COMPREHENSIVE REVIEW, ANALYSIS AND EVALUATION OF THE ENGLISH LANGUAGE LITERATURE OF THE PERTINENT STUDIES AND METHODOLOGIES USED TO OBTAIN THE DIETARY INTAKE AND EATING PATTERNS OF INDIVIDUAL ADULTS

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ENGLISH LANGUAGE LITERATURE OF THE PERTINENT STUDIES AND METHODOLOGIES

USED TO OBTAIN THE DIETARY INTAKE AND EATING PATTERNS OF INDIVIDUAL ADULTS

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Dietary histories have been taken by hospital dietitians for more than thirty years in an effort to determine how to aid an individual in adapting his previous dietary habits to a therapeutic diet required by a present illness. A great variety of highly individualized techniques exist in this area of dietary interview; the major purpose of the interview being to adapt a specific therapeutic diet pattern to the economic, cultural and educational environment of the individual patient.

As hospital dietitians have joined the traditional members of the public health team and have considered the community as "the patient", they have found it necessary to obtain dietary information from large population samples. Just as epidemiological principles involved in the study of mass phenomena differ in important respects from the principles involved in the clinical study of an individual, so the nutritionists in public health find that methods effective in obtaining information about dietary intake from an individual in a hospital environment need adaptation when applied to large population groups. Many efforts toward such adaptation have been made.

In recent years, the rapid development of epidemiological studies of cardiovascular disease has required nutritionists to consider the development of methods which can be used in the broad population studies of disease phenomena. This problem has challenged members of the Faculty of the School of Public Health and the staff of the Survey Research Center at the University of Michigan.

The following are our guidelines to the development of methods for these purposes:

1. They must apply to individuals and not only to group averages.
2. They must reflect long term food patterns.
3. They must be sufficiently simple to be usable for the study of large populations, at reasonable cost.

4. Last, but not least, they must be valid, reliable and objective.

It becomes immediately obvious that an attempt to develop methods which will fulfill these requirements demands the coordinated, interdisciplinary approach of the various professional groups represented by the fields of nutrition, statistics, the social sciences and epidemiology. All of these disciplines have contributed to our considerations of the complexity of the problems inherent in dietary survey methodology. Furthermore, all of these disciplines must be involved in the development of procedures to be followed in the determination of the design for research in this area.

The relationship of the areas of statistics, social science, nutrition and epidemiology are illustrated in the chart below.

PURPOSE: To collect long term, large scale, dietary information

STATISTICS
(Design, evaluation and processing of the data)

SOCIAL SCIENCES
(Social psychological factors related to the collection and evaluation of dietary information)

NUTRITION
(Specific independent variables involved in the problem)

EPIDEMIOLOGY
(Problem of possible dietary factors as a cause of chronic disease)
From the field of epidemiology come questions regarding relationships indicating that dietary factors may be important in the development of disease. From the field of nutrition comes specific information regarding some of the independent variables that may be involved. Some of the competencies of social science and statistics are needed to solve problems in the area of nutrition and epidemiology.

The immediate need for developing useful methodologies is related primarily to the epidemiological investigation of cardiovascular diseases. However, it must be emphasized that the problem of dietary survey methodology is one that is basic to many other fields of study. The immediate and long term goals of the study are in the content area of nutrition. The field of nutrition includes knowledge of dietary needs, food composition, food preparation practices and meal patterns. This discipline has an appreciation of the almost endless variations involved in the choice and use of food in the American scene.

The social sciences have a most important contribution to make in the area of the context and the collection of information regarding food habits. This discipline can help the other members of the team appreciate the relationship of social phenomena to food intakes. Social scientists can also contribute knowledge relating to limitations of memory; they can help us to develop a more objective methodology; they have pioneered in the development of the use of trained lay interviewers for large scale, cross sectional studies.

The field of statistics has important contributions to make in the area of study design and in the processing of data. Statisticians can contribute immeasurably through their ability to handle variations of secular group phenomena and social position, such as sex, age, and status. Statistical techniques are most important for handling variation between samples; between methods; between interviewers; between observations within methods.
The staff and members of the Advisory Committee have together represented a great diversity of background and experience. One of the major challenges facing the group at the outset of the study was the problem of effective communication between disciplines. (See Sheps and Taylor (1954) for a discussion of these problems.) This cross fertilization of disciplines has been an extremely valuable part of the activities involved in accomplishing the literature review.
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INTRODUCTION

This report deals with a critical and objective look at the methods which have been used in the collection of dietary information. Consequently, this literature review is directed toward the interests of nutritionists, statisticians, social scientists and epidemiologists who have a primary interest in the methods used in the gathering of dietary information from population samples. We recognize and acknowledge the valuable contributions made by the large number of persons who have been involved in the complex problem of dietary studies. We are attempting to use their experience and their results. Any evaluation is strictly from the standpoint of our own goals, which frequently were not those of the authors whose studies we have reviewed. We have studied their reported methods with our own particular needs in mind; we have attempted to determine whether or not these methods could be used as such or altered to meet the criteria which we have established. The criteria for methods useful for our purpose as briefly outlined in the preface are:

1. They must provide a basis for determining the position of an individual on a scale of consumption of important foodstuffs and/or nutrients.

2. They must provide data on long-term patterns, i.e. those existing over at least one year's time.

3. They must be applicable to studies of large populations. This implies that
   a. The methods must be such that they can be applied by trained lay interviewers.
   b. The methods must permit the collection of data within reasonable time expenditures in order to minimize interviewer cost, and time and demands on the respondent.

4. They must be validated internally with respect to interviewer and respondent errors and externally with respect to alternative methods of assessment.
The point of emphasis to be made is that we have attempted to study the reported methods with a focus on epidemiological requirements. We have studied the reports of dietary methodology which:

1. Include any method that actually measures, purports to measure, or gives promise of measuring food intake or food habits over a long period—28 days or longer.

2. Include tests of reliability, validity and/or consideration of objectivity problems.

3. Include studies of methods of collecting information.

4. Include tests of memory ability for food and food quantities.

AND

We have included representative studies which:

1. Have been done for epidemiological investigation.

2. Give particular consideration to social factors.

The literature review represents the first and a very important step in achieving our ultimate goal. Keeping our criteria for a useful method in mind, we first determined the questions we needed to ask of the literature in order to summarize and evaluate the information related to the methodologies reported. Taking each of the important segments of our general purpose in detailed sequence, we have tried to fit together to serve our purposes, studies which have to a major degree served other purposes when undertaken by the particular investigators.

Since this is a review primarily of methodology rather than substantive findings, we have not considered it necessary to cite every study using essentially the same methodology but have chosen studies that document variations of methodology. We have selected studies that fall within our area of interest and that illustrate the points considered. Methodology is not always described in great detail. We may have misinterpreted some of the publications. For any such errors of omission or commission, we express our regret.
We have sought to find aid in achieving our ultimate goal -- the development of methods of collecting information about food eaten by a large number of individuals over long periods of time that minimize the need for the use of expensive professional personnel.

The table of contents will direct the reader to the literature review selected to answer the questions posed. The overall plan involved consideration of questions under the major categories of

Methods of collecting data
Considerations in collecting and handling data
Problems involved in the study of large numbers of people
Developing individual level information
Needs and problems related to long term studies
Possible cultural, social and psychological factors of dietary intake
Problems arising out of combined needs
Perspective

Each major category includes numerous sub-headings which suggest the complexity of the questions asked of the literature.

The literature review has served many purposes. It has been a means of bringing together persons with a variety of experiences for focus on the literature and the problems involved in evaluating it with our own set of criteria in mind. It is our strong feeling that many of the difficulties of interdisciplinary work reported by Sheps and Taylor (1954) may be resolved more readily by common group acceptance of a defined task outside of or beyond any of the separate disciplines. We are here attempting to solve a problem of epidemiologic methodology, and questions of pre-eminences or rivalry among disciplines are relatively unimportant except as contributions to problem solutions. In this sense the problem is superdisciplinary.

The literature review has reinforced our original premise: the literature does not supply us with information regarding any one method that can presently be used with large population samples, at relatively low cost, using lay interviewers, and an instrument that would lend itself to use over extended periods of time.
We hope that the literature review will provide assistance to others who are seeking answers to the complex problems involved in dietary survey methodology. Its ultimate value will be realized only if it is used as a basis for further work filling in the many large gaps revealed between current knowledge and the current goal of determining the kind of dietary information it is possible to collect through an instrument used by lay interviewers. In order to assess the usefulness of such a procedure, a penetrating study of a number of different methods that could be used must be made, since the validation of the data obtained by any one method is of greatest importance.
Chapter I

METHODS OF COLLECTING DATA

An early systematic attempt to review and describe some of the considerations that are applicable to our problem was made by Bigwood (1939). This investigator points out the major consideration that the dietary collection method to be used depends on the specific problems with which it is concerned.

This includes the level of data to be collected -- individual or family; the amount of detailed information necessary -- the amount of error of method tolerable; the scope of the problem -- a large population or a limited group; the amount of variability and source of variability of respondents -- over seasons, weeks or days; the duration of the collection period; the competency of the staff and number of the staff.

Other reviews, including the Bulletin of the National Research Council (1949) and the report by Leitch and Aitken (1949) have discussed and documented most of the problems pointed out by Bigwood (1939). They have further pointed out that methods of collecting individual dietary information can be categorized into several groups in terms of how the data are obtained and the period covered. Individual dietary histories which aim to discover the usual food pattern over a relatively long period are contrasted to 24 to 48 hour recalls in terms of the time dimension. It is also noted that dietary records can be kept either by the investigator or more frequently by the subjects. Records can cover one day to two weeks or more. Information regarding food consumed can be provided through records on weights, household measures or estimated quantities. (Widdowson and McCance 1945; Youmans, Patton and Kern, 1942). At the time of these
views little systematic work had been done in comparing each of the
techniques with each other. Since the publication of these reviews, some
effort has been made to compare the various methodologies, as summarized
in the Report of the Diet Methodology Committee for the Conference on
Methodology in Epidemiological Studies of Cardiovascular Disease (1959)
and by Young and Trulson (1959). Comparison of the latter two articles
with the earlier reviews gives a very useful picture of the change of intent
and the evolution of systematic thinking in the area of obtaining dietary
information. The earlier dietary survey work was aimed at establishing
amounts of nutrients needed, assessing the adequacy of diets and/or pro­
viding information useful in determining emphasis in nutrition education.
More recently interest has been focused on the assessment of the relationship
of diet and dietary habits to chronic diseases. This change has brought about
renewed interest in long term dietary trends and more careful consideration
of the objectives of the dietary study. (The Report of the Diet Methodology
Committee for the Conference on Methodology in Epidemiological Studies of
Cardiovascular Disease, 1959).
Development of Systematic Thinking in this field is shown by the current
approach to the problems of collecting dietary information. Prior to
initiating dietary studies today, the investigator is likely to ask himself
a set of questions as follows:

1. What are the objectives for the dietary aspect of this study?

2. What are the hypotheses under consideration?

3. What information is obtainable from the dietary intake? What level
   of accuracy is necessary?

4. What shall be the time span involved in the study?

5. What are the alternative methods which may be used?

6. Who shall be the subject and who will be the informant? What are their
   levels of interest, information and ability to communicate?
7. Who will record the information? What are their levels of competence?

8. How certain is the investigator that this method is securing the information desired? What is the validity and the reliability of the technique being used for this dietary study?

9. What added information is needed from the subject?

10. How can the data be processed?

When the investigator asks himself these questions and more, he finds that he does not have all the answers. He is forced to gather information in order to formulate his problem more clearly and to choose the ways and means he will take to obtain information using criteria specific to his methodological problem. Actually, within each of these broad categories of questions, there are more particularized questions depending on the problem under investigation.

**Current Methods of Collecting Food Intake Information**

At the Conference on Methodology in Epidemiological Studies of Cardiovascular Disease (1959), the Diet Methodology Committee reported that "the methods most commonly used or most reasonably considered for epidemiological studies are

1. Intake at specific meals recorded concurrently by means of weights.
2. " " " " " " " " " " household measures.
3. " " " " " " " " " " by recall estimates of quantity.
4. " " " " " " " " " " by means of frequency of occurrence.
5. " " " " " " " " " " frequency of occurrence.
6. Current usual intake recorded by recall of estimates of quantity.
7. " " " " " " " " " " frequency of occurrence.
8. Past changes in " " " " " " frequency of occurrence.
9. Past changes in intake recorded by recall in terms of frequency of occurrence of food items."

Young and Trulson (1959) more recently have added one other method:

"9. Past changes in intake recorded by recall in terms of frequency of occurrence of food items."
We have found it useful to think of only two distinctly different methods of collecting dietary information: food records in weighed, measured or estimated amounts and the dietary history. These methods are modified in many ways to meet the needs of various investigators.

We are grouping the methods one through three mentioned previously as examples and modifications of "food records" and methods four through nine are considered as modifications or uses of parts of the "dietary history" method.

Food records.

We have chosen to make reference to the weighed food record as an example of the type of approach used by the many workers who suggest that this is the most accurate type of record one can obtain. The few references that we have cited provide some information related to the beginnings and the early development of the methods.

Mitchell (1935) reported using dietary studies obtained by records in weighed amounts as a teaching device with college home economics students. Widdowson (1936 a) saw advantages in the detailed information that could be obtained from this method and has used it extensively in field studies.

In 1945, Widdowson and McCance expressed the viewpoint that information for dietary surveys requires that "in all cases the total food consumed must be weighed." Widdowson (1947) gives further details regarding the method to be used. Each subject is given a "spring butter balance", weighing up to two pounds and calibrated in 1/4 ounces. The subject is also given forms for recording the food eaten during one week, and instructions. The following are the written instructions:

"1. Weigh each kind of food separately, just as it is served to you. If raw, say so. If you are eating any food such as fish or chops that contain bones, or fruit with skin or stones, please say whether your weight included the waste, e.g.:

Kipper, weighed with bones.
Orange, weighed without skin.

W/4"
There is no need to weigh the waste, but please weigh any food you leave and deduct it from the food you first weighed out.

"1. If you weigh anything on a plate do not forget to subtract the weight of the plate before entering the result on the form.

"2. You need not bother to weigh eggs. Just count them and put the number. Sugar may be weighed, or measured in lumps or by the teaspoonful, (say whether level or heaped).

"3. Please say whether your bread is white or brown.

"4. Do not forget to put down all sweets and chocolates under 'Extras'.

"5. For stewed and tinned fruit weigh the fruit and juice together.

"6. Do not include gravy in the weight of the meat; measure the gravy separately in tablespoonfuls. Please say what kind of meat or fish you eat.

"7. It is a good plan to weigh out for yourself at the beginning of the week 1/4 lb. or 1/2 lb. of butter and always use from this piece. You need not then weigh the butter as you eat it, but simply put '1/4 lb. of butter started' and '1/4 lb. of butter finished', when it is so. If any butter weighed out to you remains at the end of the week, say what it weighs.

"8. We are very anxious to know how much milk you drink per day and how you drink it, so please weigh the milk if possible or measure it in tablespoons. Say how much milk you drink alone, and how much you put in a cup of tea, cocoa, etc. Do not forget to put down how many lumps or teaspoonfuls of sugar you take in your drinks."

In Widdowson's study of 916 school children these instructions were given in various ways -- to mother and child by interview, to mother by letter, to child by teacher in the classroom. The children were not personally supervised while the food was weighed and eaten. When this collection technique is used the methods of instructing the subjects and of supervising and checking their work has varied both with the study (Widdowson 1936 and 1941) and with the investigator (Durnin and Thomson -- 1958).

Bigwood (1939) indicated in a League of Nations Monograph that the procedure for "exclusively individual enquiries" consists of "weighing the food actually consumed by the person concerned." Since this is an international publication and a classic one in the field of dietary methodology,
it is understandable that the weighing method is considered by many to be the "gold standard". Another reason why this method may be held in highest regard by many is that it carries the prestige of the physical sciences, since physical measures are used.

Modifications of the "food record" as described above

(1) Food records of shorter periods of time, such as, one day or three days have been frequently used as a basis for study.

(2) The methods of determining and recording the amounts of food have varied. For example, household measurements, estimated amounts, and numbers of units have been used separately and in combination.

(3) Instructions for keeping the records have varied -- sometimes they have been given in an interview with one subject, sometimes to groups of subjects, and usually by written instructions in addition to the verbal instructions.

(4) Supervision of the record keeping has varied from none to frequent visits for purposes of checking the measurements and the recording of them, and also for purposes of clarifying information where necessary.

A few of the current studies in the epidemiology of cardiovascular disease are modifications of the food record method. Cantoni (1959) describes a repetitive diet record technique that is being used in some studies in monasteries. The records are kept in household amounts by the individuals. Additional information on quantities and recipes is obtained from the cooks.

Diet history

Leitch (1949) stated that the origin of the questionnaire survey "is obscure." Some steps in the origin of the diet history are indicated in the following report:
Turner (1940) chairman of a sub-committee of the Diet Therapy Section of the American Dietetic Association, described a method that could be used by dietitians to give physicians a quantitative appraisal of the home dietaries of patients.

Five steps were suggested for obtaining a preliminary diet history:

1. Interview the patient for a "typical menu." The previous 24-hour or 48-hour intake is suggested as a logical starting point to obtain a definite impression regarding regularity of meals and distribution of food.

2. Use a food intake list to obtain more detailed information on the frequency of the use of specific foods and to estimate the quantities used. It is also used to obtain information on practices of handling foods -- purchasing, storage, and preparation.

3. Obtain an account of food purchases and distribution of foods among the family members.

4. Compare the information from the three sources and discuss discrepancies with the patient.

5. Make up a revised list of foods eaten and amounts ordinarily used by the patient.

The committee indicated that this preliminary account might be quite accurate for some individuals and of very doubtful value for others. Therefore, a record of actual food intake was suggested to obtain further information. The limitations of measured amounts was recognized and the value of amounts weighed in grams was appreciated. It was noted that the food record alone may be insufficient since it may not be typical of usual patterns of eating.

Burke (1947) who had assisted the sub-committee of the Diet Therapy Section, described "the dietary history as a tool in research". She has developed the method and has used it very extensively. In reporting
longitudinal studies of children, Burke et al. (in Stuart, 1959) briefly reviewed the features of the method.

1. It is a technique designed to measure the average nutrient intake of an individual over a considerable period of time, taking into account fluctuations in intake during the period covered by the history...

2. The essential parts of this technique are
   a. a cooperative and intelligent informant...
   b. a nutritionist interviewer trained in this technique;
   c. a standard set of procedures for translating lay descriptions of diets into scientific units of nutrient intakes.

3. The person taking this history must gain the confidence and cooperation of the informant, must not hurry him, must convince him of interest and must motivate him. "It is important to realize that in this type of dietary history considerable time is required to develop sufficient skill in the entire technique."

4. The interviewer records the subject's usual pattern of eating, both at and between meals, in common household measures and the extent to which the usual pattern of eating varies. If these variations are so extreme that the individual has no clear pattern of eating, it may be impossible to determine the average daily food intake.

