\varepsilon_{i-1} + u_i \;;\; i = 1, 2, \ldots, 12$$

and that the u_i are independently and identically distributed with mean zero and variance σ^2. Under these assumptions the generalized least squares estimators for the mean, standard deviation, and standard error of mean are:

$$\tilde{\mu} = (\underline{x}'\Omega^{-1}\underline{x})^{-1}\underline{x}'\Omega^{-1}\underline{y}$$

$$\tilde{\sigma}^2 = \frac{\underline{\tilde{\varepsilon}}'\Omega^{-1}\underline{\tilde{\varepsilon}}}{N - 1}$$

$$\tilde{\sigma}_{\mu} = [\tilde{\sigma}^2(\underline{x}'\Omega^{-1}\underline{x})^{-1}]^{\frac{1}{2}}$$

If ρ is unknown, it can be consistently estimated by:

$$\hat{\rho} = \left(\sum_{i=2}^{N} \hat{\varepsilon}_i\hat{\varepsilon}_{i-1}\right) / \sum_{i=2}^{N} \hat{\varepsilon}_{i-1}^2$$

Then the "feasible" GLS can be applied to estimate the parameters of the first equation.

An important implication of assumed structure for "persistence" in consumption patterns is for forecasting. The forecasting question is: Given the sample to day i, what is the "best" estimate of the individual intake for the day i + 1? Using the first and second models shown, the expected value of the individual intake for the day i is:

$$\hat{y} = (1-\rho)\bar{\mu}+\rho y_{i-1}$$

Data for the 100 sampled subjects were used to estimate autocorrelation coefficients based on 12 intake records per person to quantify the persistence in daily intakes. These estimates were made for food energy, fat, iron, and vitamin A. These four dietary components were selected for evaluation because it was believed that food energy intake levels would be relatively consistent across days, fat intake would represent macronutrient intake consistency, and iron and vitamin A intakes would represent micronutrient intake for a widely distributed and a more food specific micronutrient, respectively.

First, the autocorrelation coefficients for each of the 100 females were estimated. Then estimates of the expected next-day intakes for each subject were calculated using 3 days' intake to predict the fourth-day intake, 6 days' intake to predict the seventh-day intake, 8 days' intake to predict the ninth-day intake, and 11 days' intake to predict the twelfth-day intake. All of these forecasts were calculated with and without ρ, the persistence factor. The difference between the actual (known) intake for each individual on days 3, 6, 9, and 12 and the forecasted intake based on the days in the sample up to these "test" days were used to estimate the absolute value of the "error." The forecasts were made without autocorrelation and with autocorrelation. Finally, for each individual the absolute error was determined for the difference between the GLS forecast and the GLS estimated mean intake including the added sample day.

After these calculations were made for each of the 100 sample subjects, absolute errors for estimated daily intakes were averaged across the sample to obtain a mean absolute error estimate for the total sample for each diet component. These estimates were made using both GLS and OLS forecasts. To further illustrate the importance of the persistence factor in forecasting intake levels and evaluating added days of intake data, the sample was partitioned into two subgroups based on values of the estimated autocorrelation coefficients for the individuals. One subgroup contained individuals with estimated autocorrelation coefficients greater than 0.3, and the other subgroup was composed of individuals with autocorrelation coefficients less than or equal to 0.3.

Estimates utilizing the autocorrelation hypothesis showed that 27 of the 100 subjects had coefficients for food energy intake greater than 0.3 (Table 1), indicating that these individuals exhibited considerable persistence in caloric intake. Interest-

Table 1.--Summary of Estimated Coefficients of Autocorrelation for Food Energy, Fat, Iron, and Vitamin A

Dietary component	Absolute value		Sign	
	<0.3	>0.3	-	+
	Simple autocorrelation hypothesis ($\hat{\rho}$)			
Food energy	27*	73	45	55
Fat	26	74	58	42
Iron	28	72	59	41
Vitamin A	29	71	56	41

* Number of subjects with autocorrelation coefficient estimators for food energy greater than 0.3.

ingly, similar numbers of subjects had relatively high estimated autocorrelation coefficients for fat (26), iron (28), and vitamin A (29). Forty-five of the subjects had negative autocorrelation coefficients for food energy. These negative values indicated that eating patterns alternated from high to low consumption levels, while the 55 positive values showed consistency in levels of food energy intake. The numbers of positive values for fat, iron, and vitamin A were somewhat less, indicating that intake levels of these three dietary components were somewhat less consistent than those of food energy.

Mean absolute error values for estimated daily individual intakes for the sample are summarized in Table 2. These results indicate that the major gains in accuracy of mean daily intake estimates occurred prior to day 7. That is, subsequent to day 6, added sample days generally contributed relatively less to the accuracy of the estimates. Accuracy in this case is measured in an operational way -- the forecast based on previous days contrasted with the actual intake value in the comparable day. Table 2 shows that the mean absolute errors for the estimates when no autocorrelation was included were larger. Thus, the patterns in consumption were valuable in estimating next-day intakes and, in general, reduced the value of an additional day in improving the accuracy of the estimated mean.

Since a larger autocorrelation coefficient means greater persistence in consumption, it follows that forecasts for individuals with larger autocorrelation coefficients should require fewer days for accurate estimation of next-day intake than estimates for subjects with small autocorrelation coefficients. Results for the empirical testing of this proposition are in Tables 3

Table 2.--Mean Absolute Errors for Estimated Daily Individual Intakes of Food Energy, Fat, Iron, and Vitamin A

Dietary Component	Day and mean absolute error estimator			
	Day 3	Day 6	Day 9	Day 12
	GLS forecast and actual intake (β)			
Food energy (kcal)	458	456	361	315
Fat (g)	30	26	21	18
Iron (mg)	3.8	3.0	2.8	3.3
Vitamin A (IU)	3,155	3,163	3,080	3,021
	OLS forecast and actual intake			
Food energy (kcal)	450	493	386	333
Fat (g)	30	27	23	20
Iron (mg)	3.8	3.3	3.2	3.4
Vitamin A (IU)	3,185	3,278	3,219	3,277
	GLS forecast and GLS mean intake (β)			
Food energy (kcal)	173	117	74	86
Fat (g)	11	7	5	5
Iron (mg)	1.4	1.0	1.0	1.0
Vitamin A (IU)	1,093	823	703	784

and 4. The values in Table 3 are for absolute errors between GLS forecast and GLS mean intake and show a limited decrease in accuracy between day 3 and day 6. Similar conclusions cannot be drawn from Table 4 for individuals with autocorrelation values of less than 0.3.

Previous research has shown that individuals who usually consume large amounts of food have larger standard deviations of mean daily intake than those who usually consume small quantities of food. It follows then physiologically that if the consumers of lower levels of food energy are near maintenance levels, predicted intake levels should be more accurate than those for "large" eaters. To test this hypothesis, the 100 subjects were arrayed from highest to lowest in estimated average food energy intake. Then the top quartile and bottom quartile in this distribution were selected as subsamples. GLS estimates for

Table 3.--Mean Absolute Errors for Estimated Daily Individual Intakes of Individuals with Autocorrelation Coefficients of Greater than 0.3

Dietary Component	Day and mean absolute error estimator			
	Day 3	Day 6	Day 9	Day 12
	GLS forecast and actual intake ($\hat{\rho}$)			
Food energy (kcal)	394	326	370	289
Fat (g)	26	18	21	16
Iron (mg)	3.3	2.1	2.3	2.3
Vitamin A (IU)	3,108	2,755	2,146	4,001
	OLS forecast and actual intake			
Food energy (kcal)	387	456	395	323
Fat (g)	26	24	28	20
Iron (mg)	3.4	3.2	3.4	2.9
Vitamin A (IU)	3,068	3,247	2,899	4,426
	GLS forecast and GLS mean intake ($\hat{\rho}$)			
Food energy (kcal)	157	164	110	152
Fat (g)	12	10	9	9
Iron (mg)	1.4	1.1	1.2	1.1
Vitamin A (IU)	1,231	1,047	1,042	937

mean daily intakes and mean absolute error values for GLS and OLS forecasts were calculated for these two subsamples.

Tables 5 and 6 provide the forecast evaluations for "small eaters" and "large eaters," respectively. These results show clearly that "small eaters" have much more predictable consumption patterns than "large eaters." In fact, very little additional information is gained after day 6 for "small eaters"; i.e., the average root mean square error estimates are nearly the same for days 6, 9, and 12 (Table 5). The "large eaters" also showed greatest gains in accuracy of estimated mean daily intake prior to day 7 (Table 6). However, added observations after day 6 did improve, albeit in a limited way, the accuracy of the forecasts relative to observed intake levels.

Table 4.--Mean Absolute Errors for Estimated Daily Individual Intakes of Individuals with Autocorrelation Coefficients of less than 0.3

Dietary Component	Day and mean absolute error estimator			
	Day 3	Day 6	Day 9	Day 12
	GLS forecast and actual intake ($\hat{\rho}$)			
Food energy (kcal)	482	504	357	324
Fat (g)	31	28	21	19
Iron (mg)	3.9	3.3	2.9	3.6
Vitamin A (IU)	3,175	3,330	3,461	2.621
	OLS forecast and actual intake			
Food energy (kcal)	473	506	383	336
Fat (g)	31	28	22	20
Iron (mg)	3.9	3.4	3.1	3.7
Vitamin A (IU)	3,233	3,290	3,350	2,808
	GLS forecast and GLS mean intake ($\hat{\rho}$)			
Food energy (kcal)	179	100	60	61
Fat (g)	11	6	4	4
Iron (mg)	1.4	0.7	0.5	0.5
Vitamin A (IU)	1,037	731	565	721

Results of this analysis demonstrate:

1. The importance of reflecting appropriately patterns in day-to-day food consumption in the estimation of mean daily intake levels.
2. The importance of consumption patterns in evaluating contributions of added days of intake information to the accuracy of estimated daily intakes.

The general results on contributions of numbers of days to the accuracy of mean intake estimates suggest that we can conclude that for the dietary components examined, the benefits of additional days of recorded intake fall off importantly after 6 days. The exact nature of the patterns in intakes between days of individuals warrants more investigation. In the present

Table 5.--Mean Absolute Errors for Estimated Daily Individual Intakes of Small Eaters

Dietary Component	Day and mean absolute error estimator			
	Day 3	Day 6	Day 9	Day 12
	GLS forecast and actual intake (ρ)			
Food energy (kcal)	350	213	311	258
Fat (g)	26	14	17	16
Iron (mg)	3.0	2.5	2.3	3.1
Vitamin A (IU)	1,800	1,781	2,535	2,272
	OLS forecast and actual intake			
Food energy (kcal)	355	241	327	245
Fat (g)	26	14	19	15
Iron (mg)	3.1	2.9	2.4	3.2
Vitamin A (IU)	1,862	1,925	2,533	2,185
	GLS forecast and GLS mean intake (ρ)			
Food energy (kcal)	113	60	56	69
Fat (g)	8	4	4	4
Iron (mg)	1.0	0.7	0.5	0.7
Vitamin A (IU)	702	610	586	508

analysis, this pattern assumed a first-order autoregressive form. With larger samples, permitting analyses of day-to-day effects in more detail, alternative models of persistence should be investigated, as well as perhaps physiological and institutional reasons for patterns in individual intakes.