5. A "cross-check" is used to review the average intake of specific foods or food groups. It is used to verify, to clarify, and to minimize errors.

6. The interviewer uses the information obtained to determine the subject's "average" daily intake.

7. The "average" daily intake is converted to nutrients using a specific, composite food table.

Modifications of the "diet history" as described above

1. This basic method has been used in part. For example, either a twenty-four hour recall or a food list method are sometimes employed to obtain information regarding food intake.

2. The dietary history has been used by investigators with different training or less training from those trained by Burke. The Burke Method requires the services of a skilled and experienced nutritionist; in fact, only a few nutritionists in the United States have been trained in the use of this technique.

3. The recall portion of the history has been extended to longer periods of time than the 24 hours indicated here in the basic method; in other cases, the recall of only one meal has been used.
4. The length of time used for the interview has been shortened considerably in some cases, and it has been lengthened in others.

A number of modifications of the "dietary history" that are being used in current studies of cardiovascular disease were described by Cantoni, et al. (1959). In one study, interviews are conducted after a heart attack has occurred with the subject or with a relative. A typical day's menu and a food list are used. The respondent is asked the frequency that foods are used, the usual size of serving, and the amount of fat used in food preparation.

In another current study described by Cantoni (1959), the nutritionists begin the interview of the subjects by obtaining the twenty-four hour recall and the typical day's eating pattern. Then instructions are given for completing questionnaires at home. The questionnaire is designed to give information regarding amounts, kinds, and frequency of use of food eaten in the previous month.

Studies Comparing Methods

Comparative study of the two distinctly different basic methods

With two distinct methods, each having strengths and weaknesses, it would seem logical that attempts be made to make comparisons of the methods.

The following characteristics seem to be necessary for a fair comparison:

(1) The methods must be used in the most careful manner that is recommended by the investigators who use them most extensively.

(2) The comparison should be made over a sufficiently long period of time so that the comparison is fair to the method whose greatest strength probably lies in the length of time covered.

(3) Weighing should be the measurement technique to fairly determine the accuracy of the techniques during specific periods of time.

Huemann and Turner (1942) conducted an investigation that came as close to measuring up to these standards as any such study found in the literature. They studied 21 dental clinic patients, aged 6 to 14 years. At the
beginning, they obtained a detailed diet history from each of the subjects and/or the mothers of the subjects. Following the interview, a food intake record was kept in the home using a gram scale for a period of 10 to 14 days. The weighed record of food intake was repeated every three or four months, three or four times, so that the period of time covered for each child ranged from at least 6 months to one year. Calculations were made for 12 nutrients for comparative purposes. After study of the variation of the amounts of nutrients, the authors concluded that no single diet record could be considered "typical" of a subject's food intake over a period of time in the majority of cases studied. This study represents an investigation that can illustrate how validity and reliability information can be obtained through new and powerful analysis techniques. Our detailed analysis of this study appears in the appendix.

We have not found, since the 1942 publication, a study that approaches the standards suggested here as being essential to a comparison of the comprehensive dietary history and the record of weighed food intake.

**Comparisons of modified methods**

Dietitians and nutritionists have been interested in finding methods of obtaining food intake information which would be more economical than methods currently in use. As a result, various portions of basic techniques and modifications of basic techniques have been used.

Three way comparisons of modifications of the two basic techniques and a short technique have been made.

Young et al. (1952 c) reported studies of comparisons of

1. One 24 hour recall
2. Diet history
3. Seven day dietary record in household measures
The subjects who totaled 166 were from three states. The type of subjects differed in each state—pregnant women, 7th and 8th grade pupils, and high school and college students. The order of the procedures used was the same as the order listed.

This study intended to help answer the questions: In estimating the nutrient intake of an individual, how do the data from the three techniques compare and further, and in estimating the mean nutrient intake of a group how do the three methods compare? Using ten nutrients, it was found that the twenty-four hour recall technique did not give the same information as an estimate of individual intake from the average of the results of the dietary history. The findings also indicated that for the individuals studied the twenty-four hour recall did not agree with the estimates obtained by the seven-day record technique.

At the group level of analysis, we find that the dietary history gave generally higher estimates of intake than the twenty-four hour recall and that this finding varied somewhat from group to group studied in terms of the number of nutrients to which it applied. On the other hand, it seems that the seven day record and the twenty-four hour recall gave similar results and might be interchangeable for population group studies.

Trulson (1954) reported a comparative study of
(1) Seven day dietary record in household measures (I)
(2) Diet history (II)
(3) Three or more 24 hour recalls (III).

Subjects were rheumatic fever patients seen in clinics. Food intake information obtained by the three methods was available from 37 patients between the ages of 7 and 12. The information was obtained from the patients during a two year period. The order or the spacing of the collection methods within the time period for the specific patients is not clearly stated, but
the intent was to get an accurate picture of the usual diet from each of these alternative methods. The methods were compared for milk intake, protein intake, intake of eggs, intake of foods high in carotene and intake of foods high in ascorbic acid.

Table One shows the comparisons of the three methods in terms of intercorrelations of results for individuals, from Trulson (1954).

Table I -- Comparison of Methods (Correlations) for Individuals. (Pearson r. Coefficients) ***

<table>
<thead>
<tr>
<th>Food group</th>
<th>I vs. II</th>
<th>Comparisons</th>
<th>II vs. III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I vs. III</td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>.65 **</td>
<td>.71 **</td>
<td>.51 ***</td>
</tr>
<tr>
<td>Protein</td>
<td>.67 **</td>
<td>.54 **</td>
<td>.67 **</td>
</tr>
<tr>
<td>Eggs</td>
<td>.46 **</td>
<td>.38 *</td>
<td>.30</td>
</tr>
<tr>
<td>Foods High in Carotene</td>
<td>.47 **</td>
<td>.32 *</td>
<td>.26</td>
</tr>
<tr>
<td>Foods High in Ascorbic Acid</td>
<td>.54 **</td>
<td>.41 *</td>
<td>.46 **</td>
</tr>
</tbody>
</table>

N=37

** The probability of finding a correlation this size when the actual correlation is zero is less than one chance in one hundred.
* The probability of finding a correlation this size when the actual correlation is zero is less than one chance in twenty.
(Trulson - 1954).

This table shows that better agreement is found between the three methods for milk intake and protein intake and that there is more agreement between methods I and II, the seven-day record and the diet history than between the other pairs of methods. There is least agreement at the individual level between methods II and III, the diet history and the combined 24-hour recalls.

*** We might note that the formula, mentioned in the article to compute the significance level of the correlations found in this table, was incorrect, and more accurate formula is given by Fisher (1921). The formula presented by Trulson could not have been used to obtain the results in the table.
Table 2 shows the comparisons between the means of the groups for each of the methods.

Table 2 — Comparison of Methods (Means) For Groups

<table>
<thead>
<tr>
<th>Methods</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>I vs. II</th>
<th>I vs. III</th>
<th>II vs. III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (cups/day)</td>
<td>3.02</td>
<td>3.52</td>
<td>2.83</td>
<td>0.50*</td>
<td>0.19</td>
<td>0.69*</td>
</tr>
<tr>
<td>Protein (gms/day)</td>
<td>65.20</td>
<td>65.74</td>
<td>61.80</td>
<td>0.54</td>
<td>3.40</td>
<td>3.94</td>
</tr>
<tr>
<td>Eggs (servings/wk.)</td>
<td>3.45</td>
<td>3.39</td>
<td>3.07</td>
<td>0.06</td>
<td>0.38</td>
<td>0.32</td>
</tr>
<tr>
<td>Foods High in Carotene (servings/wk)</td>
<td>5.31</td>
<td>4.12</td>
<td>5.01</td>
<td>1.09</td>
<td>0.30</td>
<td>0.89</td>
</tr>
<tr>
<td>Foods High in Ascorbic Acid (serv./wk)</td>
<td>5.85</td>
<td>4.91</td>
<td>4.42</td>
<td>0.94</td>
<td>1.43</td>
<td>0.49</td>
</tr>
</tbody>
</table>

*Differences found are significant, the chance of this size difference occurring by chance is less than one chance in twenty. (Trulson - 1954).

For this group of subjects, differences in the results of the three methods of assessment were only significant for the milk intake. The two tables published by Trulson (1954) illustrate the general finding that group level agreement is more easily attained than individual level agreement.

Comparative studies of basic techniques have been made with parts of basic methods.

The comprehensive dietary history was compared with a 24 hour record method by van den Berg and Mayer (1954). Obese pregnant women were requested to record food eaten on one day of their choosing. They were expected to follow written instructions without verbal explanation and when their records were returned there was no checking of them with the subjects. Records obtained from 35 patients were compared with information obtained approximately one week later by the comprehensive dietary history. The results of this study show that in terms of mean differences in calories, proteins, fat, and carbohydrates, the two methods disagree widely. The probability of such discrepancies
occurring by chance alone being less than one in a thousand.

Mean differences and standard errors of the differences between the results of the methods were also compared in terms of foods or food groups. For the milk and meat and fish food groups, no significant mean differences were found. However, for the food groups, cereal, bread and crackers and the group including desserts, significant mean differences were found in the results which compared the two methods of assessment.

The results of this study are interesting. However, it is our opinion that workers in the field of dietary survey methodology would not usually use a twenty-four hour record in the manner that it was used here. The comparisons made were, therefore, a little less than fair to the 24 hour record method.

The seven day weighed record technique was compared with the 24 hour recall by Thomson (1958) and Morrison, et al. (1949) in two pre-tests. The food eaten by eight scientists living in a residential club was weighed for a twenty-four hour period, without their knowledge. Later they were asked to recall the food and amounts that they had eaten. A comparison of the results expressed in calorie values of the two methods showed agreement within pairs which was little better than chance. Morrison, et al., (1949).

Twenty pregnant women who were cooperating satisfactorily in a survey that involved weighing of food for seven days were selected. (Thomson - 1958). In the middle of the weighing period they were asked to recall the food that had been eaten and recorded during the previous 24 hours. Recall gave an underestimate of the weighed results. Only results for calories were compared.

The seven day weighed record technique was compared with the 24 hour recall by another pair of workers, Chamberlain and Pike (1948). Twenty University freshmen kept 7 day weighed records, and they were also asked to recall the food eaten in the previous 24 hours. Their results show that Vitamin C was the only nutrient on which the group average was materially different between the two methods. Their data showed that at the individual level
considerable differences were found in the results for calories, protein, fat, calcium, iron, vitamin A, vitamin B1, riboflavin, niacin, and vitamin C.

Other studies of modified methods have been made.

In studies of individuals, dietitians and nutritionists have investigated a number of aspects of techniques to attempt to determine usefulness and economy. The types of studies have indicated some of the wide variety of factors involved in use of the various methods that affect the accuracy of the results obtained.

Meredith, et al. (1951) compared actual weighed food items eaten by children in a school lunch with what they remembered eating as learned by interview. Ninety-four students were included in the study. The differences in average nutrient values between the computed and the recall intakes were significant for only ascorbic acid and vitamin A, of the thirteen nutrients compared. (Calories, animal protein, vegetable protein, fat, carbohydrate, calcium, phosphorus, thiamine, riboflavin, and niacin)

Eppright et al. (1952) studied the nutrients received by school children as first estimated by 25 mothers in comparison with the same foods which were weighed by the mothers. The two sets of records were compared, the mean of the nutrient intakes as calculated from the estimated diets was higher than the mean as calculated from the weighed diets. The mean differences for fat were significantly different at the 1% level; differences between the means of the results of the two methods for calories, protein, calcium, vitamin A, and riboflavin were significantly different at the 5% level. The differences of the means for carbohydrate, ascorbic acid and thiamine were not large enough to be significant.

Ohlson et al. (1948) had preliminary interviews with 67 white and 14 Negro women before 7 day records or 24 hour recalls were obtained. They studied
the information about milk consumption as indicated by the interviews as compared with actual records. These subjects consistently over-estimated their milk consumption.

Steele, et al. (1952 a) studied the nutrient content as revealed by 7-day records from adolescents as compared with those based on interviews with the adolescent and also those based on interviews with the mother of the adolescent. This study was carried out with 11 boys and 11 girls and their mothers. Comparing the results of the three methods, it was found that the seven-day record and the mother's interview showed no significant mean differences at the 5% level on the 10 nutrients compared for the boys, except calories. For the girls, the two methods showed significant differences in the results on eight of the ten nutrients. Comparison between the seven day record kept by the boys and the boy's interviews showed significant differences for protein, calcium, phosphorus and vitamin A. The seven-day record and the girls' interviews showed even less agreement. There were significant mean differences found for 9 of the 10 nutrients compared. When the results of the mother's interview and the child's interview were compared, there were no significant mean differences for boys and only one significant mean difference for girls, (thiamine).

Steele, et al. (1951) studied the nutrient value of unchecked and checked 7 day records made by 87 seventh and eighth grade boys and girls. As a group the unchecked dietaries gave no differences larger than 10% for the 9 nutrients compared. On an individual basis, 16% of the subjects showed discrepancies higher than 10%.

Young, et al., (1953) studied the nutrient value of diets as learned from estimated and measured amounts of food. Sixteen to 56 subjects of various types were studied in each of six states. The methods used varied with the circumstances of each study. The basic conclusion of these studies was that
weighed or measured food records are desirable.

Collins (1949) reported a study in which Austrian school teachers obtained 24 hour dietary histories from 1,822 individuals who included all age groups and made up a sample 10,000 individuals in Vienna. The caloric value of these findings were compared with the calories per head per day rationed for the use of the individuals of the same age groups. At the lower age levels the caloric values obtained by history were larger than the amounts rationed; at the higher age levels they were lower. Some of the effects of stresses of war time rationing were recognized. The conclusion was made that, "...in times of acute shortage, the 24 hour dietary history technique is unreliable as a true estimate of food intake."

In studies of families, Murray et al. (1952) studied methods of obtaining family food consumption data by a record method and by a list method that involved homemaker recall. Subjects were 84 families of low income in Mississippi and South Carolina. Each lay interviewer obtained information by both techniques. The study was planned with two sets of parallel areas in four counties. Other phases of the survey were made as parallel as possible. Differences of statistical significance appeared for only a few items or food groups. There is no clear cut evidence that either technique biases the results that were obtained.

Strom et al. (no date) compared an interview recall technique with a diary record in a pre-test of a study for the Market Research Corporation of America. Data on this pre-test and others by these workers are not available. This group felt that since they were trying to picture a longer time period, the time dimension of the dietary record was advantageous.
Comparisons of group averages and individuals within groups

Carroll et al. (1952) studied nutritive value of weighed food available to individuals, as averages of groups, served from four kitchens of an Ohio institution and compared this with sample individual weighed portions. There was reasonably good agreement between the results of the two methods for calories, protein, calcium, vitamin A and ascorbic acid. The data for thiamine, iron, niacin and riboflavin showed some differences between the two methods.

Young and Pilcher (1950b) compared findings regarding nutrients obtained from 7 day records for families with information regarding individuals within the families using typical mid-week one day records of the individuals. The findings showed that the data from the individuals consistently under-estimated the family 7 day record data. This result held true for farm, rural non-farm and village families for the 9 nutrients calculated.

Some notations regarding the units used in findings of these studies

In these comparative studies of collecting techniques it is important to note the units for reporting findings.

Most of the studies have used nutrients. The number of nutrients has varied considerably. For example, Thomson (1958) and Morrison et al. (1949) based their findings and conclusions on only the total calories. On the other hand, Huenemann and Turner (1942) reported their findings on 12 nutrients. Many of the studies reported here were a part of the North Eastern Regional studies; findings were regularly given for 10 nutrients in this group of studies.

A few of the studies reported findings by use of foods. For example,
Ohlson et al. (1948) used milk as the unit of study. Trulson (1954) used milk, protein, eggs, foods high in carotene, and foods high in ascorbic acid. Murray et al. (1952) used pounds and money value of foods as well as nutrients.

A unique aspect of the study by Meredith et al. (1951) was that some of the comparisons were concerned with numbers of food items:

- the number in the meals related to those recalled
- the numbers reported that were larger or smaller than those weighed and recorded
- the numbers incorrectly identified.

Nutrients were studied as well.

In most of these comparative studies of techniques for collecting information, a twenty-four hour period has been used as the unit of time for the basis of comparison. Examples of a longer time period are Young et al. (1952a) and Murray et al. (1952). Both groups of workers used a week as the unit of comparison.

The confusing multiplicity of approaches and data is apparent from the foregoing discussion. The salient features of the studies reviewed here, therefore, have been summarized in Table 3 in order to provide a clearer picture of the large amount of work already done in this field. In each of these studies, the question arises whether the data reflect the true dietary intake (validity) and whether the method itself is reproducible in the hands of the same or different investigators (reliability or objectivity). These questions have been asked of all of these studies but we have come to the same conclusion as Wiehl (1959): "The weaknesses and strengths of different methods are well known to most investigators even though statistical data on the reliability and validity of the various methods are limited."
As an illustration, for reasons already mentioned, we selected the study of Hueneman and Turner (1942) for detailed analysis and found (see Appendix A) that even this meticulous investigation fell short of desirable standards. In the subsequent section, the problems of validity, reliability and objectivity will be reviewed in general to serve as a basis for the design of methods which will not only provide the desired nutritional information but yield finite and statistically interpretable margins of error for each of them.
<table>
<thead>
<tr>
<th>Methods Compared</th>
<th>References</th>
<th>Evaluation in Terms of Foods</th>
<th>Evaluation in Terms of Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparative Study of Two Distinctly Different Basic Methods:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>History vs. 3 or 4 records—weighed</td>
<td>Huismann &amp; Turner (1942)</td>
<td></td>
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<tr>
<td><strong>3-Way Comparisons of Modified Methods:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One 24 hr. recall v. history vs. 7 day record in household measures</td>
<td>Young et al. (1952c)</td>
<td>x</td>
<td>V V V V V M M M</td>
</tr>
<tr>
<td>3 or more 24 hr. recalls vs. diet history vs. 7 day record in household measures</td>
<td>Trulson (1952c)</td>
<td>x</td>
<td>V V V V V M M M</td>
</tr>
<tr>
<td><strong>Comparative Studies of Basic Techniques with Parts of Basic Methods:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>History vs. 24 hour record</td>
<td>van den Berg &amp; Mayer (1952c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record—weighed vs. 24 hour recall</td>
<td>Thomson (1952c)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>7 day record—weighed vs. 24 hour recall</td>
<td>Chamberlain &amp; Pike (1942c)</td>
<td>x x</td>
<td>V V V V V M M M</td>
</tr>
<tr>
<td><strong>Other Studies of Modified Methods:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individuals:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>School lunch as observed by nutritionist vs. recall of lunch by children</td>
<td>Meredith et al. (1951)</td>
<td>x</td>
<td>x x x V V V V V M M</td>
</tr>
<tr>
<td>One day of food weighed by mothers vs. estimated amounts</td>
<td>Eppright et al. (1952c)</td>
<td>x x x</td>
<td>V V V V V V M</td>
</tr>
<tr>
<td>Interview vs. 7 day record or 24 hour recall</td>
<td>Ohlson et al. (1952c)</td>
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<td></td>
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<tr>
<td>7 day records by adolescents vs. interviews with adolescents vs. interviews with mothers</td>
<td>Steele et al. (1952c)</td>
<td>x x</td>
<td>V V V V V V M M M</td>
</tr>
<tr>
<td>Checked vs. unchecked 7 day records</td>
<td>Steele et al. (1951)</td>
<td>x x</td>
<td>V V V V V V M M</td>
</tr>
<tr>
<td>Estimated quantities vs. measured quantities</td>
<td>Young et al. (1952a)</td>
<td>x</td>
<td>V V V V V V M M</td>
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<tr>
<td>Families:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7 day records vs. list for homemaker recall</td>
<td>Murray et al. (1952)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Interview vs. diary record</td>
<td>Strom et al. (1952)</td>
<td>x</td>
<td></td>
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<tr>
<td><strong>Group averages &amp; individuals within groups:</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ave. of food available in institutional kitchens vs. individual weighed portions</td>
<td>Carroll et al. (1952b)</td>
<td>x x</td>
<td>V V V V V V M M</td>
</tr>
<tr>
<td>7 day family records vs. typical one day record for individual</td>
<td>Young &amp; Pilcher (1950b)</td>
<td>x x</td>
<td>V V V V V V M M</td>
</tr>
</tbody>
</table>
Long Term Methods of Obtaining Information

The nutrition literature supplies information regarding the use of both of the basic methods modified in a number of ways to learn about food intake of individuals over long periods of time. A few of the studies covered long, consecutive periods of time; other studies have covered long periods of time by use of information obtained intermittently. Representative studies have been summarized.