The evidence of patterns in day-to-day individual intakes for all dietary components raises many questions about previous estimates of reliability of estimated mean daily intake and sample size. That is, if eating patterns are incorrectly assumed to be independent between days, results are altered appreciably when persistence factors are not incorporated in the estimation and evaluation process.

Table 6.--Mean Absolute Errors for Estimated Daily Individual Intakes of Large Eaters

Dietary Component	Day and mean absolute error estimator			
	Day 3	Day 6	Day 9	Day 12
	GLS forecast and actual intake (β)			
Food energy (kcal)	488	558	390	358
Fat (g)	36	33	23	23
Iron (mg)	3.1	3.4	3.0	3.5
Vitamin A (IU)	4,663	3,013	3,057	2,471
	OLS forecast and actual intake			
Food energy (kcal)	472	645	401	416
Fat (g)	35	35	25	27
Iron (mg)	3.1	3.8	3.8	3.8
Vitamin A (IU)	4,401	3,057	3,046	3,274
	GLS forecast and GLS mean intake (β)			
Food energy (kcal)	198	163	93	111
Fat (g)	14	9	5	6
Iron (mg)	1.3	0.9	0.8	0.6
Vitamin A (IU)	1,843	649	578	1,461

METHODOLOGY FOR PREDICTING NUTRIENT INTAKE

Stanley R. Johnson, Karen J. Morgan, and Gary L. Stampley
Iowa State University, Nabisco Brands, Inc., and the University of Missouri

The 1977-78 Nationwide Food Consumption Survey (NFCS 77-78) and the 1985 Continuing Survey of Food Intake by Individuals (CSFII 85) were designed to provide food consumption and dietary status information for population subgroups defined by location of the household and by socioeconomic features of the households and household heads. The present analysis has the objective of estimating functional relationships between intakes of female household heads and other household members by sex-age group. These relationships are estimated for means of subsamples created by cross-classifying the NFCS 77-78 participants using socioeconomic features of households and household heads. The sex-age groups are the 14 for which RDA have been established.

Food energy and two micronutrients, ascorbic acid and iron, were examined in the exploratory portion of the analysis. The estimated linkages, when appropriately estimated and validated, will be applied to the CSFII 85, a nationwide survey of females 19 to 50 years of age, to draw inferences about consumption patterns of the other sex-age groups. If statistical linkages can be established, surveys of the U.S. population for food consumption patterns and dietary status can be conducted more economically or, with the same resources, more frequently.

METHOD

For the preliminary analysis, the population subgroups were defined by cross-classifying region, urbanization, race, and total usual food expenditures per capita per week (above and below the sample mean). This provided a total of 48 sample means for use in estimating the linkages between average intakes by female household heads and average intakes of other household members by sex-age group. A number of screens were applied to the sample, assuring that the individuals were from the same household and that the information necessary for the analysis would be available. Application of these screens left 5,353 households for the preliminary analysis.

Two models were estimated, a simple model and a main-effects model. The simple regression model included a constant term and the subsample mean intake of the female household head as explanatory variables. The dependent variable was the subsample mean intake of the other household members. The regressions were estimated for each of the sex-age groups. The concomitance of the means required for regression analysis was established by including in the subsamples only observations in which the female head and the other member were from the same household.

The main-effects regression model included dummy variables for region, urbanization, race, and food expenditure.

The simple and the main-effects models were estimated by ordinary least squares and weighted least squares. For the weighted least squares estimates, adjustments were made to reflect the fact that subsample means used as the observations for the regressions were for different sample sizes.

RESULTS

Findings from the preliminary analysis were encouraging and are described briefly below.

- Average intake of the female heads by population subgroup were strongly related to mean intakes of other household members calculated for the same population subgroups. For the three dietary components examined, the statistical significance pattern between mean intakes of female household heads and mean intakes of other household members were similar, suggesting that these relationships can be utilized for both food energy and micronutrients.

- A goodness-of-fit statistic (percent root mean square error), calculated within the sample, suggested that the explanatory power of the relationships for both main-effects and simple models was reasonably high for most sex-age groups. Average percent mean square errors were in the range of 10 to 20 percent.

- The explanatory power of the regressions relating subsample mean intake of female heads of households to subsample mean intakes of other household members by socioeconomic group was different by sex-age group. Generally, these differences were as anticipated. Intake of the female head of household had stronger explanatory power for both males and females in the younger sex-age groups. For the individuals in the 11-to-14-year-old and 15-to-18-year-old RDA categories, the explanatory power of the regression models was not as strong. Female head intake exhibited good explanatory power for the male RDA groups of ages 19-22 and 23-50.

- The estimated effects of socioeconomic partitioning variables in the regressions were mixed. Of the socioeconomic partitions, region and urbanization were most frequently statistically significant. The significance of these variables suggests differences in food consumption patterns by location and urbanization, perhaps due to relative prices, preferences of the household, differences in the food supply, and other factors.

Based on these preliminary findings, additional research is being conducted to extend the estimated linkages to other diet components. Refinements in the functional forms of the estimated relationships, weighting schemes for the regressions, screens applied to the sample data, and other technical aspects of the estimation process are being implemented. The estimated models are also being validated structurally and in a hold-out sample from the NFCS 77-78.

ASSESSMENT OF NUTRIENT ADEQUACY USING FOOD CONSUMPTION SURVEYS: DISCUSSION OF THE NAS REPORT

Helen Smiciklas-Wright
The Pennsylvania State University

This paper discusses the National Academy of Science's 1986 report, "Nutrient Adequacy: Assessment Using Food Consumption Surveys."[1] This is not a presentation of original research.

The report represents the deliberations of a subcommittee convened by the Food and Nutrition Board of the National Research Council (NRC). The subcommittee was assembled to respond to a request by USDA for a study of criteria for evaluating dietary adequacy.

The Subcommittee on Criteria for Dietary Evaluation (a subcommittee of the Food and Nutrition Board's Coordinating Committee on Evaluation of Food Consumption Surveys) had the following membership:

Jack L. Filer, Jr. (Chairman)
George H. Beaton
Jacob J. Feldman
Helen A. Guthrie
Jean-Pierre Habicht
Richard Havlik
D. Mark Hegsted
Kent K. Stewart
Helen Smiciklas-Wright
Anastasios A. Tsiatis

National Research Council Staff:
Virginia Hight Laukaran, Staff Officer
Frances M. Peter, Editor
Judith Grumstrup-Scott, Editorial Consultant

Sushma Palmer, Executive Director, Food and Nutrition Board

Contributions were also made to the subcommittee by Susan Welsh, Betty Peterkin, Robert Rizek, Brucy Gray, and others from USDA.

Specifically, the subcommittee's charge was to develop criteria for the use of survey data in the evaluation of dietary adequacy, paying particular attention to applications to data from the Nationwide Food Consumption Survey.

The charge reflects the fact that an important use of food consumption survey data is to monitor the prevalence of inadequate nutrient intakes among the general population.

---

[1] National Research Council. 1986. Nutrient Adequacy: Assessment Using Food Consumption Surveys: A Report of the Subcommittee on Criteria for Dietary Evaluations. Washington: National Academy Press. Figures in this article are from the Report.

The subcommittee recognized that any deliberations about dietary adequacy needed to address the following topics:

- Multiple definitions of adequacy
- Nutrient requirement variability
- Inter- and intraindividual food intake variability

DEFINITIONS OF ADEQUACY

Multiple definitions of adequacy are possible. Definitions range from adequacy for preventing clinical morbidity to adequacy for maintaining specified tissue levels of a nutrient. Evaluation of dietary adequacy necessitates an understanding of the meaning of requirement estimates. The subcommittee was reminded frequently that discussions about nutrient adequacy or requirements needed to ask the question, "Requirement for what?"

VARIABILITY IN NUTRIENT REQUIREMENTS

Interindividual variability in nutrient requirements is well accepted. Given this variability, the committee considered how appropriate it was to use nutrient standards or nutrient recommendations such as the NRC Recommended Dietary Allowances (RDA) for assessing adequacy.

George Beaton has described nutrient recommendations as single point descriptions of an underlying distribution of requirements with the single point generally set at the right-hand tail of the distribution.

In the past, standards such as the RDA have been used to define the prevalence of inadequate nutrient intake. More specifically, proportions or fixed cutoffs of the RDA -- such as 60 percent or 70 percent -- have been used to define the prevalence of inadequate intakes.

The subcommittee deliberated at length the appropriateness of using the fixed cutoff approach. It argued that this approach has potential for misclassification.

Figure 1 illustrates why the potential for misclassification exists, given the variability in nutrient requirements. The right-hand curve represents the intake for the distribution of people who adequately meet their requirements, and the left-hand curve the intakes for those who inadequately meet their requirements. A fixed cutoff point selected somewhere in the area of overlap could designate "at risk" some whose requirements are actually met and vice versa.

We concluded that the fixed cutoff approach doesn't fully consider the variability in nutrient requirements and may lead to imprecise estimates.

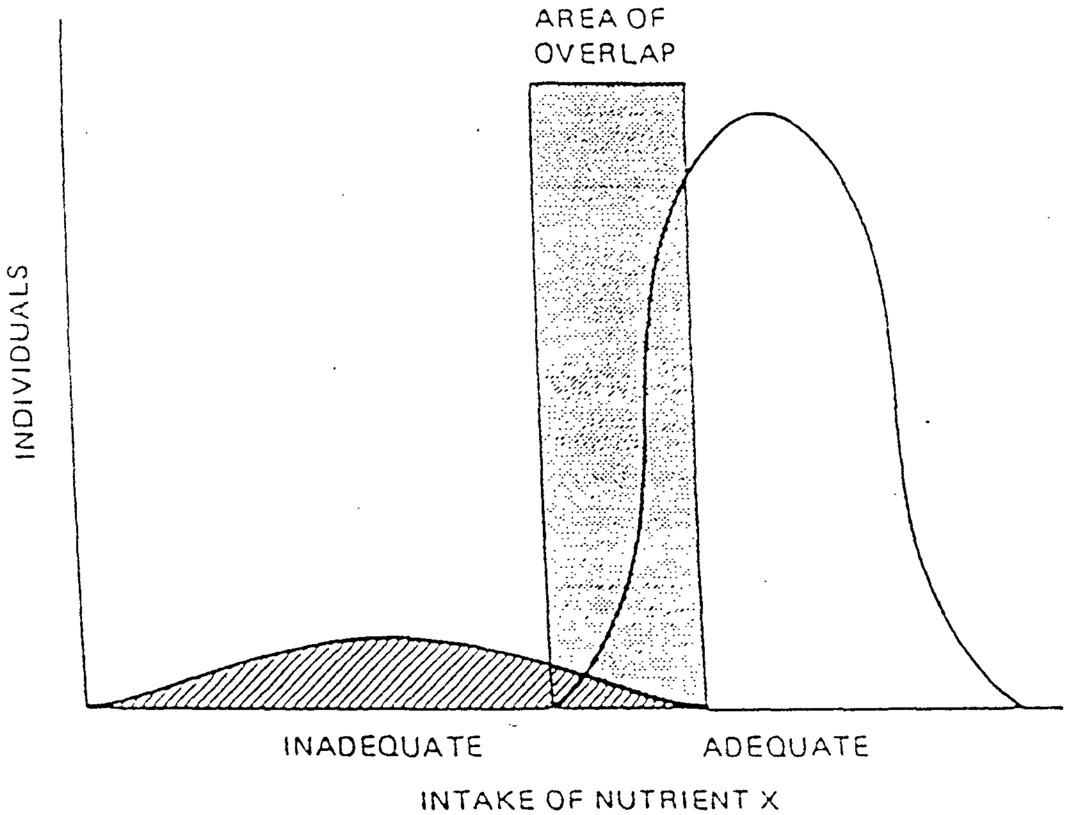

Figure 1.--Distribution of people who truly fail to meet their requirement (inadequate) and those who truly meet it (adequate) for a hypothetical nutrient.

NUTRIENT INTAKE VARIABILITY

Day-to-day variability of food inatke is the third factor that needs to be considered when food consumption data are used to monitor prevalence of inadeauate intakes. Figure 2 shows a frequently reproduced figure taken from a 1972 paper by Hegsted.

The data show that as the period of observation (i.e., the number of days of dietary intake data) increases from 1 day to "several" days, the intraindividual, or within-person, variation is progressively removed, the distribution tightens, and the total observed variance decreases. Enough days of observation should describe the distribution of usual intakes.

The subcommittee's report reviews statistical procedures for estimating a distribution of usual intakes from actual observed data. The report shows how Nationwide Food Consumption Survey data based on 3 days of dietary data were adjusted statistically to estimate intake over longer periods.

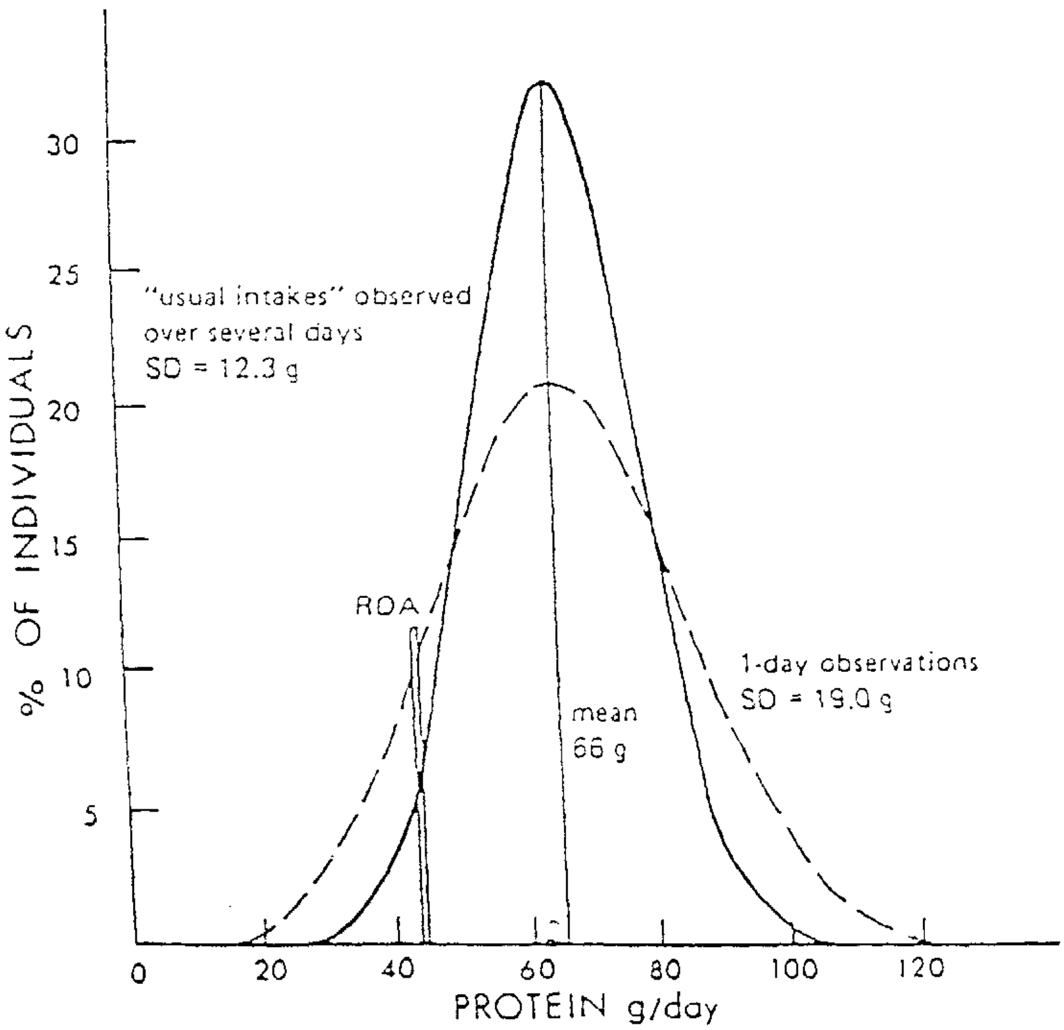

Figure 2.--Effect of multiple days of observation on the apparent distribution of nutrient intake.

Figure 3 illustrates such an adjustment. It presents an iron intake distribution curve for NFCS 1-day intake data by female adults and a curve for estimated usual intakes.

The committee deliberated at length as to how best to consider variability in requirements and intakes in any analysis of dietary adequacy. We posed the basic question as follows: How many individuals in a population are likely to have intakes below their own requirements? Essentially, this becomes a "probability of risk" question -- the probability that a particular level of intake is adequate or inadequate for a randomly selected individual of a given class. Such a

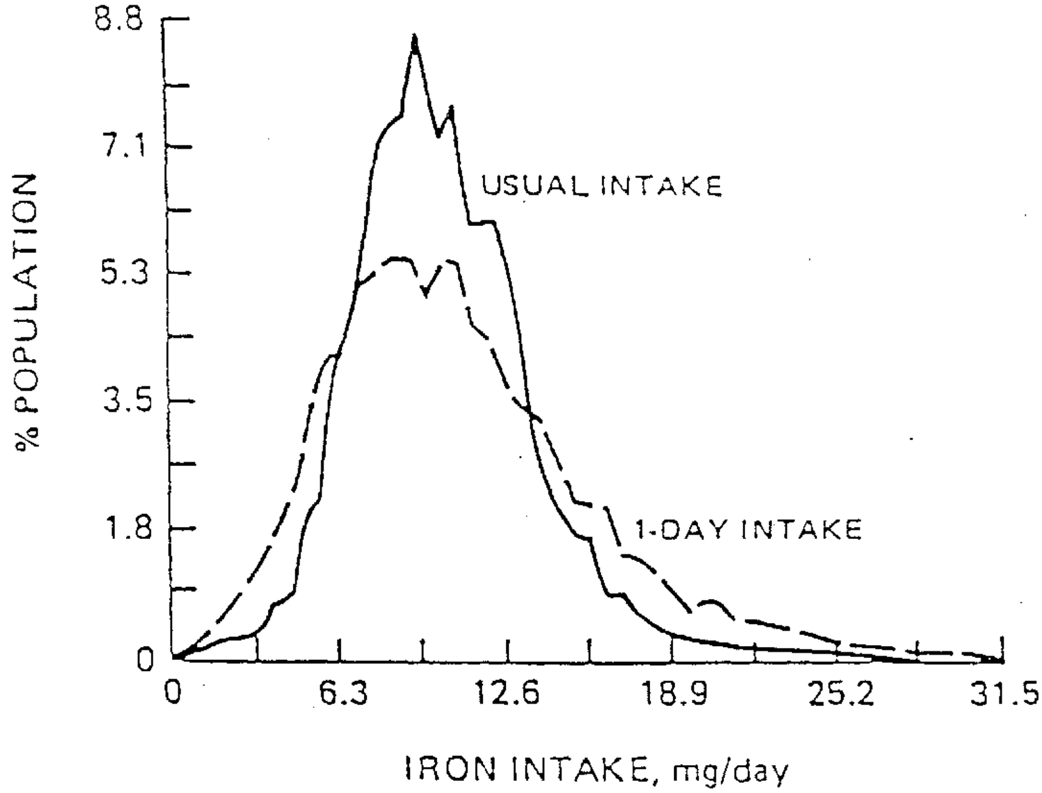

Figure 3.--Comparison of 1-day and adjusted distribution for iron intake by female adults. Derived from NFCS 77-78 data analysis.

probability is derived from the juxtaposition of the two distribution curves:

A. The distribution of individual requirements
B. The distribution of usual intakes

The concept of the probability approach for prevalence estimates is not new. It has been discussed in the literature for some time. The subcommittee was certainly in agreement about supporting the concept of the probability approach for estimating prevalence of inadequate intakes. Their report presents some actual applications of the probability approach to NFCS data. Table 1 shows how prevalence estimates based on the probability approach compare with those based on the fixed-cutoff approach.

It is evident that the fixed-cutoff approach at certain cutoffs may give prevalence estimates that are similar to those of the probability approach. But whether this agreement occurs, and at which cutoff level, is a function of the relationship between requirement distribution and the intake distribution.

Table 1.--Comparison of Estimates of the Prevalence of Inadequate Intakes for Adults Using Probability and Fixed-Cutoff Approaches (adjusted NFCS data)

Nutrient and sex group	Prevalence estimates				
	Proba-bility	Fixed cutoff			
		100% RDA	80% RDA	70% RDA	60% RDA
	percent				
Protein (males)	2.3	6.5	2.4	1.3	0.8
Vitamin C (males)	39.6	57.5	44.5	36.3	27.1
Iron (females)	23.0	98.2	91.2	81.6	62.5

The subcommittee reviewed (and I believe that this is a strong feature of the report) the impact that errors in nutrient intake measurement could have on the probability-approach-based prevalence estimates. For example, what is the impact on prevalence estimates of under-reporting or over-reporting of nutrient intakes? What is the impact of variability caused by analysis of nutrient content of foods? With the help of USDA's staff and other statistical consultants, the subcommittee used a series of simulation analyses to assess the impact of such errors. These simulations led us to conclude that random errors (although they diminish accuracy) don't seriously impair the estimates of prevalence.