Long Consecutive Periods of Time

A few studies of the food intake of individuals have covered long consecutive periods of time. In some of these, the subjects were individuals living in their own homes. Chappell (1955) recorded the weighed amounts of food eaten by one professional woman for a period of 70 weeks and that eaten by her father for 17 weeks. Ohlson (1948) obtained weighed records from ten women for a period of four to six months.

Other studies of food intake of individuals that covered long consecutive periods of time were in controlled group situations. Koehne and Morrell (1934 and 1935) studied food intake of individuals for long consecutive periods. Her subjects were 28 girls, six to twenty-eight years of age, who were hospitalized. A menu was repeated each week and amounts of food were adjusted to meet the desires of the individuals. Records, mostly in weighed amounts, were kept and studied. In the controlled U.S. Army setting, Konishi, et al. (1957) have been able to study the weighed food intake of 98 individual soldiers, eighteen to twenty-five years of age, for a period of 28 days. Chalmers, et al. (1952) and Young, et al. (1953) also studied adults for 28-day periods. Their subjects totaled 18 (sixteen women and two men), secretaries, stenographers, technicians, professors, and graduate students who kept records in estimated servings and household measures.
Long Periods of Time—Information Obtained Intermittently

Some studies have covered long periods of time with information obtained intermittently. A few of these involve periods of time longer than one year, using a repeat Burke method. Burke et al. (1959) are studying 125 children from birth to eighteen years. The comprehensive interview to obtain "usual" intake, cross-checked in detail, is obtained five times during the first year of life, twice yearly through the tenth year, and yearly from the tenth to the eighteenth year. Reed and Burke (1954) also reported using this method with three children and three mothers every six months over a five year period. Trulson and McCann (1959) used a modified Burke method to obtain information from 39 Italian-Americans in 1958 who had been studied as part of a large group in 1956. Beal et al. (1945 and 1953) studied some individual children for the first five and the first ten years of life by use of the Burke method.

A variety of other methods have also been used to study periods of time over one year with intermittent assessments. Harper (1956) studied food practices of three samples of women. One group included 23 college women from whom 24-hour food intake records were obtained four times during a 20 year period from 1935 to 1955. Ohlson, et al. (1950) studied food intake of eighteen women by interviewing for information on dietary habits and a twenty-four hour recall on the original contact, repeating twenty-four hour recalls three or four times and then having the women weigh their food intake for ten day periods. Kelley, et al. (1957) used twenty-four hour recall interviews in estimated amounts periodically over a seven-year period to study 52 white women and 63 negro women. Chope (1954) also used twenty-four hour recall interviews at the beginning and end of a four year period to study 306 aged individuals, most of whom lived in their own homes. Dean (1956)
used a seven-day record method at the beginning and end of one year and then a twenty-four hour recall method six months later in a study of 103 women in industry. Trulson (1955) used two seven-day records made by 70 pupils, thirteen months apart.

Other studies involved periods of time from one month to one year and used intermittent assessments. Huenemann and Turner (1942) used ten to fourteen day periods of weighed food intake of 25 children for three or four periods spaced at three or four month intervals. McHenry, et al. (1945) had 31 adults who were laboratory technicians or university graduates in medicine or other sciences keep records in estimated amounts for the first week of each month for a year. Eppright et al. (1952) used three day records in household measures in the spring and fall to study 161 school children nine to twelve years of age. Dieckmann et al. (1951 a and b) obtained information from 602 women who weighed their food and recorded the amounts for alternate three week periods during pregnancy. Murphy, et al. (1954) studied obstetrical patients of one physician in a New England college town for as long as nine months (48 women) or for four months (27 women). The method used here was records in household measures for two or three seven-day periods. Marr, et al. (1959) used seven day records of weighed food intake at the beginning and end of a six months period. Twenty-five bank officers were included in both parts of the study. Ohlson, et al. (1950) studied 200 women by repeating twenty-four hour recalls several times over a three to four month period. Thomson (1958) used two records of weighed food intake six weeks apart in a study of eleven pregnant women.

"Usual " Food Intake—by One Assessment

In some studies a "usual" food intake is obtained once. Babcock, et al. (1954 and 1955) combined a thirty minute interview to learn "usual" intake with a seven-day food consumption method for a total of 318 male industrial workers.
Epstein, et al. (1956) used an interview method with 702 adults, mostly Italian and Jewish, to study the previous twenty-four hours by recall and to modify it to the "customary" food intake. An attempt was made to validate the histories with respect to calories by comparing the estimated caloric intake with the intake predicted from the nomogram by Boothsby and Berkson (1936).

Validity, Reliability and Objectivity: Some Concepts Useful to the Nutritionist

In interdisciplinary planning for dietary studies, it is imperative that nutritionists understand the concepts of validity, reliability and objectivity measurements as described and used by social scientists and statisticians.

Validity may be described as "A measurement procedure is valid if it measures what it purports to measure." — (Report of Committee on Design and Analysis of Studies for the Conference on Methodology in Epidemiological Studies in Cardiovascular Disease, 1959) It may be thought of as the accuracy of the method in measuring what the method is supposed to measure.

When the researcher has a perfectly calibrated measuring device and a purely objective technique for its use, there are still likely to be minimal error variations in his measurements. These errors of measurement tend to be at a minimum in this kind of situation.

The nutritionist, however, has a far more difficult problem in assuring accurate data collection. The first problem is that in obtaining dietary information, there is no ultimate criterion measuring device that can be used for calibration of other devices. This would even be true if a weighed diet were used as a baseline since there are known sources
of errors in weighed or measured diets due to non-homogeneity within foods and inaccuracies in analysis.

Further validity problems vary with the purposes of the study. If one were interested in a particular person's intake for a day as contrasted to a year, the problems in obtaining valid measurements would be somewhat different. Measuring a day's intake would not include the extended time dimension measurement problem. Validity problems in measuring intake for one person also differ considerably from measuring hundreds or thousands of individuals. Although the intent is accuracy in all cases, the "how to" problem differs very clearly. It would be desirable for a study of food intake for epidemiological purposes to measure the actual amount of food eaten in the time period affecting the development of disease. Therefore, to be absolutely valid, a method would have to accurately reflect what is eaten during the time span in which the disease develops. Furthermore, the need for "accuracy" is determined by what is physiologically meaningful. The best methods devised only approximate what is actually eaten. Different methods have different kinds of limitations which affect their validity for epidemiological purposes. One of the first problems is how well the data collected over a short period of time compare with the results obtained by a technique which covers the desired longer time period. This problem points to the difficulties of the concept "usual diet" which will be discussed in more detail later. For purposes of simplicity and clarity, we will call this problem representative validity.

Another aspect of the validity problem is that there are other variables known to be highly related to the variable we are measuring.
The question is does the variable we are interested in co-vary with this related variable. Reed and Burke (1954) demonstrated that correlation between measurements of dietary intake of protein by histories taken over long periods and the child's rate of growth of muscle in the lower leg. We will refer to this kind of validity problem as one of concurrent validity.

A further kind of validity problem deals with the ability of the measurements taken by the given measuring device to predict future correlated events. For example, if the results of a food habit study show that an individual of normal weight is eating excessive calories, we will expect to observe gain in weight over time providing calorie intake is the only variable. If the relationship holds, we have more confidence in the validity of the dietary intake measurement technique. This kind of validity problem will be referred to as predictive validity.

As previously mentioned, the validity of a given measure depends on its ability to measure what it purports to measure and not other variables. We wish to know the proportion of the variance in the measuring device which can be attributed to the construct, whether the construct is "calories", "protein" or "usual diet". This kind of validity problem will be labeled construct validity. A more detailed discussion of this kind of problem in another context is presented by Cronbach and Meehl (1955) and criticized by Bechtoldt (1959).*

Tests of validity

If there were an ideal criterion method, the validity of any other

* These ideas on validity are more thoroughly illustrated in the American Psychological Association Technical Recommendations. March 1954.
method could be compared with the criterion method by calculating correlation coefficients between the measurements made by the two methods for specific food items or nutrients. The coefficient would show the relationship between the methods of measurement. Another possibility would be to measure the proportion of agreement among the total items (both in amount and kind) upon which it is possible to agree. Alternatively, we might use regression analysis which has the advantage of showing measures of bias directly.

This latter kind of assessment technique seems more appropriate to our problem, since we are interested in obtaining information on food items rather than nutrients and because food items are more multitudinous and less homogeneous than nutrients.

Another alternative is to take the approach that if several methods are independently well developed, they may all be good and that the best way of determining how good they are would be to compare and contrast the results obtained by each method. We would be looking for the convergence of independent approaches in the measurement of amount and kind of food items as well as the ability of the assessment techniques to discriminate between different amounts and kinds of food items. (cf. Campbell, D. T. and Fiske, D. W., 1959) We would also be able to distinguish where differences between assessment methods did occur and be forced to determine the reasons for these differences.

Summary of examples of multi-method, multi-nutrient analysis

Since the procedures of Campbell and Fiske embody many of the considerations outlined, we have analyzed the data from Huenemann and Turner (1942) using the Campbell and Fiske technique (1959). See Appendix B.
In summary, we note that basing an analysis on the limited sample of 21 children, ages 6 to 14 years for whom there were complete data (the diet history and the first two diet records), we found that the methods of measurement used were deficient in their ability to satisfy the rather lenient requirements of convergent and discriminant validation. In general, the three methods used: the dietary history, the first two week record, and the second two week record, do not fulfill the necessary requirements. These findings may mean that the "usual diet" concept has only limited usefulness for the group studied; there is much more variability from time to time so that a two week period does not cover the variability adequately. Other findings from this analysis suggest that the methods used had rather limited validity, and point to the need for further investigation of methodology.

Further considerations affecting validity include the problem of mixed foods and of differences in recipes for food items with the same title. The latter problem might be at least partially solved by using food tables applying to specific geographic areas, ethnic groups, etc. if these variations were known. Further, we need to know how much variability there is around the "usual diet" for individuals in the population. This latter type of information is needed in order to estimate how frequently food intake must be measured to be within a given level of error for long term study purposes.

There are additional long term problems, including changes not only in food habits but in diet content and food processing and preparation which change over time and might lead to the need for a revision in technique of valid assessment with time.
Reliability

A measurement procedure is reliable if it gives the same results when used repeatedly in the same situation. (Report of the Committee on the Design and Analysis of Studies for the Conference on Methodology in Epidemiological Studies in Cardiovascular Disease, 1959) It may be thought of as reproducibility.

Ideally, the reliability of a method would be measured by using simultaneous assessments of the same individuals in the same situation. Reliability thus defined implicitly covers a group of methodological problems. Situations and individuals can be similar, but they can never be exactly the same. Therefore, it is necessary to use reliability estimates. Several factors can affect reliability estimates but this depends in part on the measure of reliability used. There are several sources of error which may affect the reproducibility of a method of studying food habits, if we accept the idea that the best possible reliability estimate would be a comparison of two simultaneous assessments of the same individuals in the same situation. The following are examples:

(1) Each assessment affects the result of subsequent assessments.

(2) Individuals eat differently at different times — in food items, in amounts, in methods of preparation of food.

(3) Individuals respond differently to different research methods, different investigators, and at different times.

(4) Investigators affect the results because they differ as individuals in contacting different respondents, use methods differently and act differently at different times.

The first two of these "errors" are not errors of the method in real sense but would be reflected in "measure-re-measure" reliability estimates.

Reproducibility measures may be assessed by correlation coefficients,
analysis of variance techniques and standard errors measures depending on the research design used.

We might further note that validity is dependent upon reliability. There is a mathematical relationship which limits the amount of validity of a given method to some lower degree than the given method's reliability. A method may be perfectly reliable but not valid. A method which is valid must be reliable to a higher degree.

**Objectivity problems**

Objectivity can be thought of as standardization. This applies to the method, the way it is used, and the general conditions under which it is used. It also means scoring by a systematic, pre-determined method and presentation of results in a way that is comparable to the work of other investigators. It is important to our work as it relates to the ease of training of a research worker. A more objective procedure is more easily taught.

Emphasis on objective collection and processing of data is especially important when a method is being planned for large numbers of interviewers and subjects, since we want to know exactly how the data were collected in all of the different areas of the country. Developing an objective method also facilitates ease in communicating the details of the technique used to other investigators and enable them to compare it with other techniques which they may prefer.

In research one may compromise some facets of objectivity in order to increase validity; that is, allowing extreme differences in question "probes" of the technique will violate strict objectivity requirements, but may allow more accuracy (validity). Also, using local names for
specific food items may increase accuracy (validity).

Application Considerations

There are some further applied problems brought into focus by the concepts of validity, reliability and objectivity. The concepts of validity and reliability are not understood in the same way among different disciplines. This is particularly true when areas of practice, such as medicine and dietetics, are compared to the research fields of social psychology and statistics. These latter disciplines have developed more concrete methods of coping with the problems of attaining validity, reliability and objectivity than many of the health sciences. Since the need for better individual food intake information has increased, more assistance is being sought from these disciplines.

Thus, it may be helpful to relate validity and reliability considerations to a dietary history of a type commonly used by nutritionists and hospital dietitians who are interested in accuracy. In the comprehensive diet history, a nutritionist uses the previous 24 hours as a logical starting point. However, she recognizes that for many reasons this may not give a true picture for either this particular 24 hours or for other days. She uses past information about which foods and food groups are most important for the purposes for which she is getting the information, and she works to re-check in order to obtain more accuracy. She may proceed by learning about the total family and the food purchasing practices of the family. With this information, she does some cross-checking using what she can learn about food available for the family divided by the days or meals for which it is used, and again by the number of family members. If the answer she obtains is within prescribed limits when compared with the information from the 24-hour recall, she assumes that it
may be fairly "typical" or "usual" in respect to that particular food. However, she realizes that for particular seasons of the year, there will be great variations for particular foods.

If, on the other hand, the answer she obtains seems unreasonable when compared with the information from the 24-hour recall, she attempts to get further information to learn about the discrepancy. She may try to learn answers to questions like these:

Do food likes or dislikes or ideas about food needs account for the individual's receiving more or less than the amount of food available per individual?

Does it appear after some further questioning that the information obtained in the 24-hour recall or in the total food available is too high or too low?

Because of the practical considerations such as time and good relationships with the individual, she can do only a certain amount of probing in any one interview. She then is systematic in using the information she has obtained. In other words, her technique for attaining accuracy has been an attempt to attain "representative" validity; that is, how well do the data collected over a shorter period of time represent reality over a longer period of time. She is also interested in construct validity. For example, the subject may have indicated having "orange juice". The nutritionist does not immediately accept the ascorbic acid content of her own concept of "orange juice". To the subject, orange pop and fresh orange juice may be equivalent. In obtaining specific information of this nature, the validity of the information is being improved; that is, several techniques are used to assess the same problem and to the degree that they agree one can more easily assume that reality is being measured.

The nutritionist attempts to be an interviewer who puts the individual
at ease. She avoids showing approval or disapproval when information is
given. She attempts to ask for information in a way that does not suggest
a preferred answer. In other words, she is attempting to obtain objective
and accurate information.

When the next individual is seen, the nutritionist will ask for the
same kind of information in essentially the same way. By questioning in
a pre-arranged way, she will get specific information to help in a pro-
ductive approach for the purposes of the interview.

These are approaches to reliability and validity, although not
quantified. By better understanding the concepts and problems of validity,
reliability and objectivity as they are used by research methodologists
and as they apply to dietary survey methodology, various disciplines can
work together more effectively to test these aspects of the various methods.

Further illustrations of the usefulness of the concepts of validity,
reliability and objectivity for classifying the information gained in
studies of methodology of dietary data collection can be found in Appendix
A.
Chapter II
CONSIDERATIONS IN COLLECTING AND HANDLING DATA

It appears that the collection of data and the handling of it are considered together in a substantial amount of the nutrition literature. Although very closely related, the collection and handling of data can be separated into three phases — collecting, analyzing, and processing. The collecting phase is the obtaining of the necessary information; the analyzing phase is the conversion of the information into the form for processing and application to the problem; the processing phase is the application of the information to the problem.

At the collection level, there are many distinctive aspects that involve separate decisions and possible problems. The following will be discussed in some detail: kind of dietary information desired, kind of related information desired, limitations of memory, respondent differences, interviewer differences, and original food grouping schemes. Obviously, the accuracy of the data that is collected is basic to the results of handling.

The analysis and processing phases will be considered together in much less detail later.

Collecting of Information

When data are being collected in studies of food intake, one is attempting to answer first—"What foods are eaten?" In most cases, it is also important to know, "How much of these are eaten?" It may also be important to know more about the answers to these questions: When are the foods eaten in relation to other foods? In relation to physical activity? Where are the foods eaten?
Each of these questions will be discussed in more detail.

"What foods are eaten?"

Helpful information regarding well-described single foods can be used in conjunction with the U.S.D.A. Handbook No. 8 (1950) which provides a vast amount of information on food value of specific types of foods.

Even with single food items, it is not always possible for an individual to know what the food is and then to communicate what the food is to another individual. Meredith (1951), for example, found that children confused "grape juice" and "grapefruit juice". While adults would be expected to have less difficulty with this type of distinction, they have considerable difficulty in making other distinctions, such as, kind of milk, when there is a wide variety of types—homogenized milk, skim milk, vitamin D enriched milk, vitamin D enriched skim milk, multi-vitamin milk, evaporated milk, non-fat dried milk and numerous other milk products.

Kinds of cheeses also involve a difficult problem of identification. Considerable information is available, such as the "Standards of Identity" established by the Food and Drug Administration. However, people do not know or communicate these distinctions.