This conclusion would not be accurate if there were serious systematic errors. The subcommittee noted the lack of data concerning errors in nutrient intake measurement. There were differing opinions about the magnitude of unmeasured methodological errors.

The committee deliberated at length (and heatedly) the practicality of the probability approach -- more specifically the probability of developing the information and the time required so that the approach can be applied. Applying the probability approach requires information about the mean and approximate symmetry of the nutrient requirement.

Certainly, we agreed on the conceptual elegance of the probability approach. The principal argument that engaged the committee was whether sufficient data on mean requirements were available and how precise the estimates of mean nutrient requirement need to be to provide a rational basis for analysis. We concluded that there was the need for clarification on two issues:

1. The extent to which the dietary intake data are adequate or are excessively flawed for application of the algorithm.
2. The extent to which average requirement data are indeed available somewhere for application of the algorithm.

Finally, the report made the following recommendations concerning assessment of nutritional adequacy:

- Develop multiple criteria for nutritional adequacy.
- Adopt a probability approach where feasible for analysis of dietary adequacy.
- Use a descriptive presentation of the mean, variance, and percentile distributions when no probability assessment can be made.

VALIDATION OF A FOOD FREQUENCY METHOD

Frances A. Larkin, Helen Metzner, and Adam Drewnowski
School of Public Health, University of Michigan

This study was funded by the Human Nutrition Information Service as part of the ongoing research on dietary methodology. Work was carried out at the School of Public Health, University of Michigan.

The purpose of this study was twofold: (1) to develop a 1-year retrospective food frequency questionnaire, including usual portion size, to estimate nutrient and food consumption and (2) to validate the food frequency estimate against 16 days of actual recall and records. The 16-day mean was used as the standard. The sample included 228 men and women, black and white, 25 to 50 years of age, with a range of income and education, living in Ann Arbor and a nearby community.

The food frequency questionnaire that was developed included 113 food groups developed from intake documented in the Nationwide Food Consumption Survey and arranged in a sequential card sort format. The respondents decided on whether or not the food was eaten seasonally, how often the food was eaten (from more than once a day to 1-3 times a month), and the usual serving size. The 16 days of dietary intake were obtained during the same 1-year period.

We evaluated the degree of similarity between methods in a number of ways, including portion size and frequency of consumption, which are not reported here. I will present two comparisons which will give some indication of the results and the questions that remain.

RESULTS

A comparison of nutrient values for the mean of the 16 days and the food frequency estimation shows a consistently high reporting on the food frequency questionnaire (Table 1). The difference between the methods ranged from 27 percent for protein to 123 percent for vitamin A. The difference for calories was 30 percent.

Respondents varied in the degree of difference between the methods; in addition, there was variability among the 16 days of each respondent. We wondered whether there was a relationship between the degree of difference between the two methods and the variation among the 16 days. A diet that changes greatly from day to day may be harder to summarize in a "usual" diet estimate. We found that correlations by gender-race groups between the differences and variances from the records were not significant.

For perspective, Table 2 shows the calorie variability over 16 days of several of the first respondents enrolled in the study. The range, mean food record values, standard deviation, food frequency calorie estimates, and the differences between the two methods are shown. The latter is expressed as a negative when the FFQ exceeds the 16-day value.

Table 1.--Comparison of Nutrient Intake Estimates from Food Frequency Questionnaire (FFQ) and 16-Day Mean, Total Sample

Nutrient	16-day mean	FFQ
Energy (kcal)	2,114	2,766
Protein (g)	79	100
Fat (g)	92	119
Carbohydrate (g)	231	321
Calcium (mg)	820	1,096
Iron (mg)	14	20
Vitamin A (IU)	5,760	12,854
Vitamin C (mg)	120	193

The question is: In what proportion of the sample is the food frequency estimate of daily intake reasonable considering the distribution of day-to-day variability reported in the food records?

Each respondent's food frequency estimate was compared with the distribution of his or her 16 days for energy and the macronutrients (Table 3). The respondent was then categorized into one of the following six groups according to whether his food frequency estimate in relation to the mean of his 16 days was--

--more than two standard deviations less than the mean,

--between one and two standard deviations less than the mean,

--between mean and one standard deviation less than the mean,

--between the mean and one standard deviation more than the mean,

--between one and two standard deviations more than the mean,

--more than two standard deviations more than the mean.

In general, these analyses show that, in the context of individual day-to-day variation, the food frequency questionnaire estimates energy intake plus or minus one standard deviation for about half of the group. The food frequency questionnaire estimated protein, fat, and carbohydrate for approximately 50 to 60 percent of all respondents except black women.

Table 2.--Food Energy Values for 16 Record Days for Eight Respondents

	Respondent number				
	1	2	3	4	5
	kilocalories				
16-day record:					
Range	3,494-6,440	1,238-4,073	657-1,841	1,179-3,053	1,030-3,630
Mean	4,350	1,746	1,244	1,840	1,861
S.D.	959	708	279	544	639
FFQ	5,122	2,264	1,735	2,058	3,919
Difference	-272	-518	-491	-218	-2,058

More specifically, the distribution for calories shows that 20 percent of the total respondents had food frequency estimates between one and two standard deviations greater than the mean of their record days. Twenty-four percent of the respondents had food frequency estimates that were more than two standard deviations greater than the mean of their record.

Among the separate gender-race groups, white men showed the best agreement. About 58 percent had food frequency estimates within one standard deviation of their records. This is the highest percentage in this category (plus or minus one standard deviation) among the race-gender groups. White men also have the smallest proportion, about 16 percent, beyond two standard deviations greater than their mean. White women show the next best agreement, 52 percent within plus or minus one standard deviation. Black men came next and black women are last with 31 percent agreement of plus or minus one standard deviation. Thirty-five percent of black women are beyond two standard deviations greater than their mean.

In all groups, the distribution is toward the upper end of the scale. There are few respondents in any of the four gender-race categories who have food frequency estimates that fall between one and two standard deviations below the mean. A few black women had food frequency estimates that fell more than two standard deviations below their 16-day mean values.

Among the macronutrients, respondents generally had the greatest trouble estimating food intake defined as carbohydrate intake. Food frequency estimates were within one standard deviation of the records for about 51 percent for the total group, more for white men, and considerably less for black women. Values in the

Table 3.--Percentage of Respondents in Categories Defined by the Relation of Their FFQ Values to the Daily Variation of Their Record Values for Selected Dietary Components by Sex and Race

Group	N	Relation of FFQ Value to Mean of Record Values					
		>2 S.D. less	1-2 S.D. less	<1 S.D. less	<1 S.D. more	1-2 S.D. more	>2 S.D. more
		CALORIES					
		percent					
Men:							
White	64	0.0	12.5	25.0	32.8	14.1	15.6
Black	43	0.0	2.3	20.9	27.9	23.3	25.6
Women:							
White	73	0.0	5.5	27.4	24.7	20.5	21.9
Black	48	2.1	8.3	8.3	22.9	22.9	35.4
Total	228	0.4	7.5	21.5	27.2	19.7	23.7
		CARBOHYDRATE					
		percent					
Men:							
White	64	0.0	6.3	31.3	29.7	20.3	12.5
Black	43	0.0	4.7	20.9	34.9	9.3	30.2
Women:							
White	73	0.0	4.1	23.3	30.1	19.2	23.3
Black	48	2.1	4.2	10.4	18.8	20.8	43.8
Total	228	0.4	4.8	22.4	28.5	18.0	25.9
		FAT					
		percent					
Men:							
White	64	0.0	12.5	29.7	32.8	10.9	14.1
Black	43	0.0	2.3	37.2	20.9	20.9	18.6
Women:							
White	73	0.0	8.2	32.9	28.8	15.1	15.1
Black	48	0.0	8.3	29.2	14.6	18.8	29.2
Total	228	0.0	8.3	32.0	25.4	15.8	18.4

Table 3.--Percentage of Respondents in Categories Defined by the Relation of Their FFQ Values to the Daily Variation of Their Record Values for Selected Dietary Components by Sex and Race--Continued

Group	N	>2 S.D. less	1-2 S.D. less	<1 S.D. less	<1 S.D. more	1-2 S.D. more	>2 S.D. more
		Relation of FFQ Value to Mean of Record Values					
				PROTEIN			
		--------percent--------					
Men:							
White	64	1.6	10.9	29.7	34.4	9.4	14.1
Black	43	0.0	4.7	37.2	20.9	14.0	23.3
Women:							
White	73	0.0	1.4	30.1	32.9	19.2	16.4
Black	48	0.0	4.2	16.7	25.0	29.2	25.0
Total	228	0.4	5.3	28.5	29.4	17.5	18.9

highest extreme group, more than two standard deviations, range from 13 percent of white men to 44 percent of black women.

For fat, food frequency estimates were within plus or minus one standard deviation of their records for about 57 percent of the total group. The porportion of extreme values (more than two standard deviations) ranges from 14 percent for white men to 29 percent for black women.

Protein estimates are similar to those of fat. Estimates were within one standard deviation for 58 percent of the total sample. The proportion of extreme values ranges from 14 percent for white men to 25 percent for black women.

Summarizing the results by gender groups, white men showed the best agreement: About the same percentage of white men fell in the high extreme category for carbohydrate, protein, and fat (13 and 14 percent). White women were next; they ranged from 15 percent in the high extreme category for fat to 23 percent for carbohydrate. Black men were next in order; the high extreme categories ranged from 19 percent for fat to 30 percent for carbohydrate. The group with poorest agreement, black women, had 25 percent of the respondents in the extreme category for protein, 29 percent for fat, and 44 percent for carbohydrate.

We extended the analysis to the food groups (Table 4). (High-fat foods include mayonnaise, peanut butter, cream sauces and the like.)

The fruits and juices category had the smallest percentage of respondents (16 and 33) whose food frequency estimate was within plus or minus one standard deviation of their mean. Among race-gender groups (not shown) black women had the most trouble with this food group; 56 percent estimated their frequency beyond two standard deviations above their mean for fruits and juices.

In contrast, beverages, including alcohol, had the most respondents, 82 percent, within plus or minus one standard deviation of their mean.

The food frequency questionnaire overestimates intake when compared to recall/record values. What accounts for the difference? In our study, demographic differences such as age, marital status, education, and occupation were not related to the differences between methods. Among black men, questionnaire scores were significantly higher for those with an annual income of less than $20,000, but income was not a factor with other

Table 4.--Percentage of Respondents in Categories Defined by the Relation of FFQ Calorie Values to the Daily Variation of Calories in Food Records, by Food Group, Total Sample

Group	N	Relation of FFQ Value to Mean of Record Values					
		>2 S.D. less	1-2 S.D. less	<1 S.D. less	<1 S.D. more	1-2 S.D. more	>2 S.D. more
		percent					
Meat		0	4	42	34	10	9
Dairy foods		0	0	37	37	16	10
Eggs		0	0	24	47	15	14
Bread, cereal		0	2	35	37	15	11
Vegetables		0	0	46	35	11	8
Fruits, juices		0	1	16	33	18	31
Beverages, including alcohol		0	6	51	31	10	2
Desserts		0	1	46	32	10	11
High-fat foods		0	1	36	30	12	20

groups. White women with higher body mass index scores had better agreement between methods. The number of foods reported from different food groups showed no consistent relationship to either method. Time spent in completing the food frequency questionnaire was not related to agreement.

SUMMARY

Estimations of the food frequency questionnaire involve a series of decisions. We have not identified any one factor that explains good or poor agreement between methods. An estimate of "usual" diet was within plus or minus one standard deviation of their 16-day records for about half of the respondents for energy and macronutrients, but the percentage varies by race and gender groups.

IMPLICATIONS OF MODIFIED NUTRIENT DATA BASES

Loretta Hoover
Human Nutrition, Foods, and Food Systems Management,
University of Missouri

With computer technology, compilation of nutrient data bases with many food items and numerous food constituents is possible. However, the necessity of large nutrient data bases for dietary surveys is sometimes questioned.

The projects summarized in this paper were undertaken to determine what consequences result if shortened nutrient data bases are used to compute the mean nutrient intake data values for the Nationwide Food Consumption Survey (NFCS) of individuals. For the purpose of this discussion, modification means <u>shortening</u> a nutrient data base to include fewer food items.

The results from two separate projects are presented in summary fashion. In the first project, two data bases with fewer than 500 foods, designated as S2 and S3, were evaluated for the spring quarter of the NFCS. The followup study resulted in a midsize data base, designated here as S1, that was evaluated for all four seasons.

Analyses of Dietary Intake Records

Season	NFCS	Nutrient data bases S1 (2371)	S2 (396)	S3 (200)
Spring	X	X	X	X
Summer	X	X		
Fall	X	X		
Winter	X	X		

SOURCES OF DATA

The nutrient data base for the first project contained data for energy and 14 nutrients for 4,404 food items. The data base for the second project included 4,569 foods after being augmented with foods consumed by Hispanic populations. Over 1,000 of the food items had nutrient profiles identical to another food item and differed only in food item description.

Three-day dietary intake records were supplied by USDA for individuals in 22 sex-age categories. Complete 3-day dietary intake records were present for 27,920 individuals. The numbers of individuals included in each sex-age group are shown in Table 1.

METHOD

Dietary intake records were selected observing the following criteria:

- All included records must contain 3 days of data.
- No records were permitted to contain incomplete data for any day.
- No records for nursing infants were included.

Table 1.--Number of Individuals in Each Sex-Age Category

Sex-Age Category	Number of individuals			
	Spring	Summer	Fall	Winter
Males & females:				
under 1	72	115	114	134
1- 2	219	238	285	312
3- 5	239	267	358	288
6- 8	508	576	706	677
Males:				
9-11	183	220	298	260
12-14	260	268	331	309
15-18	327	303	358	411
19-22	239	126	146	148
23-34	639	326	365	420
35-50	638	330	318	369
51-64	524	247	281	336
65-74	247	122	153	164
75 and over	103	68	73	82
Females:				
9-11	200	250	273	311
12-14	262	280	323	294
15-18	338	361	398	382
19-22	272	176	176	190
23-34	772	479	595	548
35-50	754	459	571	538
51-64	643	396	492	432
65-74	313	216	273	255
75 and over	162	131	158	147
TOTAL	7,914	5,954	7,045	7,007

Baseline nutrient intake values were calculated using the original nutrient data base for comparison with the results of the shortened nutrient data bases and to validate computer program logic. Weighting factors were not used.

Frequencies of consumption were analyzed for all food items in the nutrient data base. A majority of the food items were associated with a low frequency of consumption. Food items consumed repeatedly over the course of a day -- such as beverages, fats, sugar, and bread items -- had the highest frequencies.

Next, the retained food items were determined by considering both food consumption frequency and nutrient profiles. Those foods for which a retained food was substituted were designated as inactive items.

For each substitution level, a cross-reference file was loaded to pair each food item in the original nutrient data base with one of the foods designated as a retained item.

The goodness-of-fit between inactive and retained foods was analyzed using the SAS regression analysis procedure with the no-intercept option.

Dietary intake records were reanalyzed using each of the three cross-reference files to identify the differences in nutrient intake values that could be attributed to the change in the size of a nutrient data base.

Evaluation of the differences in nutrient intake values was accomplished by enumerating the absolute percentage differences in mean nutrient intake values, performing analyses of variance on the mean nutrient intake values for each sex-age group for each food constituent, and comparing mean intake values with RDAs.

SOFTWARE

Computer software for cluster comparisons (Figure 1) was developed to appraise the subjective substitution assignments made during each of the data base reduction tasks.

CHLIST was used to list clusters.

CLUSTER comparison report showed the percentage differences in nutrient values between a retained item and the inactive items for which it was substituted.

RETAINED items report identified the percentage differences in nutrient values among all of the retained items. While similarity in nutrient profiles was desired in the clusters, large percentage differences were desired among the retained items.

REGRESSION analysis was performed to determine goodness-of-fit for the inactive items.

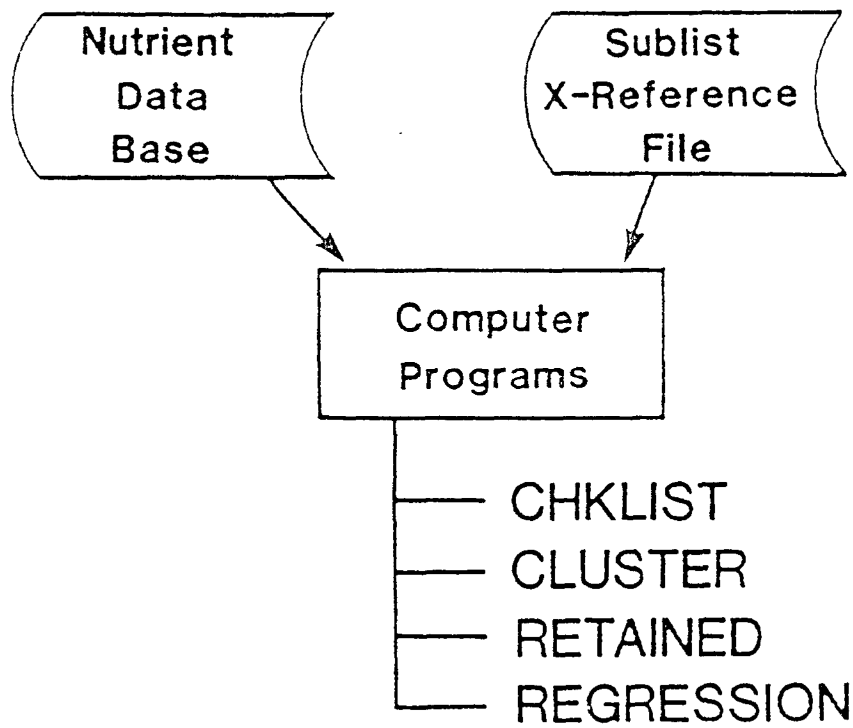

Figure 1.--Computer software used in appraising food item substitutions.

RESULTS

The goodness-of-fit analysis for substitution level 1, the midsize data base, revealed that 92 percent of the food items had R^2 between 0.9 and 1.0 and Beta values between 0.7 and 1.3 (Table 2). Fewer than 400 itmes had R^2 or Beta values outside the desired ranges.

R^2 values for substitution level 3 of the 499 most frequently consumed foods are illustrated in Figure 2. Of those 499 foods, 80 percent had R^2 between 0.90 and 1.0. Of those, 130 of the foods were retained items that had a perfect fit of 1.0.

Beta values for substitution level 3 are illustrated similarly in Figure 3, where 66 percent of the 499 most frequently consumed foods had Beta values between 0.90 and 1.10 and 83 percent were between 0.70 and 1.3.

The number of food items in the nutrient data bases at each substitution level are shown in Table 3. The three shortened nutrient data bases were used to recompute mean nutrient intake values. The minimum and maximum absolute percentage differences between the baseline data and the shortened nutrient data bases were determined for each nutritional component for the 3-day average nutrient intake.

Table 2.--Goodness of Fit for S1

Food group	NFCS	R^2		Beta	
		0.9-1.0		0.7-1.3	
	f	f	%	f	%
Soy sauce	1	1	100	1	100
Milk and milk products	330	284	86	293	89
Meat, poultry, fish, and mixtures	1,365	1,350	99	1,334	98
Eggs, mixtures and substitutes	57	55	96	39	68
Dry legumes, nuts and seeds	164	130	79	132	80
Grain products	997	909	91	942	94
Fruits	476	438	92	437	92
Vegetables	704	670	95	644	91
Fats, oils and salad dressings	71	62	87	64	90
Sugar, sweets, and beverages	404	294	73	305	75
TOTAL	4,569	4,193	92	4,201	92

When the 48 percent reduction was accomplished in substitution level 1, the absolute differences were less than or equal to 3.7 percent for all food constituents for all sex-age groups in all seasons. Most of the percentage differences for the standard deviations fell in the range ± 1.0 percent.

In substitution level 2, a 91 percent reduction was accomplished with 396 food items retained. Absolute differences for the spring season ranged from 0.0 to 12 percent, with a maximum difference of less than 5 percent for nine nutrients. The greatest impact was on vitamin A and vitamin B-12.