Just as the man on the street does not know the nomenclature as defined by the standards of identity, the professional person sometimes does not know the nomenclature of individuals. For example, the "pulley bone" is a very specific description of what is eaten, if it is understood to be the wishbone section of poultry. This means that the research investigator must know the special food nomenclature of the area investigated.

Meats are particularly difficult to describe and to communicate accurately to others. Here the kind of meat, the grade of meat, the particular cut, and the particular serving are all a part of "what is eaten". This is further complicated by the way the meat is cooked.
The degree of cooking ranging from "rare" to "well done" affects the amounts of fat. Leverton and Odell (1958) have added considerably to the available information on cooked meats.

Food preparation almost always involves the addition of other foods. With meats, for example, additional fat may be used for frying, flour may be used for thickening the accompanying gravy, or other cereal products may be used for breading. In each home or other kitchen, the methods of preparation vary. The accurate description of "What is eaten?" involves knowing how each food is prepared.

Moser (1953) has reported information regarding distinctive aspects of vegetable preparation in South Carolina. Use of fat in the form of meat fryings or drippings and salt pork is a usual practice. Knowledge of regional methods of food preparation are essential for interpreting the answers to what foods are eaten.

The number of completely or partially prepared food items available commercially continues to increase in this country. Therefore, the problem of what is eaten and how it is prepared includes what was done to prepare the food for commercial handling.

Methods of food preparation can: (1) Add to food value—for example, they often add calories; (2) Subtract from food value—for example, cooking causes some loss of soluble and volatile vitamins; (3) Change food value—for example, cooking breaks down starches to dextrins. The full extent of the effect of the alteration of nutrients in food preparation and possible relationships to nutrition (absorption and utilization) have not been explored. Widdowson and McCance (1943) have shown the importance of the use of water of high calcium content and cooking vessels that contribute iron.

There are food mixtures of a tremendous variety with which one must contend in learning "what is eaten". They include mixtures combined at the table; those prepared in the kitchen, those combined in the canning, freezing, baking or packaging processes. They differ from time to time as well as from
source to source. Food mixtures that are used vary according to many factors such as ethnic background and region of the country.

It is well known that food mixtures create an extremely difficult problem for dietary assessments. Much less is known about the proportion of the food intake of individuals that is made up of food mixtures as compared with relatively simple foods. If one could get quite valid information regarding relatively simple foods and information regarding frequency of use of various food mixtures, would the total information be accurate enough to be of real assistance to the epidemiologist?

"How much food is eaten?"

The answer to this question becomes more important when the findings are needed for individual level accuracy in epidemiological studies of disease. For certain purposes, grosser distinctions will suffice. For example, it has been suggested by Wiehl (1959), that description of major differences in individuals such as use and non-use or high or low use of specific food items might be useful. "Rating or grading of items into four of five categories" is suggested as being valuable. If on the other hand, one wishes to make distinctions on the basis of grams and milligrams, more detailed data is needed. In general, these methods of quantity assessment have been used—

weights,
household measures,
estimates,
frequency of use.

In England balances are made available to the households in which studies are being made. These vary in capacity and are calibrated in 1/8 to 1/2 ounces. These scales are of the type that require that the container used for the food be deducted.

In the United States, if weighing is done, the scales used are most often gram scales of a capacity of 500 or 1000 grams. The scales usually have movable dials that make it possible to weigh the portions of food without the extra work of considering the weight of the container.
Scales have been used for field studies more widely in Britain than in the United States because household scales are regularly used in British homes for the preparation of family-size recipes.

In the United States, standardized measuring cups and spoons are regularly used by housewives in their kitchens. They are convenient and accurate for measuring liquids and for dry ingredients, such as flour. They are practical measures for use in this country, and they have been used for studies of food intake. However, the conscientious person quickly finds that there are drawbacks for many foods. For example, while applesauce can be accurately measured, raw apples cannot unless they are cut up in small pieces. For this reason, units of food and estimates of amounts are used along with household measures. Using numbers of units is relatively simple with items such as raw fruit, but the problem becomes much more complicated for meat. For example, a serving of chicken may be described in a variety of ways, such as one drumstick or one piece of white meat of a certain number of inches and thickness. These methods of description inevitably involve frustrating problems in interpretation.

There has been a great deal of difference of opinion as to the best method of assessing the amount of food eaten. Leitch (1949) expresses one viewpoint:

"...the recording of remembered diets by questioning is unsatisfactory, particularly for the assessment of individual consumption." "A survey of a type intermediate between weighing and questioning, in which diets are recorded in household measures by intelligent subjects and translated into weights during cross-examination by painstaking investigations, can provide a week's record in accordance with conventional requirements."

Certainly, the best method in assessing amounts is dependent upon the specific purposes of the study.
It is also dependent upon the effect on many other factors desired to accomplish valid results. Bigwood (1939) was aware that striving for the most exact measurements to the extent of having the investigator "live with the person under observation" tends "to modify the dietary habits." He stated that "the best method will be the one which achieves the nicest balance between these conflicting tendencies."

A number of the studies of techniques previously mentioned have attempted to determine the best methods of assessing quantity.

Eppright (1952) studied differences in the way nutritionists interpret serving sizes. He studied the problem of estimating sizes of servings by having nutritionists in three states independently estimate the size of servings of 60 common foods. They reported that "close agreement existed in the estimates for a majority of the foods," and they list 13 foods for which there was the greatest range of difference in the estimates. For most foods, the range was not great. Some exceptions were hamburger patties where the estimates of a serving ranged from 33 to 85 grams, and scrambled eggs where the range varied from 50-106 grams. This study did not make any comparison with actual size of servings. The judgements were made by individuals with similar experiences.

A much more extensive study has been made to find out the actual range in sizes of servings eaten by individuals.

Beagle, et al. (1954) studied the records of weighed amounts of food eaten by 242 well women, ages 30 to 92 years from six states of the North-central Region. The women "formed a selected sample since many were in the middle and upper socio-economic groups while only a fourth of the sample had limited buying power." Selected foods were studied in a total of 3,170 records. The weight recorded was the amount actually consumed on self-selected diets.
Foods frequently used were chosen. Selected fruits, vegetables, meats, milk, bread, table fat, and sugar were included. The range of weights and mean weights, both portion averages and subject averages, were studied. Nine foods were explored further in an attempt to separate state and age differences. A wide range was found in the weights eaten of most foods -- both inter-individual and intra-individual differences. For example, sample ranges of the averages chosen by these 242 subjects in 6 states was 7 to 330 grams for potatoes and 1 to 75 grams for table fats.

Mayer (1952) discusses some of the facets of the question: "How much food is eaten?" in making the point that techniques for surveys are apt to be weakest in calories.

Mayer reports that "...generally speaking, individual survey methods seem weakest where calories are concerned. Such factors as the frequent partaking of small carbohydrate snacks, the number and size of spoonfuls of sugar in hot beverages, and individual mannerisms may easily account for variations of several hundred calories, yet escape undetected by cross checks usually designed to verify the intake of proteins, minerals, and vitamins. For example, as to fat, there are wide differences in attitude between various individuals. Some persons remove every part of the visible fat of meat, others eat it with relish. Even if this is elucidated, the degree of fattening of the meat consumed will still remain as an important source of error. Agriculture Handbook No. 8, gives figures for 'lamb, cooked' for 'lamb, carcass or side, raw' varying from 206 to 414 calories per 100 gm., or a ration of 1 to 2. If one adds to this variability the additional variability of the amount of fat used in cooking, this range can reach 1 to 2. Yet
the subject under questioning is not usually asked to (and probably could not) give information which will substantially decrease this margin of uncertainty. Similar situations develop in regard to fat content of milk, fried foods, and so on. In all these cases, the fat content (and therefore, the caloric content) is the chief variable; proteins, vitamins, and minerals are affected to a much lesser degree. Similarly, the use of household measures entails errors bearing in particular on flour, sugar, and fat -- all foodstuffs of essential significance calorically."

"When are the foods eaten in relation to other foods?"
"When are the foods eaten in relation to physical activity?"
"Where are the foods eaten?"

Much less consideration has been given to questions of this type than to those pertaining to food eaten and amounts used. It is not known whether these questions are of significance in dietary studies related to epidemiology. However, it seems reasonable to consider them.

There are indications from studies on test animals (Geiger, 1947) that essential amino acids need to be present simultaneously if the amino acids are to be used efficiently. It may be a mistake to focus most of our attention on total amounts of foods or nutrients consumed in a day, with little regard for the combinations and quantities taken at various times. There is probably much that is unknown regarding the effect of time and combination on requirement or usability of nutrients.

An individual's physical activity is considered important in the epidemiology of chronic diseases (Stanler, 1959). In the treatment of some diseases (diabetes, ulcers and obesity), it has been found helpful to distribute the food rather equally throughout the day in preference to spasmodic
periods of feast and famine. On the other hand, it has become common practice for the business man in this country to eat small amounts early in the day and to eat considerable amounts late in the day. It may be reasonable to speculate about different patterns of food intake involving quantity, meal frequency, and time of day.

There has been little interest evidenced in whether nutrients were provided by large amounts of a few foods or by smaller amounts of a large number of foods. However, we know that there are very great differences in different parts of the world.

Workers who have been interested in food combinations, physical activity and place where food is eaten have used different approaches in obtaining and using the information. Several workers have used classifications of types of meals. Osborne (1951) used eight classifications to indicate each meal of the day in a study of nutrition of older people in England.

1. A milk drink and/or bread and butter, jam, etc. and/or fried bread. No cake. With(out) other drink, e.g. tea.

2. Cake with or without category 1.

3. Cooked protein with or without vegetables.

4. Cooked protein or cheese with or without vegetables and pudding and/or category 1 and/or cake or bread.

5. Cereals with(out) category 1. With(out) cake.

6. Cereals and cooked protein or cheese with(out) vegetables, with(out) category 1, with(out) cake.

7. Other meals including salads or puddings or chips only.

8. No meat. (Cup of tea only is counted as no meal)."

Osborne says that "the results show the number of different types of meals had at different times of the day." Moser (1953) used classifications by
menu type in a study in South Carolina. (See Table 4) Although these classifications served the purposes of the investigators, they would need to be modified content wise for our purposes.

Clark and Fincher (1954) were interested in much information of this type: contribution of each meal to nutritive content of day's food (by income); food at home and away from home by meal of day; physical activity by six classifications (moderately active, very active, sedentary, resting, pregnant, lactating); proportion of total days quantities of selected foods eaten at each meal.

There has been an increase in the practice of eating meals in public places instead of in homes. In the study mentioned above (Clark and Fincher, 1954), the food value of the meals eaten away from home was compared to that of the meals eaten at home. There was some indication that meals eaten away from home were larger than those eaten at home. Information regarding where foods are eaten may be of practical significance in determining the significant food habits.

"Under what conditions are the foods eaten?"

It is known that utilization of food is affected by emotional factors and conditions of health. Some workers have evidenced interest in these factors. For example, Beal (1953) is interested in "attention given to the child at meals," and Ohlson, et al. (1950) state that

"Outside interests and activities as well as freedom from tension and strain are factors which must be evaluated in the instructions and feeding of aging workers if nutritional adequacy is to be expected."

If factors such as speed of eating or tension while eating have an appreciable effect on ability to utilize food affectively, it may be important
to include in the findings information regarding the conditions under which the food is eaten.

It is known that availability of nutrients is affected by presence of some medications; for example, the presence of mineral oil may cause a loss of vitamin A. Information regarding other medications may be important for their effect on usability of various nutrients from food. Dietary supplements are obviously important.
### Table 4 — Basis For Classification of Menus By Type

#### Breakfast

**Type I**
- Meat and/or eggs; grits
  - a) Meat, poultry, or fish; eggs; grits
  - b) Meat, poultry, or fish; grits
  - c) Eggs and grits, no meat

**Type II**
- Meat, poultry, or fish and/or eggs; no grits

**Type III**
- Light breakfast: Bread and at least one other conventional item; typically coffee with biscuit or toast

**Type IV**
- Miscellaneous: Hot cakes or waffles with accompaniments; cereal and milk as the main dish; other combinations not classified above

#### Noon and Evening Meals

**Type I**
- Meat, poultry, or fish and one or more vegetables
  - a) Includes rice and dessert
  - b) Includes rice, but not dessert
  - c) Without rice, dessert optional

**Type II**
- Vegetable meal, without meat, poultry, or fish
  (Fat pork cooked with vegetables as a seasoning allowed)

**Type III**
- Meat, poultry, fish and/or eggs; no vegetables
  - a) With rice
  - b) With grits
  - c) With other cereal and/or bread

**Type IV**
- Snacks: Composed of a few foods easily prepared or left over from a previous meal. Typical are sandwiches and a beverage; biscuit, sirup, and coffee; ready-to-eat cereal and milk

**Type V**
- Miscellaneous
  - a) Sandwiches and a salad
  - b) Fish stew or chowder as the main dish
  - c) Combinations not otherwise classified

#### Notes
- Items not mentioned are optional
- "Vegetables" include salads except those having meat, poultry, fish, or eggs as the chief ingredient; also vegetable soups.
- "Desserts" include fruits served as dessert as well as cake, pie, puddings, ice cream, etc.

Limitations of memory in the use of particular methods

Among the methods enumerated by the Diet Methodology Committee at the conference on Methodology in Epidemiological Studies of Cardiovascular Disease (1959), we find memory to be a very minimal factor when

1. Intake at specific meals is recorded concurrently by means of weighing.
2. Intake at specific meals is recorded concurrently by means of household measures.
3. Intake at specific meals is recorded concurrently by means of estimates of food.

However, memory is important for techniques which include recall. This is true whether recall is used to obtain information about specific meals or "pattern of intake" in the past.

Before tracing the effects of memory on recall of food, it is necessary to describe some of the more general facts available from the work of psychologists in the area. The general principles in simplified form can be described as follows:

1. Association between two stimuli items, events, or facts are facilitated in memory by:
   a. Primacy effects. This means that certain early associations between events, facts, or items tend to be remembered, that is, initial contacts with new situations tend to be remembered.
   b. Saliency effects. This refers to the fact that, for example, phenomena at crucial junctures in a person's life are remembered longer. Events that have an impact on an individual, such as marriage or the birth of a first child, tend to be remembered better than events of less importance which occurred at the same time. This concept also refers to the idea, for example, that a particularly good or poor meal may be remembered more clearly and accurately than one that seems "average" to the individual.
(c) **Recency effects.** This refers to the obvious tendency of an individual to remember recent events better.

(d) **Frequency effects.** This refers to the tendency of individuals to remember events and facts that occur more often to them.

(e) **Repression effects.** This refers to the tendency of people to blot out from their memory unpleasant events, i.e., they put unpleasant memories in their subconscious.

(2) **Memory Curves.** Psychologists for many years have been interested in what have been called memory curves. The typical idea inherent in most memory curves is that an individual forgets information over time and that the rate of forgetting is a negatively accelerating curve. See Figure 1.

**Suppression and Distortion in memory.** One of the more interesting ideas in this area of memory and one of the most applicable to our area of interest is that people will tend to suppress from their memory of a situation those aspects of it which do **not** fit their own general image of the situation. This aspect of distortion is also supplemented by the kind of memory which tends to more frequently remember that which is socially acceptable as contrasted to that which is not socially acceptable.

![Figure 1]

<table>
<thead>
<tr>
<th>Number of items or pairs of items remembered</th>
<th>0</th>
<th>1 day</th>
<th>2 days</th>
<th>3 days</th>
<th>1 week</th>
</tr>
</thead>
</table>

(Figure 1)
After a certain amount of time only minimal remnants remain unless the associations are reconstituted by more frequent contact or stimulation.

With these ideas in mind, we can now consider how the information available to us from psychology is applicable to the problems encountered in collecting nutrition information.

The data are available only for limited populations, and only to a limited degree. Eads and Meredith (1948) note that there will be more accurate recording and description of the amounts of food eaten if the record is made immediately after the meal, rather than recalled at a later time indicating the "recency effect".

Meredith, et al. (1951) conducted a study with school children to determine their ability to recall food eaten from school lunches. Ninety-four students (48 boys and 46 girls) ranging in age from 9 to 18 years participated during a study that lasted three days. The items and quantities on each child's tray on one day were observed and noted by a nutritionist. Later the uneaten portions were subtracted. The children were unaware of this observation at the beginning of the study, but may have been aware of it on the third day. In 30 minutes to two hours after the meal, the children were asked to recall the food they had eaten. In this study, no attempt was made to compare the data according to the time lapse between the meal and the recall. Errors of omission were most frequent for bread and margarine. Lesser quantity was reported for juices and fruit than for other items. Larger quantities for milk were reported by some children who confused half-pints with pints. There were some errors in identifying fruit juice. In this study the effect of short term recall and the differences between the accuracy of the nutritionist and the children in their ability to observe or remember what was being eaten are illustrated.
A rather interesting footnote to the general problem of the adequacy of "recall" for obtaining detailed information has been reported by Morrison, Russell and Stevenson (1949) and Thomson (1958). During a twenty-four hour period, food for the meals of eight scientists were weighed in detail. The subjects were then asked to recall what they had eaten. A comparison of the weighed and recalled values showed agreement within pairs that was little better than could be achieved by pairing at random. The recall technique tended to result in underestimations. In a further study of this problem using pregnant women, Thomson (1958) reported that in reference to calories only, three techniques were compared; recalled record using household measures, recalled record using weighed quantities and the weighed record. The first technique gave the smallest amount of information, the second the middle result, and the latter the highest and presumably the most accurate result. Bransby, Daubney and King (1948-1949) found that household measures tended to lead to overestimations if the weighed diet is taken as the criterion.

Young et al. (1952) consider the memory problem in more systematic detail. They have collected information for each classification of subject and type of food in terms of the effect of omissions. In the studies reported there were a considerable number of omissions for three types of subjects:

There were more omissions by junior high school students and certain college students than for a special group of college students who were in Home Economics. There were the largest number of omissions in such food types as "puddings", sauces and gravies, beverages, bread and rolls, and butter and fruit. The least number of omissions appeared in meats, eggs, cookies, pies and cakes. Omissions do decrease reported food intake.
and, therefore, are a source of bias which is important to consider. In these studies, no consistent patterns which are predictable in detail by type of subject or type of food were perceived.

The studies reported suggest that the problems related to memory are important to accurate detailed information collection over short periods of time; and that nutritionists have been instinctively aware of some of the psychological principles involved. Their data illustrate the principles of the memory curves and the idea behind the recency effect principle.

In dealing with the problem of collecting long term dietary information, it may be helpful to take advantage of some of the other principles described above. For example, if we want information about changes in diet composition over time, the inquiry can be tied to salient and important times in an individual’s life, thereby enhancing our ability to collect accurate information (admittedly of a rather gross nature) about the individual's changing food habits. In focusing on long term dietary intake data collection problems, the use of the frequency principle may well work to our advantage. If one is interested in the foods most frequently used by individuals, the tendency for an individual to remember these foods best will tend to be better unless these foods have become habitual and rather unconscious segments of the diet. In dealing with long term data collection problems, we might conceivably encounter problems of repression which might lead to individuals not giving us dietary information about unhappy periods.