Larger absolute percentage differences resulted in substitution level 3 with a data base of 200 food items, a 95 percent reduction. The differences ranged from 0.0 to 51.2 percent with maximum values for 11 of the nutrients associated with the sex-age group of children under 1 year of age. If those values

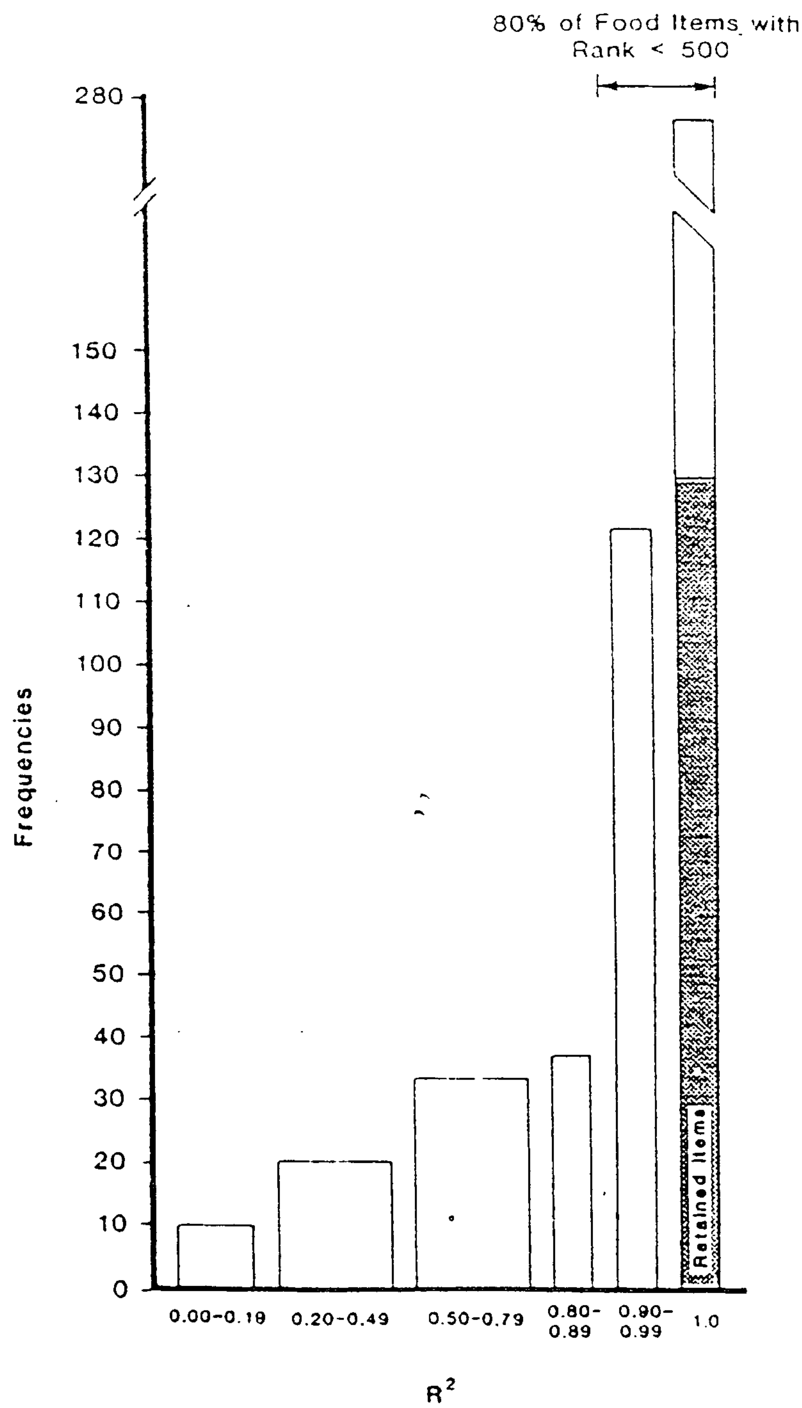

Figure 2.--Frequencies of R^2 values for items of rank less than 500 (S3).

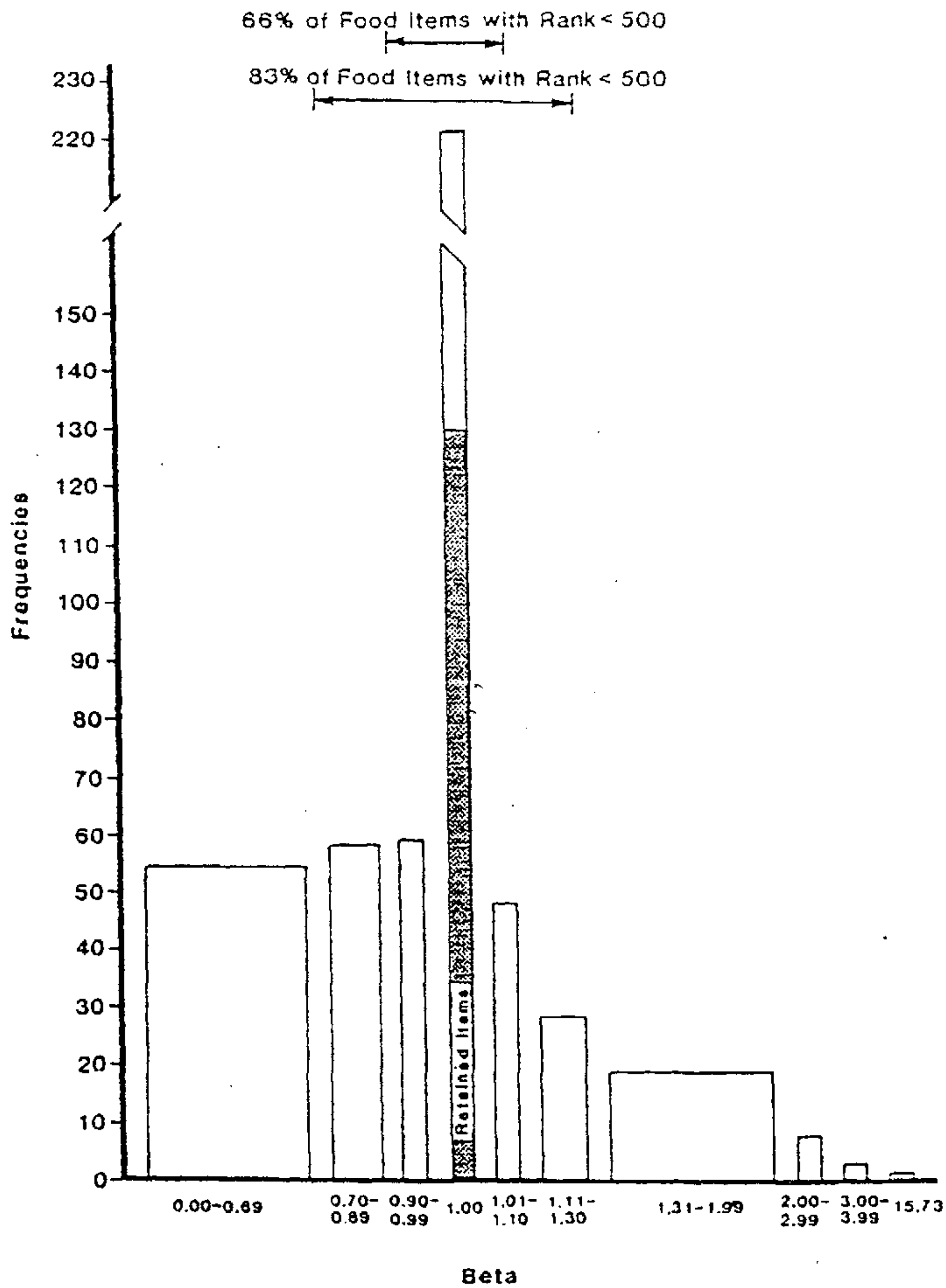

Figure 3.--Frequencies of Beta values for items of rank less than 500 (S3).

Table 3.--Number of Food Items in Nutrient Data Bases

Food Group	Number of Foods				
	NFCS	S1	NFCS	S2	S3
Soy sauce	1	1	0	0	0
Milk and milk products	330	135	321	36	24
Meat, poultry, fish, and mixtures	1,365	859	1,307	107	60
Eggs, mixtures and substitutes	57	26	51	8	3
Dry legumes, nuts and seeds	164	71	157	13	10
Grain products	997	476	956	68	47
Fruits	476	230	473	38	14
Vegetables	704	434	677	67	23
Fats, oils and salad dressings	71	33	70	11	5
Sugar, sweets and beverages	404	106	392	48	14
TOTAL	4,569	2,371	4,404	396	200
REDUCTION		48%		91%	95%

were disregarded and the second highest values considered, the ranges were reduced considerably: All nutrients except vitamin A and vitamin B-12 were within 10 percent of the baseline values, and eight were within 5 percent of the baseline. Large differences were associated with infants because very few baby foods were among the 200 retained items.

Daily mean nutrient intake values for each sex-age group were analyzed using SAS analysis of variance procedures (Table 4). The analysis was modeled as a repeated measurement design.

Significant statistical differences were not present for any nutrient when the data base was reduced to 2,371 foods. However, nine nutrients were statistically different when only 396 foods were retained. Further reduction of the nutrient data base to 200 foods resulted in statistically significant results

Table 4.--Analyses of Variance

Nutrient	F-Ratios	
	S2	S3
Energy	0.72	4.91*
Protein	0.15	9.80*
Fat	14.20*	94.12*
Carbohydrate	5.58*	35.94*
Calcium	4.26*	0.19**
Iron	30.92*	68.16**
Magnesium	6.16*	1.29**
Phosphorus	0.76	32.06**
Vitamin A	7.35*	70.01*
Thiamin	26.57*	27.32**
Riboflavin	2.51	8.67**
Niacin	7.53	26.13**
Vitamin B-6	29.96*	2.10
Vitamin B-12	2.38	5.57*
Vitamin C	2.42	4.23*

* $p \leq 0.05$
** $p \leq 0.05$ for interaction between NDB type and sex-age group

for 14 of the 15 food constituents, with the interaction between data base type and sex-age group significant for seven nutrients.

Significant interactions between data base type and sex-age group are shown in Table 5 for seven nutrients: calcium, iron, magnesium, phosphorus, thiamin, riboflavin, and niacin.

The 1980 Recommended Dietary Allowances, as adapted by USDA, were compared with the baseline nutrient values and the nutrient values computed for each substitution level (Table 6). In most instances, the percentage differences were small and were in the same direction as the baseline percentage differences.