In summary, some of the problems in the area of memory in the Nutrition Literature have been considered but the psychological principles in this area have only been partially observed. Obtaining long term dietary information using these principles can potentially be helpful in
improving the adequacy of the data to be collected. In addition, some of the more recent finds in psychology should be noted. Recall and memory can be aided by several techniques including the use of association techniques, suggestion and other kinds of stimulation. It has been found that developing aspects of the situation of reporting which are similar to the situation when the events occurred stimulates memory.
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Respondent Differences

Several very important problems have not been critically studied. These become quite crucial when one is interested in obtaining large scale, long term individual level data from a cross-section of the population. When faced with this purpose, the attributes and the variance of attributes of the respondent population become important considerations.

We become interested in the respondent's capacity to know and be aware of what and when he has eaten and often times how much. We are further interested in his ability to remember when the foods have been eaten. The saliency of food to the subject and the importance of food to him should as also be noted crucial factors in the accuracy of the responses given depending on the technique of data collection used. Further possibly important variables may include the ability and eagerness of respondents to communicate the responses to the investigator. Another factor in a large scale survey is whether all of the respondents have the same conception of what the interviewer is trying to communicate to them.

It should not be assumed that we have a "calibrated respondent"; in cases where estimations are used we tend to accept different respondents' statements of the same size of serving as being the same while this might not be actually so. For example, when the respondent tells us that he had a steak, the portion is not necessarily the same size we visualize. While we get an indication of amount by measurement or estimation of size of portion, our interpretation and use of this information will be based on the range of portion sizes that we think are likely. There is an indication that the range of portion size we are likely to assume comprises a range which is too small. Beegle et al (1954) have pointed out that a person tends to judge a serving portion in terms of his own experience. The range of portion
sizes reported by this group for a random sample population was larger than that reported by Eppright et al. (1952). In this latter study, the comparisons of judgements of sizes of servings were made by nutritionists. Dieckman et al. (1951 b) have shown that even in a limited population, size of portion varied considerably, and Young et al. (1952) have illustrated the seriousness of the problem by concluding as follows: "it would appear that errors in estimation of portion sizes are probably the largest source of error in diet record-keeping. Of the types of subjects studied, Home Economics students most accurately estimated size of food portions; other college students and junior high school pupils were least accurate in their estimations; homemakers and male industrial workers were in an intermediate position. Of the types of foods studied, those that could be reported on an item or count basis or readily measured in terms of cups or tablespoons, such as soups, sugar, beverages, bread and rolls, cookies, and eggs, were most accurately estimated. Such food types as 'puddings,' sauces and gravies, and fruit were least accurately reported. Meats, vegetables and salad, and 'casseroles' were in intermediate positions. It was noticeable that subjects had a tendency to overestimate food servings, a bias partially compensated by their failure to report some of the foods eaten or amount left on plates. However, this compensating factor of omission was neither consistent from subject type to subject type nor from food type to food type."

Thus, it is clear that we very likely do not have interval scale accuracy. Instead, we are likely to have only ordinal scale accuracy. Coombs in Festinger and Katz (1953). That is, we are only able to rank order the respondents on their frequency of intake of a given food, for example, on the intake of steak. This problem exists even if the frame of
reference of each of the respondents is accurately known. This would include different possible definitions of the meaning of a portion of steak. This might differ, for example, in different parts of the country, involving special names, meanings, and food classifications.

Another important problem that becomes more crucial in a large scale, long-term, cross-sectional study concerns the "non-response" individuals, the non-cooperative individuals, and the incomplete questionnaires or records, since these respondents are likely to be different from the subjects who cooperate and respond adequately.

In many studies the response rate is low, that is for one reason or another a small proportion of the desired subjects are included.

It is useful to note, as did Taylor (1955), the reasons and the frequency of non-response. Of the 1152 eligible households, 278 households for reasons illustrated in the table below were not interviewed:

Table 5 — Reasons for non-interview and their frequencies. (Taylor, 1955)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>No explanation</td>
<td>10</td>
</tr>
<tr>
<td>Refusal, too busy, reason stated</td>
<td>65</td>
</tr>
<tr>
<td>Refusal, too busy, reason not stated</td>
<td>11</td>
</tr>
<tr>
<td>Refusal (other than too busy)</td>
<td>31</td>
</tr>
<tr>
<td>Out of town or not home</td>
<td>108</td>
</tr>
<tr>
<td>Not reached due to work</td>
<td>5</td>
</tr>
<tr>
<td>Deaf, illness in family, mentally incapable</td>
<td>34</td>
</tr>
<tr>
<td>Language difficulty</td>
<td>2</td>
</tr>
<tr>
<td>Refused to answer the door</td>
<td>7</td>
</tr>
<tr>
<td>Bad roads flood waters, moving today</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>278</td>
</tr>
</tbody>
</table>

Further, it is necessary to check possible biasing effects due to non-response. Either this group should be compared by use of certain relevant characteristics to those substituted for them in the sample or they should be compared with the whole sample. This information would help toward showing the effect of the non-respondents on the total sample population.
Such data have been presented by Taylor (1955) as a part of a study of families in the North Central States though few other researchers have been as careful. When the percentage of non-respondents is small then the distortion in the total study is likely to be slight.

Details on the number and the characteristics of these people as compared to the total respondent groups is necessary in order to allow inferences to the group who give either inadequate or no data. At present there is only minimal information on this point in the nutrition literature. The need for a representative, cross-sectional population sample is, of course, not mandatory for all studies. For example, it may be helpful to follow a few people over a long period of time to learn how they vary over a period of time and to study, in a preliminary way, the methodological difficulties. Chappell (1955) has furnished some information of this type.

Cross sectional studies should provide information about the sample so that inferences about larger population groups can be made. This is possible only if the method chosen is feasible for the specific segment of the population that is to be studied.

In a study of the diets of schoolboys by Beltram (1950) we find some information on factors related to whether persons will keep records or not. Three factors were tested:

(1) The number of children under the age of 19 living in the home and not working.

(2) The nature of the father's occupation (as a possible indication of social status).

(3) Whether or not the child's mother was in paid employment.

Only the last factor mentioned made a difference, and here the extent of the bias on the data itself was unknown though only 15% of the mothers were in paid employment, and less than 1/2 of these latter groups either refused or failed to keep records.
Widdowson and Maclean (1947) have used a food record in weighed amounts in a large population, but because of the non-cooperative respondents, they were not able to make inferences to the larger population of individuals which they intended to study. Aside from the expenses incurred in obtaining cooperation from the respondents in order to obtain weighed food records, this technique is difficult and certainly not a feasible approach for long term, large scale, assessment. The respondent has to be especially cooperative; has to have the ability to do this rather complex task and must have the time to do the work involved.

The use of the diet history also entails a considerable number of qualifications on the part of both the respondent and the interviewer. The interviewer needs to be extremely well trained and experienced in the method, as stated by Burke (1959). She indicates further that the interviewer must gain the confidence and cooperation of the respondent. In addition there are several criteria based purely on judgement for the acceptance or rejection of the data obtained from the respondent. Burke et al. (1959) have stated that it may be impossible to determine the "usual dietary intake" for certain persons who vary considerably from time to time. The exact criteria for determining whether a "usual diet" is available for a given person has not been made specific and it is appropriate to note that the informants who vary "considerably" from time to time are dropped from the respondent population. For most epidemiological purposes, such a method is not usable, since those dropped may be quite different than the rest of the individuals in the population. The comprehensive dietary history does, however, have the great advantage of having built in "cross checks" and some information on validity and reliability (Reed and Burke, 1954).
In some of the larger surveys of food intake, we find several problems. One of the major difficulties in family consumption surveys is in obtaining cooperation from all families drawn in the probability sample. Difficulties have been found with the following groups, as noted by Murray et al. (1952):

1. Families in which the homemaker is employed away from home
2. High income families
3. Those with servants
4. Large families
5. Those burdened by care of invalids

Strom (no date) found in a large scale study of 4000 families that the recording of intricate amounts of information poses a substantial burden on the respondents. The "drop out" rate rises in direct proportion to the complexity and time burden of the survey. He also points out that careful respondent training in keeping records and standardized periodical cross checking procedures aid in assuring more accurate data.

In long term studies the problem of obtaining cooperation in keeping adequate food records is even more difficult as Dieckmann et al. (1951) have noted when they interviewed over 1000 patients for their study; only 602 could be retained over a long period of time and 461 prospective respondents kept insufficient sets of records over the five periods of study.

In an interesting study with a limited population (65 and over), two techniques of approaching respondents were used by Lyons and Trulson (1956). The first was a mail technique, the prospective respondent indicating the desire to participate by returning the post card. The second technique used was an interview. The second technique proved to be significantly superior in allowing records to be obtained. Comparing the results of these two groups of people contacted by the different methods, no significant differences \( p < .01 \) were found in their diets as regards calories, protein, or vitamin C. They also found that it took contacts with 786 persons (age 65 and over) to get 100 individuals in their sample. Differences in intake between the 686 and 100 are, of course, unknown.
Interviewer differences

Let us now turn to the problem of whether there are significant differences between interviewers. Given the same technique to be used with interviewers who are well trained, the initial problem concerns possible differences in the results obtained due to some factor of which the interviewers are unaware. Church et al. (1954), have made a first approach to the problems in this area of collecting nutrition information. Here a direct comparison was not possible, because these workers were only able to collect one history from each person. In order to overcome this problem, a random sample of subjects was selected from a homogeneous group for each interviewer. The idea was that the mean intakes for these randomly selected sub-groups should be no more varied than would be expected for the means of the specific sub-samples used. Therefore, differences between the means could be attributed to "interviewer effects." In this study which was limited as described above and applied only to three selected samples, it was concluded that interviewers with similar background and training, and who were working together as a team were able to obtain comparable data.

In the study of families in the North Central States, Taylor (1955) used a design so that six pairs of interviewers for six sub-regions of the study were divided, a different pair of interviewers being assigned to each sub-region. "The interviewing assignments in each sub-region were then divided so that two of the four segments drawn in each county were assigned at random to one interviewer and the other two segments to the other interviewer."

"Under the above design, comparisons between the two interviewers were possible in each sub-region." This design allows for the problem that "if a question was such that interviewers obtained quite different responses to
it then in an analysis of that particular question there would result a large component of variance attributable to interviewer." While Taylor gave mainly the method of analysis the sample findings showed no significant differences attributable to the interviewers.

From other areas of research several factors are known to be possible sources of bias which can vary from interviewer to interviewer. These problems as applied to other research areas have been well reviewed by Kahn and Cannell (1957) and Hyman et al. (1954). We can categorize these bias effects as follows:

(1) Background factors: Background differences between the interviewers in terms of their social class may influence their attitudes toward others and the foods they eat. This may cause distortion from respondents. If, for example, there were differences in race in some of the interviewers who were working in the same sections of the South, they would likely not get the same results from a given respondent even though they conducted the interview in the prescribed manner.

(2) Psychological factors: In general, there is a tendency for the responses obtained by given interviewers to be influenced by their own opinions and reactions. This has been documented by Cahalen et al. (1947) and Blankenship (1940).

(3) Behavioral factors: The problems with interviewers in this area concern factors like differences in

(a) Asking questions
(b) Probing for added information
(c) Recording responses
(d) Motivating the respondent to give information

A study by Guest (1947) illustrates some of the problems. He arranged assignment of interviewers so that the same persons who were coached to give
the same responses were interviewed by each of the interviewers. As a result of analysis of the tape recordings of the interviews, Guest concluded that the attitudes of the interviewers were the main source of their errors. Other studies have been able to categorize interviewer errors as follows:

1. Errors in asking the questions
2. Errors in formulating probes
3. Errors in recording responses
4. Fabrication of responses or the intentional omission of interview questions.

The most frequent behavior error on the part of the interviewer seems to be in "asking the question" incorrectly.

In addition, there are what might be called situational effects. By situational effects we mean the effects of the procedures for establishing the interview itself, the physical setting of the interview, the mode of recording the interview, the effect of accidental distractions, the need for confidentiality or anonymity of the respondent or even the effect of who is sponsoring the data collection. All of these situational factors can, and sometimes do, have an effect on the responses, but in the area of dietary data collection, we have no idea whether they are important or significant effects. The other category of possible factors are relational effects such as:

1. The interviewer's relationship with the respondent, that is, whether or not the interviewer likes the respondent.
2. The respondent's relationship with the interviewer, that is, whether or not the respondent likes and trusts the interviewer.
3. The attitude of the interviewer toward the interview.
4. The attitude of the respondent toward the interview.
5. Status differentials between the interviewer and respondent.
6. General rapport.
Here again, in the specific context of the area of collecting dietary information, there is little, if any, research on these problems, but in general, researchers are aware that they might exist. At present the extent of these problems are an unknown quantity.

Food grouping for collection purposes

With the vast numbers of foods eaten in this country, it is essential to do considerable grouping of them. The grouping is important at the collecting level and again at the end of the processing level. The less grouping that is necessary during the processing of the data, the greater the breadth of the information that can be obtained.

The basis for grouping of food at the collection level will be dependent on the method used. If the method is a weighed week-long record of food eaten or some adaptation of this, the problem of food grouping is relatively simple. It is based upon meals and between meal snacks. However, the way food falls into meals is not so clear cut as one might think at first consideration.

While we in this country ordinarily think of three main meals, the British include tea as a fourth meal. Hospital dietitians in the United States usually consider three meals daily but public health nutritionists may accept a three meal plan less rigidly because of their contact with groups of people who eat only two meals daily. Harper (1956) observed that 16% of a sample of 101 Negro women 40 to 90 years of age ate less than three meals a day. Three meals a day usually suggests breakfast, lunch and dinner. However, in practice, three meals a day may frequently be brunch, dinner and bed-time meal.

If the method of collection is the comprehensive dietary history or some part of this such as, the 24-hour recall, or the food list or questionnaire, then the food grouping is an entirely different problem. In these instances memory for food is crucial and the groupings of the food must be logical from
the viewpoint of the respondent. The key for remembering food eaten is to ask the questions in a way that elicits information as it is perceived by the subject. Most men consider that meat is the most important food. In using food lists in North Dakota, according to Canton et al. (1959), the nutritionists have found that it was best to start with meat and work through to the rest of the food intake. Further, men do not consider that they are eating meat unless it is a clearly visible slice or piece of meat. If meat is served in a mixed manner, many men will not include it when asked for information about meat and meat substitutes. Swanson (1960) and those with whom she worked found that questions such as the following did not work out:

"Does she eat meat, fish, or poultry?
How many times a week?
How many servings daily?"

"Does she eat green and yellow vegetables?
How many servings daily?"

These workers directed their questions to the interviewer which is a different approach.

Many men help their wives with marketing and occasionally with the cooking. In homes where both are working or are in school, this practice is apt to occur; it has become popular and socially acceptable for the man of the house and even the President of the United States to cook on special occasions. Therefore, it may be meaningful to ask men:

"When you do the marketing, what do you buy?"

"What are you most apt to buy that your wife did not have on her list?"

Further questions regarding frequency and amounts in the frame of reference familiar to the person may give valuable information.

In this hurried society, it has become important to know what can be prepared quickly. The way people group food may be very specifically related to this. Asking questions related to time involved may elicit considerable information.
Indications of "favorite" or preferred meals may give valuable information regarding dietary intake. Moser (1953) has made the following suggestions related to a method of collecting dietary information:

"The questionnaire used in the interview contained a long list of foods and food groups which each man was asked to rate as very good, good, moderately well-liked, tolerated, or disliked; if he was unfamiliar with a food it was designated as 'not tried'. The respondent was also asked to give menus for meals he preferred for Sunday and for a mid-week working day and to list the foods actually eaten the day preceding the interview."

In the results, eight samples are given to show relationships between menus preferred for Sunday, for a weekday, and the meals for the preceding day. (See Table #6.) The similarity in these illustrations would suggest that one might learn just as much by asking "What do you like to eat?" as in attempting to find out what was eaten the previous day. The subjects illustrated were men 15 to 58 years of age in two counties in South Carolina. Incidentally, in a number of cases for the evening meal, there is an indication that it was the "same as dinner." This could be interpreted to mean that two meals may have been eaten -- not three -- but that the questionnaire was written in such a way that three meals were expected.

The central point that we have tried to make is that in grouping foods for collection purposes, we should try to make use of the associations people naturally develop while they are eating which would facilitate memory rather than superimpose some set of procedures which would aid in our processing of the data once it is in hand.
<table>
<thead>
<tr>
<th>Morning</th>
<th>Noon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferred for Sunday:</strong></td>
<td></td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td>Fried ham and eggs</td>
<td>Roast beef</td>
<td>Same as dinner</td>
</tr>
<tr>
<td>Grits</td>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Stewed butterbeans</td>
<td></td>
</tr>
<tr>
<td>Jelly</td>
<td>Macaroni and cheese</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Sliced tomatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coconuts cake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iced tea</td>
<td></td>
</tr>
<tr>
<td><strong>Preferred for a weekday:</strong></td>
<td></td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td>Fried ham and eggs</td>
<td>Fried chicken</td>
<td>Same as dinner</td>
</tr>
<tr>
<td>Grits</td>
<td>Butterbeans or stringbeans</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Tomato sauce</td>
<td></td>
</tr>
<tr>
<td>Sirup</td>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Cornbread</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iced tea</td>
<td></td>
</tr>
<tr>
<td><strong>Meals, preceding day:</strong></td>
<td></td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td><strong>(Sunday):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ham and eggs</td>
<td>Fried chicken</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Macaroni and cheese</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Candied sweetpotatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fruit salad</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canned peaches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iced tea</td>
<td></td>
</tr>
<tr>
<td>** Preferred for Sunday:**</td>
<td>III Farm Negro, Orangeburg, November</td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td>Fried fresh fish</td>
<td>Stewed chicken</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Boiled cabbage</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Cornbread</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canned peaches</td>
<td></td>
</tr>
<tr>
<td><strong>Preferred for a weekday:</strong></td>
<td></td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td>Ham and eggs</td>
<td>String beans boiled with pork</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Rice</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Cornbread</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Iced tea</td>
<td></td>
</tr>
<tr>
<td><strong>Meals, preceding day:</strong></td>
<td></td>
<td><strong>Same as dinner</strong></td>
</tr>
<tr>
<td><strong>(Sundays):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sardines (canned)</td>
<td>Baked sweetpotatoes</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Boiled lima beans</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Cookies</td>
<td></td>
</tr>
<tr>
<td><strong>Preferred for Sunday:</strong></td>
<td>III Farm white, Spartanburg, June</td>
<td><strong>Tomato sandwiches</strong></td>
</tr>
<tr>
<td>Scrambled eggs</td>
<td>Fried chicken</td>
<td></td>
</tr>
<tr>
<td>Bacon</td>
<td>Rice, gravy</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Fried corn</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Fried okra</td>
<td></td>
</tr>
<tr>
<td>Sirup</td>
<td>Stewed squash</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Rolls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fruit salad</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plain cake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peaches and cream</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iced tea</td>
<td></td>
</tr>
<tr>
<td><strong>Preferred for weekday:</strong></td>
<td></td>
<td><strong>Tomato sandwiches</strong></td>
</tr>
<tr>
<td>Bacon and eggs</td>
<td>Green beans boiled with fat pork</td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>Fried corn; Fried okra</td>
<td></td>
</tr>
<tr>
<td>Biscuit</td>
<td>Sliced tomatoes</td>
<td></td>
</tr>
<tr>
<td>Sirup</td>
<td>Cornbread; Coconuts cake</td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>Milk</td>
<td></td>
</tr>
</tbody>
</table>

Tomato sandwiches, Peaches and cream, Cake, Milk, Fried fish, Mashed potatoes, Cabbage slaw, Biscuit, Peaches, cookies, milk.
Table 6 - Menus, Men 45-58 Years of Age - continued

III Farm white, Spartanburg, June - continued

<table>
<thead>
<tr>
<th>Morning</th>
<th>Noon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meals, preceding day:</td>
<td>String beans boiled with salt pork</td>
<td>Fried ham</td>
</tr>
<tr>
<td>Bacon</td>
<td></td>
<td>Vegetables from dinner</td>
</tr>
<tr>
<td>Scrambled eggs</td>
<td>Fried okra</td>
<td>Biscuit</td>
</tr>
<tr>
<td>Toast</td>
<td>Macaroni and cheese</td>
<td>Peach pie</td>
</tr>
<tr>
<td>Coffee</td>
<td>Sliced tomatoes</td>
<td>Milk</td>
</tr>
<tr>
<td></td>
<td>Cucumbers with vinegar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornbread</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peach pie</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buttermilk</td>
<td></td>
</tr>
</tbody>
</table>

IV Farm negro, Spartanburg, June

Preferred for Sunday:
- Scrambled eggs
- Biscuit
- Cornflakes and milk
- Coffee

Preferred for a weekday:
- Fried ham and eggs
- Grits
- Biscuit
- Jelly
- Coffee

Meals, preceding day:
- Fried salt fish
- Grits
- Biscuit
- Sirup
- Coffee

- Roast Beef
- Boiled potatoes
- Green beans
- Fried corn
- Cornbread
- Apple pie
- Buttermilk

- Roast
- Green beans
- Corn
- Cornbread
- Buttermilk
- Blackberries

- Boiled ham
- Mashed potatoes
- Tomato sandwiches
- Bread
- Cornflakes and milk
- Peach pie

Analyzing and Processing of Information

Food grouping for processing purposes

After the groupings at the collection levels are planned to obtain the best possible information, it is desirable to use all of the obtained food items and to use them with the descriptions that are as accurate as possible. The number of food items is likely to be very great. Regrouping is inevitable. The way that the regrouping is done is basic to obtaining valid results.