IMPLICATIONS

To study the dietary practices of population subgroups, it may be necessary to use either a larger nutrient data base including

Table 5.--Analysis of Interactions for S3

Sex-Age Category	Ca	Fe	Mg	P	B-1	B-2	Nia
Males & females:							
under 1	X	X	X	X	X	X	X
1- 2	X	X	X				X
3- 5	X				X		
6- 8			X				X
Males:							
9-11	X		X		X		
12-14	X		X		X	X	
15-18			X	X	X	X	X
19-22	X		X	X	X	X	
23-34	X		X	X	X	X	
35-50	X			X	X		
51-64	X		X	X	X		
65-74	X	X		X		X	X
75 and over			X		X	x	
Females							
9-11	X		X			X	X
12-14					X	X	X
15-18	X		X		X		
19-22			X		X		
23-34			X	X	X		
35-50			X	X	X		
51-64	X		X	X	X		
65-74	X		X	X	X		
75 and over	X			X			

Table 6.--Comparisons with Recommended Dietary Allowances

Nutrient	Maximum absolute deviations from baseline					
	Spring			Summer	Fall	Winter
	S1	S2	S3	S1	S1	S1
	percent of RDA					
Calories	0.4	1.9	7.7	0.4	0.2	0.3
Protein	.7	6.7	5.6	.8	.5	.5
Calcium	.6	2.4	16.2	.6	.7	.5
Iron	1.0	8.0	65.4	1.0	1.5	1.0
Magnesium	1.7	21.7	53.3	.8	.8	.4
Phosphorus	.7	3.4	28.7	.6	.8	.8
Thiamin	2.5	5.0	77.5	2.0	3.6	2.0
Riboflavin	.9	12.0	42.0	1.7	3.1	3.3
Niacin	.8	5.6	44.3	1.4	1.5	1.5
Vitamin A	1.0	16.0	29.0	1.0	2.0	2.0
Vitamin B-6	.8	5.9	22.5	.9	1.0	1.0
Vitamin B-12	2.0	20.0	25.3	4.0	3.0	1.1
Vitamin C	2.9	3.9	45.7	2.9	3.4	2.8

typical foods or a shortened nutrient data base tailored to food consumption practices. The impact of using a shortened nutrient data base to analyze the dietary intake of an individual is not known.

More research is needed to identify the consequences of using shortened nutrient data bases for estimating other nutritional components such as sodium, zinc, or folacin. Also, more research is needed to determine what degree of reliability can be expected in data preparation when data coders select foods from a shortened nutrient data base to represent the food actually consumed by an individual.

The cost-effectiveness of using a shortened nutrient data base should be examined. Making substitutions may take as much time as locating the description of an actual food in a code manual or from a name list.

These uncertainties should be investigated prior to adoption of a shortened nutrient data base.

FOOD CONSUMPTION/COMPOSITION INTERRELATIONSHIPS

Frank N. Hepburn
Human Nutrition Information Service

Special, new requirements were imposed on the nutrient data base in order to conduct the current and planned continuing food consumption surveys. Because of the longitudinal aspects of a continuing survey, we must be able to frequently and rapidly revise the data and thoroughly document the time and nature of changes. Secondly, the decision to track sodium in food and to account for the use of different fats imposed the requirement to provide alternate nutrient data for a given food, depending on whether or not salt was added and on which source of fat was named by the survey respondent. To meet these special requirements, the USDA Nutrient Data Base for Individual Food Intake Surveys, Release 2, 1986, was constructed on a recipe basis.

This paper describes new interrelationships between food consumption and food composition data bases created by the recipe system and indicates some of the advantages gained in maintaining, evaluating, and improving the quality of the nutrient data base.

Briefly, the basic nutrient composition data are provided in a Primary Nutrient Data Set (PDS), consisting of the nutrient profile of items that are basic foods or that serve as components of reported foods. Most of the data for the PDS are taken directly from the USDA Nutrient Data Base for Standard Reference. Data that the Standard Reference file lacks are supplied by new analytical data on hand in the Nutrient Data Bank or are imputed. There are no blanks in the PDS. Data in the PDS are linked to the Nutrient Data Base through a Recipe Linking File, which provides the proportions of each component in the food. Corrections are taken into account for changes in moisture and fat and for retention of nutrients during preparation. Over 4,000 different foods are contained in the Nutrient Data Base for the survey. They are fully described by this system in terms of the approximately 2,500 items in the PDS, since many of the components are used in many recipes. About one-half of the items are foods as eaten and are treated as a single-ingredient recipe.

The source of each nutrient in each component of the PDS is documented by attaching a source code to each nutrient value. Codes 1 and 3 refer to values published in Agriculture Handbook No. 8 (AH-8). They are analytical or are calculated in a direct manner from analytical data and are not considered to be imputed. Code 2 refers to new analytical data not yet incorporated into revised sections of AH-8. Source code 4 refers to those values that have been imputed to fill blanks in AH-8. Remaining missing values that have been filled in with imputed values are identified by code 6. Imputed values are our best estimates and are usually based on values for a similar food or another form of the same food. Source code 5 pertains only to fortification nutrients in some breakfast cereals and are the values shown in italics in Agriculture Handbook No. 8-8. Although based on extensive industry analytical data, they are calculated to a statistical basis for nutrition labeling and may not represent mean values. Code 7 indicates assumed zero values, such as for cholesterol or vitamin B-12 in foods of vegetable origin.

Although the distinction between analytical and imputed is not always clear cut, we can assume that the bases for imputed values are generally less well founded.

ANALYSIS

At the beginning of CSFII 85, we examined the Primary Data Set to determine the degree to which values were analytical. Data from source codes 5 and 7 were ignored for this comparison. Data from source codes 1, 2, and 3 were combined as analytical values; those from source codes 4 and 6 were combined as imputed values. The proportion of analytical data was calculated as the percentage of total data coded as either analytical or imputed. Results are shown in Table 1.

It is evident that the proportion of analytical data is high for the more familiar nutrients that have been tracked over a longer period (equaling or exceeding 90 percent), whereas analytical

Table 1.--Percentage of Analytical Data in Primary Data Set
[Excludes assumed zero and nutrient label data]

Nutrient	Percentage	Nutrient	Percentage
Calcium	97	Cholesterol	80
Protein	97	Magnesium	75
Fat	96	Zinc	73
Thiamin	91	Copper	67
Riboflavin	91	Vitamin B-6	64
Niacin	91	Vitamin B-12	64
Sodium	90	Vitamin A (RE)	61
Potassium	90	Folate	56
Phosphorus	90	Carotene	54
Iron	90	Dietary fiber	29
Vitamin C	83	α-tocopherol	28
Vitamin A (IU)	80		

data of the components newly added to the survey are below 30 percent for all foods.

We also examined the data for "better sources" of nutrients. For this analysis, we excluded food sources that provide insignificant amounts of a nutrient per serving portion.

Table 2 compares the overall data in the PDS to those from only better sources for the nutrients found to be below 90 percent analytical. Except for magnesium, analytical data of the better sources is a greater percentage than that of all foods, indicating that more analytical data are available for the better sources. Even though the better sources of vitamin E and dietary fiber showed higher percentages of analytical data than for all foods, the values remain relatively low, indicating that our knowledge of these components is much weaker than of other nutrients.

The recipe linking system permits converting food consumption data into equivalent amounts of the components contained in the PDS -- in effect "running the recipe file backward." This makes it possible to evaluate the PDS in terms of the foods actually

Table 2.--Comparison of Analytical Data Sources in Primary Data Set

Nutrient	All data	Best sources
	---------percent---------	
Vitamin C	83	92
Vitamin A (IU)	80	89
Magnesium	75	72
Zinc	73	79
Copper	67	71
Vitamin B-6	64	72
Vitamin B-12	64	70
Vitamin A (RE)	61	73
Folate	56	69
Carotene	54	88
Dietary fiber	29	40
α-tocopherol	28	39

reported by survey respondents. We have performed such an analysis using the food consumption data (4 days) for 1,088 women (weighted number) in CSFII 85. Total amounts of foods consumed were equated to the corresponding amounts of items in the PDS in accordance with their proportions prescribed by the recipe file. Applying nutrient composition data to these weights of components then provides the amount of each nutrient contributed by each recipe component.

To examine the Primary Nutrient Data Set in terms of foods consumed, we sorted the nutrient contributions by items in descending order.

In Figure 1 the rank order of food items is plotted against the percentage of total intake of carotene. Each point represents a specific food item. For carotene, most of the intake is accounted for by only a few items. The first four--raw carrots, cooked carrots, tomatoes, and melons--provided 50 percent of the total carotene consumed, and 33 items provided 80 percent.

In contrast, the data for iron (Figure 2) show the widest distribution of nutrient sources, 217 items being required to account for 80 percent of total intake. Items in the steepest portion of the curve include enriched flours and breads, ground beef items, and enriched pasta and rice.

Another manner of examining the Primary Nutrient Data Set in foods consumed is illustrated in Table 3, which shows the number of items required to reach 80 percent of the total intake as a measure of the distribution of nutrient concentration. Also shown is the number of items in each total that have source codes indicating imputed values (codes 4 and 6). Because fortified breakfast cereals were found to be significant sources of some nutrients, the table also shows the number of items whose values are based on label claims (code 5). The data confirm the finding of the previous analysis that the data for dietary fiber are far weaker than those for protein, fat, or cholesterol.

For vitamin B-6, thiamin, riboflavin, and niacin, approximately the same number of foods were required to provide 80 percent of the total intake, but the data for vitamin B-6 are less well founded than are those for the other vitamins. Significant numbers of breakfast cereals contributed importantly to the total.

For the rest of the vitamins shown, fewer foods were required to provide 80 percent, indicating that these nutrients are present in greater concentrations in certain foods than are other components. The data are weaker for vitamin E, folacin, and vitamin B-12 when one considers the proportion of imputed values

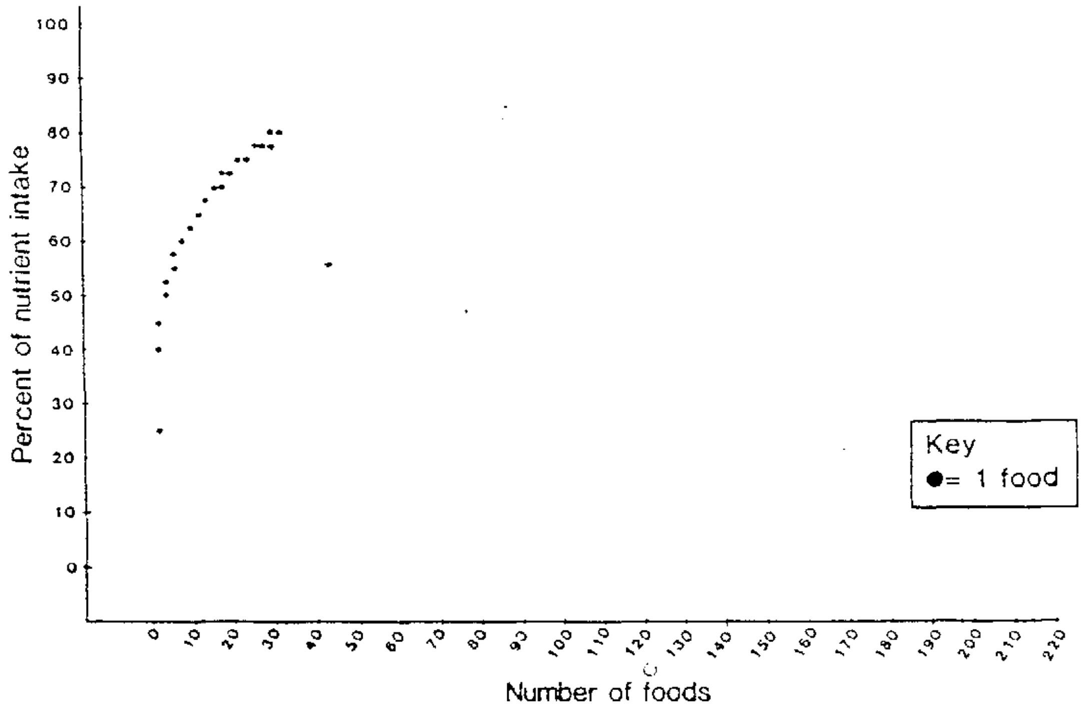

Figure 1.--Number of foods needed to provide up to 80 percent of total intake of carotene.