The possibilities for methods of regrouping increase tremendously with these factors: the detail of information obtained, the detail of information desired, the time period covered and the desire for individual level accuracy.

Without machine methods, it is essential that grouping be accomplished as soon as possible. For this reason, it has been practical for investigators to use food groupings to simplify methods as much as possible. For example, Thomas et al. (1954) carefully worked out a "Rapid Method for Qualitative Appraisal of Food Intakes of Groups." This involved establishing one score for each subject. This scoring method was tested for reliability by food analyses, calculations from food composition tables, and ratings of maternal dietaries determined in another laboratory. They found that "the over-all ratings by scoring showed fair agreement with those determined from both analyzed and calculated values." However, it is important to remember that what was desired in this instance was an over-all score to indicate adequacy.

Leichsenring and Wilson (1951) devised a "Food Composition Table for Short Method of Dietary Analysis." This has been and continues to be very
useful for many purposes. "The means for the food groups were derived from
the values for commonly used foods, weighed in accordance with the findings
from food consumption studies in the United States."

Babcock (1950) devised a "Simplification of the 'Long Method' for
Calculating the Nutritional Value of Diets." The following is a quotation
from the introduction to this publication:

"In the course of organizing a nutritional survey project, this
laboratory had the problem of calculating the nutritional value
of a large number of diets with limited time and personnel.
Short methods of calculation, though useful for certain types
of work, were rejected as not sufficiently accurate for our re­
search purposes. The use of weighted-average food values in the
short methods raises a question concerning the validity of cal­
culations for diets that are known to follow the general pattern
on which the short method is based. In the short methods, also,
it is necessary to classify some foods of rather dissimilar com­
position together, and compound foods such as soups, salads, and
fruit pastries may not fit into any of the classifications."

The Babcock method was devised to obtain information on percentages of Nation­
al Research Council recommended amounts for physically active men.

Very often groupings have been made early in the analysis and results
have been expressed in terms which seemed to be most important for the
purpose at hand. For example, specific nutrients per day or percent of
N.R.C. Recommended Allowances for nutrients have been determined. While
it is sometimes expedient to do this, in many studies much information present
in the raw data is lost by this method. For example, information lost
includes details regarding food items, meal patterns, combinations of food,
relationships to activity, places of eating, factors about conditions under
which the food was eaten.

The Dietary Methodology Committee for the Conference on Methodology
in Epidemiological Studies of Cardiovascular Disease (1959) pointed out
the value of extending the calculations and studies of inter-relationships
If records are carefully obtained. One of the recommendations of this
group was that a means of preservation of basic data collected in dietary
studies be explored.

The practical advantages of broad food groups, food groupings accomplished
quickly, and calculation for the nutrient of greatest current interest,
all oppose the more basic and less immediate needs of obtaining accurate
and detailed information; such information will allow further study as
knowledge increases and will be useful to test a large variety of hypotheses.

If grouping is done too soon, one can expect the kind of inaccuracy
that Lowry and Reese (1951) found when they studied score cards. One
of their procedures was to study 100 dietary records known to be adequate
according to the Recommended Dietary Allowances. They applied a number of
score cards to these same records. The results showed the importance of
using great care in claims that score cards can show adequacy.

Fortunately, machines are now available which make grouping less necessary
and allow grouping to be delayed and accomplished in stages according to the
hypotheses to be tested. Various kinds of food groupings that have been
commonly used by nutritionists are shown in Table 7. Although the nutrients
of major concern may be quite different from those considered in the develop-
ment of the "Food for Fitness Plan", the kind of rationale used in the food
combinations as described in the U. S. Department of Agriculture publication,
"Essentials of an Adequate Diet", 1956, may be helpful.

There are great advantages in reporting results by foods. From this
information, calculations for nutrients, adequacy and relationships can be
made again and again as increased knowledge allows us to invade into new
hypotheses. In many cases older raw data could be used and efficiently.
regrouped to test the new hypotheses as they develop in research.

Widdowson (1947) indicated that she considered the information about foods to be very important when she stated:

"While records of the amounts of the actual foodstuffs are of more interest and importance than the results of calculations of the chemical composition of the diets, a survey of this sort would not have been complete until the results had been expressed in chemical terms."

Widdowson, et al. (1936 a and b, 1941, 1947) expressed results of studies in approximately twenty foods or food combinations, as well as in nutrients.

Trulson, et al. (1949 a and b, 1954) have expressed results in milk; meat; fruits and vegetables high in ascorbic acid; fruits and vegetables high in carotene; and protein.

Clark and Fincher (1954) reported proportions of total day's quantities of selected foods eaten at each meal; quantities eaten per homemaker in a day and proportions eaten at each meal; quantities of selected food groups consumed in one day -- averages per homemaker, by income in four cities; contribution of eleven food groups to nutritive content of food for one day -- percent of each nutrient contributed by eleven food groups in four cities.

Leverton, et al. (1959) were also interested in showing food-related information on nutrients. Part of the information reported consisted of mean daily calories and percentage of total calories supplied by different food groups in the self-chosen diets of 353 women (seven-day records) and fat intake of women in different age groups, as percentage of total calories.

One of the recommendations reported from Diet Methodology Committee for Conference on Methodology in Epidemiological Studies of Cardiovascular Disease, 1959, included the statement that "it may be as important to
investigate the intake of certain foods, types of food or groups of food as it is to estimate the consumption of nutrients." The food grouping system that is best for a specific study and the way that it is related to other factors, including units of time, is obviously dependent upon the purposes of the study.

<table>
<thead>
<tr>
<th>Armed Forces</th>
<th>BHNHE Food Plan Groups</th>
<th>National Food Guide (Basic 7)</th>
<th>Food for Fitness Plan A Daily Food Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vegetables, leafy green and yellow</td>
<td>1. Leafy, green and yellow vegetables</td>
<td>1. Leafy, green, yellow vegetables</td>
<td>Fruits and vegetables</td>
</tr>
<tr>
<td>2. Citrus fruit</td>
<td>2. Citrus fruit, tomatoes</td>
<td>2. Citrus fruit, tomatoes</td>
<td></td>
</tr>
<tr>
<td>3. Tomatoes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Potatoes, sweet and white</td>
<td>3. Potatoes, sweet-potatoes</td>
<td>3. Potatoes, other vegetables and fruits</td>
<td></td>
</tr>
<tr>
<td>5. Vegetables, other</td>
<td>4. Other vegetables and fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Fruits, other than citrus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Fruits, dried</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Cereal and cereal products</td>
<td>9. Flour, cereals, baked goods</td>
<td>8. Bread, flour, cereals (whole grain or enriched)</td>
<td>Same</td>
</tr>
<tr>
<td>14. Fats, other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Sugar and sirups</td>
<td>11. Sugar, sirups, preserves</td>
<td></td>
<td>Other foods not in Basic 7 and the Food for Fitness Plan:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other fats</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unenriched cereals and baked goods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sugar, sirups, preserves</td>
</tr>
</tbody>
</table>
Other problems of processing

The complexity of the collecting, analyzing and processing phases differ with various methods. For example, the problems of the separate phases are quite different in an interview or food record method than are the problems of some other methods, such as those enumerated by Hunscher and Macy (1951) in which an investigator may

"(a) estimate the amount of each of the chemical components in a diet from the raw weights of edible portions of the individual foods, using average values found in tables of food composition in the literature;

(b) analyze chemically samples of the individual foods used in the diet and, with the weights of the amounts of each food eaten, calculate the nutritive values of the diet;

(c) analyze a mixed diet identical in weight and preparation to that consumed by the experimental subject;

(d) analyze a mixture of aliquot portions of each raw food obtained at the time the diet is prepared; or

(e) obtain aliquot portions of each food after meals are prepared, combine them in a composite representative of the diet for a period of time, and analyze samples of the composite."

They indicated further that "these various methods provide values of widely differing accuracy."

It is important that the limitations of chemical analyses be recognized in dietary survey work. Hunscher and Macy (1951) have pointed out some of the sources of error. Possible sources of error in sampling include: unavoidable variations among identically prepared samples of raw foods; inherent variability of foods as purchased; losses of organic and inorganic components from storage, preparation, and cooking; lack of care in measurement; lack of care in respect to oxidation and bacterial action; improper care in respect to the amount of moisture present for the type of tests to be made. Possible sources of error in chemical analyses include: lack
of care in analytical procedures to avoid loss of elements, such as nitrogen; decomposition of constituents, such as fatty acids; change in composition that prevents accurate analysis.

In food habit studies designed for our purposes, these limitations in sampling and chemical analyses are important for several reasons:

1. Chemical values may be considered as a baseline for tests of validity and reliability.

2. Results of chemical analyses are basic to the values given in tables of food value.

3. Results of studies may be given in chemical values only.

Whiting and Leverton (1959) were also interested in the problems in chemical analyses. They indicated that the presence of carbohydrates can interfere with the complete extraction of fat from food and that certain combinations of foods can pose problems that single foods do not offer.

The Diet Methodology Committee (1959) concerned itself with some of the limitations of chemical analyses:

"Acceptable methods for the analysis of food items have been standardized for a few nutrients so that reproducibility of results for analysis of separate samples of the same food is quite satisfactory. Procedures for pyridoxine determination remain unsatisfactory, and others such as vitamin A and ascorbic acid have very considerable errors. Choice has not yet been made of the best methods for fatty acid analysis. Analysis for total fat continues to present some problems and uncertainties."

Over time there have been fewer changes in methods of handling carbohydrate and protein than in handling other nutrients. However, with passage of time, there is opportunity for the development of better chemical techniques. Therefore, in using data in the literature, it is important to consider the amount of accuracy that was possible at the time of the publication. It is also important to consider whether the best methods available were used. We can expect continued improvement in standardized methods
The limitations of food tables also need to be recognized. The values in food tables are guides to the food values of any specific foods eaten by an individual at any one time. It is possible to include only a certain number of items in food tables. This is one of their important limitations when one recognizes the tremendous number of foods that are available. In addition, it is important to consider the great number of varieties of the many foods. For example, the many plant varieties have different food values, as do meat and poultry items that result from various methods for feeding and handling.

The limitations of chemical analyses are reflected in tables of food composition. As procedures are improved, there is necessarily a time lag before more accurate figures are available in the food tables. Watt (1959) has shown how directly or indirectly a few tables have formed the basis for all tables of food value. From time to time original analyses are made by workers. Then later, this information becomes incorporated in revisions of the original tables and in text books. They become incorporated either as additional items in the tables or as additional samples to be averaged or to be used by some process of weighting. Patterson and McHenry (1941) recognized one of the important problems of food tables when they stated that

"Most tables of food composition give average figures for a few analyses of a particular food; in very few cases only, minimal and maximal figures are stated."

We agree with Widdowson and McCance (1943) who summarized some viewpoints about limitations of food tables by saying:

"There are two schools of thought about food tables. One tends to regard the figures in them as having the accuracy of atomic weight determinations; the other dismisses them as valueless on the ground
that a foodstuff may be so modified by the soil, the season, or its rate of growth that no figure can be a reliable guide to its composition. The truth, of course, lies somewhere between these points of view."

As suggested by Leitch and Aitken (1949-1950), "...the report of a survey should state what tables were used."

Brewer (1959) has shown how the judgment of different nutritionists can cause discrepancies in the results of findings. In this study, the investigators submitted weighed records to eight different nutritionists for calculation. Comparing the mean figures obtained for the eight nutritionists over the ten nutrients, we find the following average mean deviations:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Average Mean Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>35</td>
</tr>
<tr>
<td>Protein</td>
<td>3.8 gm.</td>
</tr>
<tr>
<td>Calcium</td>
<td>30.6 gm.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.7 gm.</td>
</tr>
<tr>
<td>Iron</td>
<td>0.4 mg.</td>
</tr>
<tr>
<td>Vit. A</td>
<td>74.3 I.U.</td>
</tr>
<tr>
<td>Vit. C</td>
<td>4.5 mg.</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.06 mg.</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.07 mg.</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.9 mg.</td>
</tr>
</tbody>
</table>

These variations are just the average mean deviations in the results of different nutritionists' calculations of the same raw data.

Whiting and Leverton (1959) have summarized information available in the literature in which there were comparisons of food values obtained from calculation from food tables compared with chemical analyses. The comparisons were found in literature dated 1906 to 1959. The results of this study showed:
## COMPARISONS OF FOOD VALUES

OBTAINED FROM CALCULATION FROM FOOD TABLES COMPARED WITH CHEMICAL ANALYSES

<table>
<thead>
<tr>
<th>Total Assessments</th>
<th>Calculation below 10% of analysis (% of assessments)</th>
<th>Calculation within 10% of analysis (% of assessments)</th>
<th>Calculation above 10% of analysis (% of assessments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>378 Calories</td>
<td>10%</td>
<td>58%</td>
<td>32%</td>
</tr>
<tr>
<td>318 Protein</td>
<td>30%</td>
<td>54%</td>
<td>16%</td>
</tr>
<tr>
<td>259 Fat</td>
<td>26%</td>
<td>25%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Results of a study made by Whiting and Leverton, 1959.
There is more agreement in the calorie and protein comparisons than with
the fat comparisons but the calculation results tend to be above the
analysis results for calories and fat and below for protein. The differ­
ences shown here reflect a combination of many types of problems at the
collecting, analyzing and processing levels. With the wide variety of
possible errors, there is a strong possibility that some errors balance
out other errors.

Darby et al. (1959) compared dietary information obtained by several
methods. They found that "the inventory and recipe methods of calcula­
tion agree well with each other, but the analytic values are often quite
different," and also that "protein content was regularly higher and fat
content lower by chemical analysis as compared to calculated values."
The comparisons for minerals and vitamins showed that calcium, iron, and
vitamin A were higher when analyzed than when calculated. Thiamine and
vitamin C were lower by analysis. Riboflavin and niacin were approximate­
ly the same by the various methods. Possible causes for the differences
are discussed by these authors.

**Human errors and machine methods**

The human errors that are possible in handling data are of a very
great variety. They range from all of the obvious but important kind of
errors connected with transferring figures from one sheet of paper to
another to the errors of judgment in the use of the items on a food table
which most nearly represent the items of food actually eaten.

The development and increased use of machine methods reduce the oppor­
tunities for human errors of some types. But machine methods cannot
produce results that are more accurate than the information supplied.
The machine calculations will supply clear answers only to the questions that are well thought out and well planned. Therefore, well thought out long range and short range goals need to be established. Hypotheses need to be carefully stated if proof is to be found. Personnel qualified to handle the content aspects of the study, and those qualified to handle the methodological aspects need to work together to use the machine calculations effectively.

Governmental agencies have used machine methods to handle the processing of information from food intake studies for some time. The British government was using machine methods in 1948 for the Wartime Social Survey. Beltram (1950) and Osborne (1951) used machine methods. The Household Economics Research Branch of the U.S. Department of Agriculture (more recently -- Household Economics Research Division of the Institute of Home Economics, Agricultural Research Service, U.S.D.A.) has used machine methods extensively. Various regions and states that participated in the studies made possible by the Research and Marketing Act of 1946 used machine methods -- Babcock et al. (1955), Church et al. (1954), Clark and Henderson et al. (1954), Gillum and Morgan (1955), Murray et al. (1952), Steele et al. (1952), Wertz et al. (1952), Wilcox et al. (1956), Young et al. (1952 a,b, 1953 a and b). Such methods were used in the Survey of Food Consumption of Households in the U.S., Spring, 1955.

Machine methods are now being used in some of the studies of food intake that are being made in connection with epidemiological studies. For example, the IBM 650 is being used for the Albany Cardiovascular Health Center Study (New York), and more recently, the data for the Framingham study are being calculated at the National Institutes of Health, Bethesda,
Maryland. Joint planning of investigators with university and state agencies has made it possible to use medium-speed computers to process results of food habit studies (Becker, 1953). Since medium and high-speed computers are becoming much more widely available, greater use of them can be expected in the future.

There are many advantages of machine methods over hand methods. Machine computations make fast, accurate calculations and the combination of similar data possible. Very much greater detail is possible with machine computation. The punched cards used in the machine methods allow for easy storage of the data, so that they are available for study later. The study of very many more relationships is possible. In addition to the testing of the hypotheses under consideration for proof or disproof, the machine methods make it possible to study relationships for possible clues to further discovery of hypotheses for testing.
Chapter III

PROBLEMS INVOLVED IN THE STUDY OF LARGE NUMBERS OF PEOPLE

Expense

There is little information available in the literature at present regarding time and costs involved in dietary investigations. The following factors can be expected to influence costs:

(1) Quality of personnel at all stages of the survey work -- planning study, collecting data, processing data, and analyzing data.

(2) Time of personnel at the planning stage.

(3) Cost of training personnel.

(4) Relative amounts of time required by various types of personnel at the collection stage.

(5) Time and travel time involved for the collection of data.

(Included here, and especially important, is the cost of reaching the subjects who are most difficult to reach, including supplementary samples when necessary)

(6) Time involved at the processing stage.

(Included here is the cost of checking, sometimes called editing; coding, and other procedures to prepare the information for tabulation)

(7) Machine expense.

(8) The study and evaluation of the findings.

(9) The extent and detail of the reporting of the findings.

(10) The extent of the provisions to utilize the information obtained in the study.

Young and Trulson (1959) have pointed out the need for study of expenses and indicated that valuable information from current studies regarding cost should be extracted and made available to future investigators. They gave the following estimates of time costs for a study of
business and professional men in Minneapolis and St. Paul in 1953 and 1954:

<table>
<thead>
<tr>
<th>Hours Per Individual Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collecting data (including training school and travel time 1)</td>
</tr>
<tr>
<td>Editing, coding and summarizing data on food intake</td>
</tr>
<tr>
<td>Hand calculating nutritive values (including additions and averages)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

1 By nutritionists and home economists experienced in techniques of collecting dietary information and skillful in interviewing.

2 By statistical clerks experienced in these operations.

In the interests of cost, Murray et al. (1952) compared the *list method with the food-record method for study of family food consumption. They indicated that the list method was less expensive both in the cost of collecting the information (because of travel and interview time) and in the cost of processing (due to single figures for quantities rather than numerous figures that require calculation before tabulation). They also considered the fact that the list method might require greater interviewing skill which, of course, affects the cost.

* In this method, the interviewer uses a detailed listing of foods which assists the respondent in recalling food items. It has similarity to one portion of the comprehensive dietary history method used for cross-checking purposes.
Taylor (1955) reported on the time spent in the various phases of field operation:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Average hours per questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>2.75</td>
</tr>
<tr>
<td>Interviewing</td>
<td>2.37</td>
</tr>
<tr>
<td>Sampling</td>
<td>1.00</td>
</tr>
<tr>
<td>Editing</td>
<td>1.20</td>
</tr>
<tr>
<td><strong>Total field time</strong></td>
<td><strong>7.32</strong></td>
</tr>
</tbody>
</table>

The illustrations that have been cited regarding some of the cost factors are derived from studies involving quite different total numbers of people. The information reported by Young and Trulson (1959) was based on the first 67 records which were processed in a study involving approximately 119 subjects (Taylor, 1955). Murray et al. (1952) studied 238 families. The North Central studies for which Taylor (1955) was making preparation eventually involved 1,385 families (1955 U. S. Department of Agriculture series on Food Consumption of Households).

Thousands of individual subjects have been included in certain studies of food intake and nutritional status. For example, in one of the studies of the Wartime Social Surveys in England (1942), 9,219 subjects were studied by means of a standardized and structured interview method. Trulson et al. (1949 a and b), in studying 8,125 subjects, used the 24-hour recall method by means of interviews and by use of records. Strom (no date), in the study of 400 families and the individual
family members, used a 14-day mail questionnaire for information about kind of foods used in meals.

Thomas et al. (1954) used 7-day records and 24-hour recalls as the method to study 1,128 individual subjects. Widdowson (1947) on the other hand used records of weighed amounts of foods eaten in one week to study 916 subjects. Chalmers et al. (1952) used 7-day records to study 902 subjects.

These examples of studies of large groups of people illustrate that a variety of methods have been used in the past, even when the number for study was large. The literature we have reviewed suggests that food records have been used more frequently than diet histories to study large groups of people. However, Cantoni et al. (1959) have observed that "most of the current epidemiologic studies of cardiovascular diseases in which diet is being assessed are using the detailed nutrition history."

**Characteristics of People Studied**

In studies on the epidemiology of chronic disease it is desirable to obtain subjects for study who represent a "universe" of individuals of diverse types. (This will be discussed in more detail under sampling.) This is very unlike a study in which the subjects (whether large or small in total number) are being used largely because they are willing to cooperate. The characteristics of a representative sample of people can be expected to include groups of individuals very different from the cooperative individuals. (See respondent differences.) Therefore, the method used must have certain characteristics that will make it possible to reach the representative sample or allow for supplementation of the original sample.
Characteristics of the Method

The method used for large numbers of a representative sample must be simple, easily communicated, standardized, and structured.

Simplicity is essential if there are to be few non-respondents. Wiehl (1959) has emphasized the importance of short schedules for large population groups, the features of such a schedule and the importance of field pre-testing for content and for reliability. They also discussed in detail the use of such a schedule in large scale epidemiological studies of cardiovascular diseases.

The characteristic of easy communication is essential if adequately large samples of people are to be reached to make significant findings possible.

The characteristic of standardization is important for use by different workers (whether trained lay interviewers or research dietitians and nutritionists). If methods are standardized, then it is legitimate to combine findings of different workers within one study and to compare the findings of different investigators using the same standardized procedure or another clearly defined standardized procedure. A standardized technique must be communicable and clear to other investigators.

The last characteristic relates to the method used as being structured or unstructured. This dimension includes the freedom given the respondent to give alternative answers. Structured questions and answers are possible. Some of the current food intake studies are using structured questionnaires. For example, as part of their method the Albany Cardiovascular Health Center has a questionnaire which is directed to the subject in a rather structured manner. A sample question from this questionnaire follows: --
"How many eggs do you average per week for breakfast? _________

Of these, how many are

fried  _________
cooked in shell or poached  _________
scrambled  _________
other  _________

The greater the degree of structure that is possible, the greater is the ease in collecting and processing the data, but until the investigator knows either the range of the typical responses or his specific interest, a highly structured technique might not be the best instrument.

Questions of the unstructured variety give the respondent a broad range of possible answers from which to choose, as is the case in most twenty-four hour recall methods where the breadth of the alternative possible answers given by the respondent is not limited by the method used.

Characteristics of the Personnel Involved in a Study

Complex personnel needs arise if large representative population groups are to be reached through a dietary survey method with the characteristics described above. At different stages in the survey process, personnel with different kinds of qualifications are needed. Highly specialized individuals are needed for certain aspects of a study. The studies that are handled by the U. S. Department of Agriculture have regularly had the services of statisticians. The literature suggests more frequent use of statisticians in the more recent studies and those currently
in progress than in those conducted in the past. In some of the studies a few investigators have worked or are working with social scientists et al. or Stuart et al. as well as statisticians (Burke, 1959; Beltram, 1950; Strom, no date; Trulson, 1949 a and b). Some other studies in which investigators worked with social scientists are Boek (1956), Osborne (1951), and Young (1952 c and 1954).

At other stages in a large population study, it is possible to use less highly trained individuals effectively. A number of the U. S. Department of Agriculture Regional Studies (Murray, 1952; Svanson, 1959; Neun, 1956; Moser, 1953; and Clark, 1954) have used lay interviewers for data collection purposes. Lay interviewers were also used in England for the Wartime Social Studies (1942 and by Beltram (1950). Today large scale nutrition studies use statisticians and machine data processing technicians during the analysis stage. This kind of conclusion is apparent from the review of the series of cooperative studies involving the State Agricultural Experimental Stations of the United States and Institute of Home Economics of the U. S. Department of Agriculture by Morgan (1959).

**Sampling Needs**

The sampling needs of a given study depend on the intent or purpose of the study. That is, what is the population (and the attributes of that population) to which the sample data would like to infer as well as what is the specific substantive problem at hand and what is the distribution of these attributes in the population concerned. There are any number of techniques of sampling and sampling co-ordinations that may be used or adapted to a given particular problem.
In studies using large numbers of individuals, the expense of the data collection aspect of the study is considerably dependent on the actual size of the sample \(n\). As Morgan (1959) has pointed out, sampling (in this case -- the selection of subjects) is more important to studies of assessment of a population such as in the North Central Cooperative Studies (Beegle et al. 1954) than in studies searching for correlations between diet and other variables. While this is true, we would point out that in order to pin down the relationship, a wide range of variance on both variables is necessary.

Let us now consider the attributes of the different techniques of sampling. For simplicity's sake, we will consider only the relatively pure rather than the more complex types of sampling techniques which are available.

Simple random sampling refers to techniques which, if repeated in a large population a large number of times, will tend to yield all possible different samples with equal frequency. That is, this technique allows every member of the population an equal chance of being selected. This kind of result may be obtained by proper use of complete listings of the population members or by mechanical random selection techniques.

There are four general kinds of modifications of this simple selection procedure. (Kish in Festinger and Katz, 1953).

(a) **Stratification** -- which involves the classification of the population of \(N\) elements into sub-populations called strata in which the selection is made separately in each stratum.

(b) **Systematic** sampling involves the selection of a sequence of units separated on the listing by the length of an interval with the choice of one random number.
(c) **Clustering** involves the use of groups of elements called clusters as sampling units. The clusters are usually some existing grouping of the population. In each selection, a group of elements is selected jointly into the sample, e.g., members of families eating at the same table will have diets more alike than two individuals in different families.

(d) **Varying probabilities** may be given to differing sampling units, for example, the use of a selection technique with probabilities proportional to the measures of size.

This list of modifications is neither mutually exclusive nor complete but shows some of the possible approaches to sampling problems in this area. Combinations and further modifications are possible and available. Each of these has its appropriate use, but let us point out, for example, that a truly random sample cannot be drawn unless it is possible to identify each unit of the population and to make sure that the unit designated by the sample directive actually appears in the sample. Further, it is very difficult to secure answers from each of the units to be represented in the sample due to a multiplicity of factors like illness, suspicions and language difficulties, etc. (Brown in Committee on Food Research Conference on Food Acceptance Research, 1945). The modifications of random sampling mentioned above generally make it easier and less expensive to obtain data. The specific kind of sampling approach depends on the problem under investigation and the time and money available for the investigation. Further consideration to sampling problems will be given in "Problems Arising Out of Combined Needs."

It cannot be overstressed that sampling reports should be clearly stated as advocated by the Sub-Commission on Statistical Sampling for the Statistical Office of the United Nations (1950).
Chapter IV
DEVELOPING INDIVIDUAL LEVEL INFORMATION

Generally, it can be assumed that there is more confidence in dietary material when it is obtained on a group basis than when considered for the individual. (Report of Diet Methodology Committee, 195?) However, in the study of the relationship of dietary factors to disease in epidemiological studies, the unit of analysis should be the individual. Even though epidemiology is preoccupied with the group rather than the individual, knowledge obtained through the study of groups eventually has to be brought back to its constituent members. Moreover, in population surveys, the number of diseased or preferentially exposed individuals frequently form but a small segment of the total group. In order to establish statistically valid comparisons between the segment and the whole, the data pertaining to the segment must be known with a considerable degree of accuracy. This requirement permits no wide latitude for error on the individual level. The level of accuracy necessary for any given purpose might vary. For certain purposes, we may need only very gross distinctions in the data while for other problems quite accurate interval scale measurement might be necessary.

Data Collection Problems for the Individual

Since epidemiology requires knowledge of the individual and most diseases of interest affect the person over a period of time, it is apparent that the time dimension is a fundamental aspect of our problem. Particularly, if we desire to assist in the assessment of the subject's nutritional status, we need to collect data on food intake over a period of time. Thus, we
clearly have a time series problem. From the viewpoint of statistics, time series problems are the most difficult of all estimation problems. The day-to-day changes in food intake of any individual generate an interesting series of data points. In economics and physics, it is assumed that a stochastic process generates these time sequenced observations. That is, there are basic causes for the general secular trends in the time series data. Discovering the nature of this process, i.e., setting up a reasonable model, and estimating the parameters of such a model is, however, not an easy task. The nutrition problem is simpler. We are interested in learning about the mean level of intake, possible trends in the intake, variations in the intake and if it is adequate or excessive. From time series terminology, we become interested in auto-correlations; i.e., degree of time dependence of the observations. We note that this correlation is taken within individuals rather than over individuals. Another term that is relevant to nutritional measurement is the concept of the "window" or the unit of analysis. We may consider a single meal or snack as the elementary datum. What grouping of such elements is then best suited for food intake measurement? "Windows" that have been used are a single day or a 24-hour recall, units of 2 or 3 days, a calendar week or seven non-consecutive days, a 28-day period or a month. Choice of the window becomes an important decision in the sampling design for the individual especially where time series data is to be collected.

Next, it becomes relevant to consider the appropriate model for an individual's food intake. This model should be soundly based on the time series approach. It is well known that food intakes of individuals may be related to age, income and education. (National Academy of Sciences, National
Research Council, 1958) That is, at a single point in time, food intakes of individuals are associated with these factors. Thus, it appears that these factors should be introduced into the model. Estimation of any regression parameters for these factors usually will have to be done by averaging over individuals. Let us consider the description of an observation for the j'th nutrient (or food) on the i'th individual in a population. In particular, we define the k'th such observation by the m'th method as $Y_{ijkm}$. This observation may now be expressed as the sum of a number of hypothetical components. The model is, therefore, described as linear and additive. Let

$$Y_{ijkm} = m_j + f_a (\text{Age}) + f_e (\text{Education}) +$$

$$f_1 (\text{Income}) + f_s (\text{Season}) + \text{Bias}_m$$

(associated with the method) +

$$S_1$$ (random deviation associated with the method of measurement)

$$+ S_2$$ (random deviation associated with the unit of observation -- the windows)

$$+ S_j$$ (random deviation associated with the k'th observation in the j'th individual for the i'th food or nutrient.)

In this vaguely defined expression for the observation, $Y_j$, is the true average intake, which would be the parameter of greatest interest from the standpoint of epidemiology if the regression functions $f_a$, $f_e$, $f_1$ and $f_s$ all were of zero effect for the j'th individual. Each of these regression functions also contains one or more parameters of interest. With each of the random elements we may associate a variance component. Other conceptual formulations of further factors might easily be noted. The above seems a reasonable first approximation.
Sampling Considerations

With the model stated in acceptable terms, the sampling problem may be approached. The sampling may have two different objectives. First, we may be concerned only with estimation of the parameters in a model such as just described. On the other hand, for methodological studies our interest may center on the comparison of methods, e.g., 24-hour recall vs. food record. If this be our interest, a carefully designed program for sequential collection of the data will be needed. A "cross-over" design or a rotation program will permit unbiased comparisons of methods.

Size of sample now becomes a question with two dimensions. Given the epidemiological problem, there is the question of how many different individuals are to be observed. This question may perhaps be answerable from presently available information on variances between individuals. The other dimension returns us to the time series problem. Having decided on the "window" we need to determine how many "windows"? Data on individual variance in the literature is helpful in answering this question, but only partial data is presently available.

It is worth noting here that the statistics of these correlated in time observations are much more complex. Under independence, the variance of the sample mean, say $\bar{y}_j$ for the $j$'th individual, would decrease as $\frac{\sigma^2}{n}$ where $n$ is the number of successive elements observed. More observations are required to achieve the same precision when the observations are positively correlated. Further, we need to estimate the degree of the correlation.

Finally, it will be useful to consider a possible sequential approach to the sampling problem. (Hegstead and Drolette, 1960) The amounts and kinds of information needed will vary considerably with the disease under
study. One approach might be to select a sufficiently large sample of eligible individuals. A first observation is then made on all individuals drawn in the sample. Upon the basis of data obtained the individual is classified into one of several groups, observation is then continued at systematic or random time intervals for all members of the sample. When \( k_1 \) observations have been secured, it may be apparent that adequate precision has been obtained for a part of the sample. Observation is then terminated for these individuals. For other members of the sample, observation is continued until \( k_2, k_3, k_4, \) etc. observations have been obtained. Terminations (of observation) are set for members of each group as precision is found to be satisfactory.

Since research will have to be directed toward the problems considered, individual data, social group variables, and methods -- it becomes important that these be incorporated in a model and we have suggested a first possible approximation. It is the fact that there may well be inter-correlations among data that makes it necessary to consider many variables simultaneously. Any sampling and any research constitutes sampling, must take these into consideration. The model should, as it does elsewhere, give breadth and specificity to the research design. It can do so, however, only as it incorporates what is now known, which is the purpose of this report as a whole.
Chapter V

NEEDS AND PROBLEMS RELATED TO LONG TERM STUDIES

In an earlier section we have discussed the long term studies. Here we will more carefully cover some of the more knotty problems involved in this kind of study.

Concept of "Usual" Diet

Several terms are frequently used in connection with food intake and may have definite meaning to one person, but an indefinite or different meaning to another. These three common terms are "usual diet," "food habits," and "pattern of eating." The meanings of these are closely related and each expression carries the idea of invariance over time. The time period over which the consistent and distinctive characteristics persist varies from days to years. The patterns can be in effect for consecutive or intermittent periods of time.

All or part of the following features may be characteristic of "usual diets," "food habits," and "patterns of eating"—amounts of food, food combinations, methods of food preparation, and possibly other factors, such as meal plans, companionship while eating, and emotional condition while eating, food likes, ethnic factors, and other social behavior patterns are closely associated with these or related concepts.

Another term that should be considered is "profile." It has similarities to "usual diet," "food habits," and "patterns of eating." However, it has been used to refer to nutrients rather than to foods. The type of concept has more explicit measurement problems, which have been discussed and used in the area of psychological measurement. (Gaier and Lee, 1953; Cronbach and Gleser, 1953; and Helmstadter, 1957.)
Various teaching tools, such as the "Food for Fitness Plan" and the "Basic Seven Foods" can be considered as examples of dietary patterns. However, these patterns have definite limitations for use in dietary surveys for purposes of epidemiology.

In the nutrition literature the time period most often used to describe the "usual diet" is a twenty-four hour period, and the dietary intake is most often expressed in quantities of nutrients. The statisticians ask whether the quantities are meant to express the average or the mode, and suggest that figures for the mode would probably be most appropriate.

It would appear that any period taken as representative must encompass known sources of variation to achieve stability estimates, since variation not included in this estimate must appear as variation of estimate or error. Since variation between meals on a single day are very great, it would seem that 24 hours is a bare minimum, which would not represent variation between days of the week or seasons. Of course, the real problem is the qualitative determination of the contribution of these sources of variation, within a model whose residual variance is satisfactory.

Thomson (1958) who used a "profile" of food intake referred to the information given on bar graphs. The unit of time was a week and the showed the calculated amounts of eight nutrients consumed by 11 individuals in the course of two week periods.

When Harper (1956) gave information about "eating patterns" of subjects, she referred to the specific menu combinations used on the days of the assessments. She was interested in the similarities or lack of similarity in these menus for the same individuals after time periods of five to ten years had elapsed. She noted that similarities of pattern were more common for two groups of white subjects, one of which was a group of college graduates, than for another group of Negro women. The food patterns for
the non-selected sample of white women was different from the group of highly trained women but "it was just as definite and unchanged over a period of years." See Table 8 for examples given by Harper. (Page 100)

Harper based some of her comparisons of dietary patterns on a count of the identical foods in the two menus being compared. She also studied the patterns by a method that is more common in dietary studies -- calculating the percentage of subjects having the various numbers of meals.