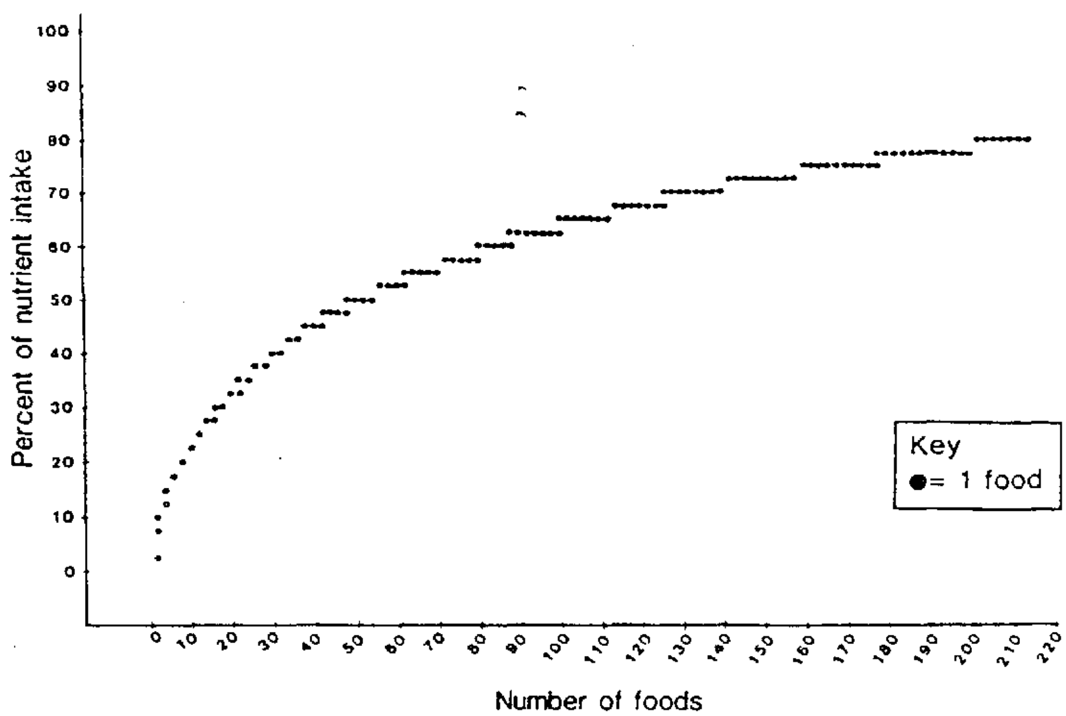

Figure 2.--Number of foods needed to provide up to 80 percent of total intake of iron.

Table 3.--PDS Items Contributing 80 Percent of Total Nutrient Intake

Nutrient	Total Items	Imputed Values	Label Claims
	-----------number----------		
Protein	150	6	0
Total dietary fiber	120	46	0
Fat	107	3	0
Cholesterol	49	4	0
Vitamin B-6	175	23	20
Thiamin	168	5	17
Riboflavin	165	5	15
Niacin	159	9	17
Folacin	129	20	14
Vitamin E	100	50	0
Vitamin A (total RE)	60	5	9
Vitamin B-12	58	9	5
Carotene	33	0	0
Iron	217	21	18
Copper	209	30	0
Magnesium	187	27	0
Phosphorus	180	5	0
Zinc	169	20	6
Potassium	159	5	0

relative to the number of items for 80 percent intake. Contrary to the previous analysis, vitamin A (RE) is expressed in relatively few imputed values. Note that 80 percent of total carotene intake was accounted for by only 33 items and that no values were imputed.

As was found by the analysis of the entire PDS base, large proportions of data for copper, zinc, and magnesium are based on imputed values. It was surprising to find that iron required the greatest number of items to total 80 percent and that 21 of those items had imputed values. This was not predicted by the previous analysis and indicates that the data for iron in the more commonly consumed foods are less well founded than are the overall iron data.

APPLICATIONS

These interrelationships between food consumption and food composition data bases allow for a methodical approach to improving the reliability of the nutrient data base. We are applying this information in setting priorities for ongoing extramural contracts to develop analytical data.

The ability to translate food consumption data into relative amounts of Primary Nutrient Data Set items has proved invaluable in identifying foods that should be studied for their content of selenium. Working cooperatively with the USDA's Nutrient Composition Laboratory, a provisional data base was constructed using evaluated data from the literature and from recent analytical studies. This data base provides information on foods highest in selenium. Application of food consumption data has identified the greatest potential sources in the diet. One study is under way and a second is planned for later this year to provide data for estimating the mean and variability of selenium in American foods.

SUMMARY

Construction of the Nutrient Data Base for Individual Intake Surveys by linking it to a Primary Nutrient Data Set through a Recipe Linking File offers several important advantages:

- Provides detailed documentation of data sources.
- Permits alternate ingredient selection (kind of fat).
- Allows for ease of update and correction.
- Facilitates quantifying the impact of a nutrient data base change on survey results.
- Provides ready evaluation of the data base.
- Identifies principal sources of nutrients in foods consumed.
- Enables improved classification of food components into food groups.

TOPICS FOR FURTHER RESEARCH IN DIETARY INTAKE MEASUREMENT

Howard A. Riddick
Human Nutrition Information Service

The research presented in these papers represents a comprehensive effort over a period of years. The topics represented cover key areas for further research:

- Survey design and evaluation
- Studies of special populations
- Complex statistical analysis
- Alternative methods for collecting dietary data
- Studies of nutrient data bases

Variability of dietary intake data is central to a number of these efforts.

Further research in dietary intake measurement is required to quantify variability in dietary intake data in a more complete and systematic manner. I will discuss two areas: sources of variability and research methods. Sources of variability include factors related to actual variation and factors related to measurement errors.

Actual variation is important because of the relationship to questions of survey design, such as the number and spread of days to be collected. Individual diets exhibit actual day-to-day variation that may be accentuated by a day-of-the week effect. This effect may be particularly strong for individuals who are working or attending school. The season of the year may affect diets because of the weather (more iced tea is consumed in hot weather), because of seasonal holidays, or because there is no school in summer. Possible interrelationships between season and day of the week need to be explored at a regional level.

Some individual characteristics may help explain differences in usual diets from individual to individual (interindividual variation). These characteristics include demographic ones such as age, race, and gender; socioeconomic ones such as education, employment status, and income; and health-related ones such as chronic illness, smoking status, and general level of physical activity.

Other factors, such as acute illness and special occasions, may be more helpful in explaining day-to-day deviations from an average diet for an individual (intraindividual variation). In a 1985 USDA survey (CSFII 85 core, wave 1) women 19 to 50 years of age were asked "Would you say the <u>amount</u> of food and drink you had yesterday was:

- less than usual,
- usual, or
- more than usual for that day of the week?"

Those individuals who indicated a deviation from the usual diet reported an average of about 250 kilocalories less (or more) than those who labeled the amount eaten as usual. Reasons given for eating more or less than usual included being at a social occasion, trying to lose weight (went to exercise and got weighed at a spa--decided to fast.), being sick or ill (an acute, rather than a chronic illness), and what I would call idiosyncratic appetite:

- I just wasn't hungry, nothing I wanted to eat.
- Too tired to eat supper.
- Just didn't feel like eating.
- Just felt like it.
- I love spaghetti.
- I love pizza.

There were also some reasons that were related to the season in which the interviews were conducted (from April through part of June):

- Mother's day.
- Secretary's day.
- Fasting for Good Friday.
- Easter dinner.
- Just after Passover--still full.
- Hot, so we BBQ, usually have more to eat.
- It was hot and nothing looked appetizing.

The interrelationship between many of these sources of variability is now being investigated by Cheryl Ritenbaugh and George Beaton in a University of Arizona extramural research project.

Measurement errors may also affect variability in dietary intake data. Measurement errors may be systematic (resulting in values that are higher or lower than actual values) or stochastic (resulting in variability that is higher or lower than actual variability). Errors may apply generally to any use of a measurement method or may be characteristic of a population subgroup such as children, the elderly, or the obese. The period of observation (number of days, whether consecutive or nonconsecutive) will affect variability, and the system of data capture may also introduce measurement errors. Researchable issues related to data capture include--

- the wording and sequence of questions and probes,
- the type of recall aids and procedures for their use,
- how the interview is administered (self-administered, personal interview, telephone interview, automated),
- the location of the interview (home versus clinic), and
- the privacy of the interview (presence of other household members).

In addition to data capture, the system used to process the data collected can also introduce errors. For food intake data, the most important processing elements relate to the conversion of descriptive information about a food to a specific numeric food code and the conversion of reported food intakes into nutritive intake values through the use of a nutrient data base.

Can we accurately measure the variability introduced by different methods? An important problem in evaluating different methods is the well-nigh impossible task of devising a standard, or reference method, by which results may be judged. The most direct and accurate methods are the most intrusive, and the act of measurement may affect what is eaten. Unobtrusive observation has been used primarily in group settings like a congregate meals program or a company cafeteria, while most food consumption still occurs in the home.

There is also a need to establish an empirical basis for questionnaire design and implementation. Input for questionnaire design comes from researchers in cognitive psychology, anthropology, linguistics, and decision theory, as well as from experts in food and nutrition. Questions need to be evaluated through administrative tests, field tests, and analysis of survey results. Evaluation of survey results includes data analysis and debriefings of both interviewers and respondents. There is no single wording of a question that every respondent will understand in exactly the same way. Social, cultural, and regional differences will be reflected in the degree to which a given question is understood.

The quality of the collected information will reflect not only this understanding but also how well the recall of respondents is facilitated by the interviewer.

Finally, a greater use of sensitivity analysis would indicate the impact of food composition variability, the use of standard recipes, and portion size estimates on dietary assessment. Foods showing the largest impact require priority in research efforts related to food composition and food measurement methodology. Frank Hepburn's paper gives an example of this type of research.

Individuals do eat differently at different times in terms of food items, amounts, methods of food preparation, and so on. Large samples alone do not necessarily compensate for all types of variability, therefore, a more complete understanding of dietary variability remains a priority for research on survey methodology. This research is under way at HNIS.