Burke et al. in Stuart (1959) have developed a very different method to study dietary patterns. The following is a description of the procedure used for determining patterns of nutrient intake:

"For the purpose of describing the individual difference in patterns of intakes over the entire 17-year period, the records of caloric and protein intakes for both the boys and girls have been classified separately into pattern groups, using the following procedure:

1. The 17-year period was divided, more or less arbitrarily, into three approximately equal intervals, i.e., 1 to 6 years (the period between the first and sixth birthdays), 6 to 12, and 12 to 18 years.

2. Within each of these three age periods the average daily intakes of calories and of protein for each year were added for each child in the Maturity Series. Thus the total protein and total caloric intakes for each child have been summarized separately by three cumulative intake figures.

3. For both sexes, both calories and protein, and for each age interval, the distribution of cumulative intakes was arranged from the lowest to the highest value and the 25th and 75th percentiles located.

4. Within each age period, each individual's cumulative intake was classified as low (L) if it fell below the 25th percentile, medium (M) if it fell between the 25th and 75th percentiles, and high (H) if it fell above the 75th percentile.

5. Each child's pattern of intake over the total period was identified by the combination of ratings for the three periods. There are 27 possible patterns of nutrient intakes ranging from LLL to HHH. These possible patterns are combined and identified by the terms given in the ll pattern groupings listed below:

(1) Cases with patterns of intake classified HHH are termed "consistently high."

(2) Case classified MWM are "consistently medium."
(3) Cases classified LLL are "consistently low."

(4) Cases grouped as MLL, HLL and HMM show an "early drop" in rank of intake, i.e. following the 1 to 6-year interval. This means that their cumulative value is relatively high in rank in the early years (1-6).

(5) Cases grouped as LLM, LHH and HHH show an "early rise" in rank of intake. Thus these patterns show low ranks of intake in the early years and relatively high levels between 6 and 18 years.

(6) Cases grouped as MML, HHL and HMM show a "late drop in rank of intake; that is, the cumulative value ranks in a higher quartile in the first two intervals than in the last.

(7) Cases grouped as LLM, LLH and MMM show a "late rise" in rank of intake, thus these patterns show low ranks of intake for the first two intervals and a relatively high level for the last interval.

(8) Cases grouped as LML, LHL, LHM, MHL, and MHH show a rise in rank of intake from the first to the second interval followed by a drop in rank in the third interval and are designated "early and late drop.

(9) Cases grouped as MLM, MLH, HLM, HLH and HMH show an early drop in rank of intake followed by a rise in intake in the last age interval and are termed "early drop and late rise."

(10) Cases classified LMM show a "continuous rise" in rank of intake.

(11) Cases classified HML show a "continuous drop."

The authors stated that this "classification allows for an objective and practical separation of the markedly divergent intake patterns as manifested by the group of children throughout their total childhoods."

Adelson (1959) has described how nutritionists well qualified in interviewing have been able to work from the recent information about eating to the information from the past. Questions about food habits are related to changes in the way of life of the subject, such as: when married, when in college, when on first job, when in military service, when a disease was detected, when children were born, and when children married.
Similarly, Finnegan (1960) observed that older women had followed three different patterns. "The first pattern was controlled by their parents, the second by themselves as homemakers and parents, and the third pattern.... was determined by their daughters or daughters-in-law with whom they were living."

The major purpose of our project could be furthered by better knowledge regarding "usual diets", "food habits", "patterns of eating", and/or "profiles." All of these expression and others that are similar have dimensions that go far beyond simply the total foods consumed in any one period of time. Clear definitions of what is meant by these expressions is basic. Answers to some of the following questions would be most helpful:

Do "clear patterns of eating" mean frequency of eating, consistent use of specific foods, consistent quantity of specific foods, regularity in total quantity and/or other factors? How are consistencies measured?

What "clear patterns of eating" related to personality or environmental factors have not been appreciated and detected to date?

How well can "core patterns" of staple food intake be detected?

What are the influences that cause different eating patterns from individual to individual?

What are the influences that cause differences over time for any one individual?

More Problems for Long Term Studies

More effort is needed in learning the circumstances related to eating patterns and the frequency of the occurrence of these circumstances. This kind of information may have great potential in assessing long term food intake of individuals.

In the past we have used such concepts as "usual diet" or "patterns of eating" or "food habits" to reflect the dietary intake of a given time period. While this is true, the time period varies considerably and the number of assessments of each individual taken varies. It should be pointed out here
that the problem of how frequently to assess depends on the individual subjects variability over time, the amount of error of the method or methods used, the level of accuracy and detail needed by the investigator, as well as the money and facilities available to the investigator.

The feasibility of a continuing study is complicated by the problem of getting continued cooperation. The problems of follow-up with one of these kinds of studies are considerable in terms of time, expense and the ability to maintain a representative sample of the population under study. A further crucial question is whether it is necessary to develop a purely long term method of data collection or is it reasonable to adapt some short term technique which has proved useful in the past and use it periodically depending on the considerations mentioned above to give us the long term picture.

Another alternative is to use a short term technique in combination with a "time slice" approach. That is, allow segments of the population to vary in age but to be matched in terms of requisite background characteristics. In this manner, short time data covering a longer period of time may be made accessible at a lower overall cost. This type of technique has been used by Widdowson (1947) and by the Cooperative Nutritional Status Studies in the Western Region (1956).

Problems with this kind of technique are in the ability to match subjects, in changes in foods and their preparation over time. (This latter point could not be considered using this technique). We know of course that food preparation changes over time and composition of various foods change. These changes have been noted in the Agriculture Handbook 62, Consumption of Food in the United States, 1909-1952, and its supplements, and recently summarized in the National Food Situation, 1960. A further problem with this technique is that time and age may not be the same continuum.
There is an other less satisfactory alternative which depends considerably on the amount of detailed accuracy that is needed. This technique would entail an attempt as Adelson (1959) has done, to try to obtain a picture of food habits at crucial points of possible changes in the food intake of an individual. This technique is only a gross kind of approach to a long term study but may be suggestive of the results of a more detailed and careful study carried out over time at much greater expense.

In summary, we have outlined some of the more crucial problems, alternatives and contingencies to be considered in order to handle the long term problem of assessing dietary intake.
### Table 8 -- Eating Patterns of Subjects (Harper, 1956)

#### Sample A (Highly trained women)

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Snack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944 Tomato juice</td>
<td>Vegetable soup</td>
<td>Fried chicken</td>
<td>none</td>
</tr>
<tr>
<td>Bran flakes</td>
<td>Lettuce and peanut butter sandwich on wholewheat bread</td>
<td>Sweet potatoes</td>
<td></td>
</tr>
<tr>
<td>Skimmed milk</td>
<td>wholewheat bread</td>
<td>Creamed celery</td>
<td></td>
</tr>
<tr>
<td>Wholewheat toast</td>
<td>Spicecake</td>
<td>Baking powder</td>
<td></td>
</tr>
<tr>
<td>Butter and jam</td>
<td>Chocolate milk</td>
<td>biscuit</td>
<td></td>
</tr>
<tr>
<td>Coffee with cream</td>
<td></td>
<td>Chocolate cake</td>
<td>with raspberry</td>
</tr>
<tr>
<td>1955 Orange juice</td>
<td>Ham sandwich on</td>
<td>Broiled liver</td>
<td>Apple</td>
</tr>
<tr>
<td>Branflakes with homogenized milk</td>
<td>wholewheat bread</td>
<td>Creamed potatoes</td>
<td>Buttered asparagus</td>
</tr>
<tr>
<td>Toast with butter</td>
<td>Sliced tomatoes</td>
<td>Sliced tomatoes</td>
<td></td>
</tr>
<tr>
<td>Coffee – no cream</td>
<td>Buttered green beans</td>
<td>Chocolate cake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ice cream</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coffee</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Sample B (White women of a random sample)

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Snack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948 Orange juice</td>
<td>Cold meat and cheese sandwich</td>
<td>Boiled frankfurter</td>
<td>none</td>
</tr>
<tr>
<td>Oatmeal cooked with raisins</td>
<td>Green onions</td>
<td>Fried potato</td>
<td></td>
</tr>
<tr>
<td>Sweet roll</td>
<td>Raw celery</td>
<td>Raw celery</td>
<td></td>
</tr>
<tr>
<td>Toast with butter and jam</td>
<td>Brownie</td>
<td>Apple pie</td>
<td></td>
</tr>
<tr>
<td>Coffee with cream and sugar</td>
<td>Coffee with cream</td>
<td>Coffee with cream</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and sugar</td>
<td>and sugar</td>
<td></td>
</tr>
<tr>
<td>1955 Banana</td>
<td>Meat sandwich with wholewheat bread</td>
<td>Roast beef</td>
<td>none</td>
</tr>
<tr>
<td>Oatmeal cooked with dates</td>
<td>Tomato with french dressing</td>
<td>Potato and gravy</td>
<td></td>
</tr>
<tr>
<td>Glazed doughnut</td>
<td>Fresh pear</td>
<td>Tomato with french dressing</td>
<td></td>
</tr>
<tr>
<td>Toast and butter</td>
<td>Cookies</td>
<td>Pineapple pie</td>
<td></td>
</tr>
<tr>
<td>Coffee with cream and sugar</td>
<td>Coffee with cream</td>
<td>Coffee with cream</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and sugar</td>
<td>and sugar</td>
<td></td>
</tr>
</tbody>
</table>

#### Sample C (Negro women)

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Snack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949 1/2 lemon in warm water</td>
<td>Vanilla ice cream</td>
<td>Roast veal</td>
<td>none</td>
</tr>
<tr>
<td>Applesauce</td>
<td></td>
<td>Buttered cauliflower</td>
<td></td>
</tr>
<tr>
<td>Grape nut flakes</td>
<td></td>
<td>Cooked carrots</td>
<td></td>
</tr>
<tr>
<td>Oatmeal muffins with jelly</td>
<td></td>
<td>Cooked cabbage</td>
<td></td>
</tr>
<tr>
<td>Coffee with cream and sugar</td>
<td></td>
<td>Pineapple salad</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baked custard with sugar cookies</td>
<td></td>
</tr>
<tr>
<td>1955 Wholewheat toast</td>
<td>none</td>
<td>Ground steak</td>
<td>Roasted peanuts</td>
</tr>
<tr>
<td>with jelly</td>
<td></td>
<td>Steamed buttered squash</td>
<td></td>
</tr>
<tr>
<td>Fried pe'rh</td>
<td></td>
<td>Stuffed celery with cheese</td>
<td></td>
</tr>
<tr>
<td>Coffee with cream</td>
<td></td>
<td>Lemon pie</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vanilla ice cream</td>
<td></td>
</tr>
</tbody>
</table>
Chapter VI
POSSIBLE CULTURAL, SOCIAL AND PSYCHOLOGICAL FACTORS
OF DIETARY INTAKE

We feel that for long term, large scale studies a broad range of psycho-social factors might be helpful as predictive devices and correlates of food intake and consequently as stratification variables to improve sampling efficiency. In a long term study of food intake we are interested in which foods are eaten; in the amount of foods eaten; in the spacing and pattern of food intake; in the general environment of where food is eaten; in the speed of eating; in changes in food habits over time and the general food availability information of the subjects under study.

**Amount of Food Intake**

We will sketch out some of the psycho-social factors which we feel might be helpful in predicting to the above aspects of food intake as well as those aspects surrounding the food intake of a given subject. The amount of food eaten and food needs certainly vary with the point that an individual has reached in the life cycle and the age of the subject. There are also sex differences not only in total amount of intake but in preferences for different foods. To illustrate some of these points and other psycho-social effects on amount of food intake, we find, for example, Babcock et al. (1954) showed that men in the group studied ate relatively less of their calories in the form of milk and dairy products than men with higher income and education levels. These men ate relatively large amounts of meat and enriched bread; they had high
consumption of unenriched bread, pastries, sweetened beverages and candy bars. They also had low consumption of citrus fruits and tomatoes. Boek (1956) found that even in a study of a relatively homogeneous group of 184 farmers, there were significant differences in food intake due to age (for total calories and for calcium). There were also significant relationships of income to total caloric intake and intake of calcium. Amount of schooling in this limited group seemed to be related to calcium intake. There are also interesting differences relating differential income to amounts of nutrient intake in studies by Murray et al. (1952) and Clark and Fincher (1954). These latter two studies deal with family groups but do show income differences which could be reasonably inferred to the individual level. These two studies do not allow any distinction between the intakes of the different members of the family. Young, Streib and Greer (1954) find that with increasing education there was increasing use of milk, eggs, fruits and vegetables high in ascorbic acid, fruits and vegetables high in carotene, as well as other vegetables, legumes, and breakfast cereals. In terms of income differences the same investigators found that as the level of income rose, the percentage of men in each of the income groups using fruits, milk, vegetables, high ascorbic acid fruit, breakfast cereals, beer, sweets and alcoholic beverages increased. Income seemed to bear no relationship to usage of meat, bread, potatoes and soft drinks. There was an inverse relationship found between income and the usage of eggs. There were also differences found between men and women. The findings on milk consumption are in general agreement with other studies in that lower income and education industrial workers tend to have lower usage levels (Wiehl, 1942 and Trulson
There is some indication that occupation (activity level), leisure time patterns, health status, role in the family and climate not only affect the total caloric intake of given individuals but the distribution of the kinds and amounts of foods and nutrients ingested. Energy expenditure studies show quite clearly the influence of activity on the dietary intake. It is clear that the change in the leisure time pattern of our society with the effect of more between meal snacks, TV snacks and more non-work time has affected the amount and kind of food we eat. The exact detailed effects have not been studied as yet. [1] and [2] (1957) have pointed out some of the overall changes in diet but have not tied these to such recent social factors as have been mentioned above.

Other social and psychological factors which might influence amount of intake are role in the family, climate and temperature, amounts of food available, amount of choice of what foods are eaten, etc. Any such relations found would aid in the design of research, and since information on psycho-social variables appears easier to collect than direct food data, this should introduce efficiencies. It may be possible for investigators to predict food intake data of groups and possibly individuals from psycho-social variables rather than having to go through the detailed nutritional studies of today.

**Spacing of Food Intake**

Information relating to spacing of food intake during the day is rather minimal. Most of the literature does not consider the breakdown of intake over the 24-hour period. One study, Clark and Fincher (1954),
which does this in detail for families, clearly shows differences for the nine nutrients over the meals of the day due to income and types of foods eaten. Clear spacing of eating differences were shown related to rural-urban distinctions especially in the South as shown by Cussler and DeGive (1952). We find these kind of differences also present in the North Central Studies. The work cycle is another factor which influences the spacing of food intake as was early shown by Engel-Frisch in the National Research Council Bulletin 108 (1943). She found that the shift worker averages about three and a third meals per day. The only "normal" meal neglected by the night shift worker is breakfast. There is a substitution of snacks for regular meals among swing shifters and about 16% do not eat dinner while 11% skip breakfast. Where breakfast and dinner are eaten by the third shifter, these are in general eaten at the time of day usually associated with these meals. On the second shift each meal appears to be about three hours later than is the usual case in the daily routine.

We should expect differences in spacing patterns of dietary intake not only within our own culture but between cultures. There are differences within our culture (as distinct from residual traditions of different cultural origins) as to which meal of the day is the one at which the most food is ingested. The spacing of intake for an infant is different than that of an adolescent, an adult or an aged individual.

With the advent of more leisure time and the more sedentary activity schedule of our lives, spacing of intake is likely to change from the three meals a day pattern to a more frequent pattern of intake during the day.
Food Preferences

There are many social and psychological factors which can be enumerated as possible predictors of food preferences. Many sub-cultures within our society show the effects of ethnic origin on their eating habits. Joffe in the National Research Council Bulletin 108 (1943) points up very clear differences between ethnic groups' food preferences in summarizing work that had been done on Italians, Central Europeans, Poles, Hungarians, Czechs and American Negroes. More detailed work in the area of ethnic differences in food intake from several cultures has been done by Lee (1957). She points out the social significance of foods in terms of quite drastically different societies, many of which have formed the basis of sub-cultures in the United States. She indicates that there are foods appropriate to different occasions during the year, to different days of the week, to different hours of the day which are culturally patterned. For example, the food of Lent among Greek Orthodox and Catholic Christians is limited to fish, dairy products and vegetable foods, or only to vegetable products. The Orthodox Jew is limited to only certain kinds of meat and fish products in the meat, fish, poultry food classification. Cultural influence on an individual's food preferences is embodied in early learning and reinforced by repetition, social norms and ideology. Consequently, food habits are hard to change. Cussler and DeGive (1952) have a very interesting summary of those social, cultural and psychological factors related to food preferences and attitudes which affect the intake of the subjects they studied from three communities of the Southeast. Moser (1953) has demonstrated the usefulness of knowledge of food preferences in order to find out about frequency of foods eaten.
Foods attain prestige value and are associated to social class distinctions as well as cultural differences, although in the United States successive immigration has confounded them. One's general attitude toward food and eating is likely to be importantly affected through early child rearing practices though the data is at times not as clear on this point as on some of the earlier points mentioned (Orlansky, 1949). In a recent article by Bryan and Lowenberg (1958), the fathers' affect on the child's eating behavior was not very important, but mothers and fathers pointed out that food preferences depended on taste, odor, texture, appearance, method of preparation, ease in eating, time required to eat the food, frequency with which the food was offered, food availability, association of food with its source or event and difficulty in digesting a food.

Food acceptability studies are also helpful as the basis for expectations of intake. Pilgrim (1957) and Lewin (1942, 1943) have developed models of how food habits are formed, developed and changed. Some aspects of these models are helpful in the understanding of factors which will enable prediction of food intake. The basic model from Pilgrim (1957) is as follows:

```
Food Acceptance
  /\      /
 /  \    /  \
Perception
    /\    /\  
  /  \  /  
Sensation
       /\      /
      /  \    /  
Physiological (internal)  Food (Stimulus)  Organism (Receptor)
      /\          /\        /\      /
    /   \        /   \  /   \
Hunger  Appetite  Environment  Learning
```
Lewin (1943) has pointed out that it is the "gatekeeper", the person (or persons) in control of the food intake for the individual, with whom it is important to be concerned in studies of food habits. The factors controlled might be categorized as those pertaining to cognitive structure, i.e., those which deal with what people think and speak about foods, and those pertaining to their motivations, i.e., the system of values behind their choice of foods. Sheer availability is also under some control by the person(s) buying, preparing and serving foods. The mother may still be the main carrier of tradition unless she accepts a submissive role. This is an area requiring much research in itself.

**General Environment of Eating and Speed of Eating**

There are aspects of the general environment that condition not only what foods are eaten, but how the body will process the food. It is likely that such factors as relative stress at meal time and speed of eating tend to affect not only what is prepared and eaten but how the body uses the food ingested. There are likely to be differences in speed of eating along the dimension of rural-suburban-urban and also along the age continuum. Differences of lesser import to us for long term studies include differences in speed of eating depending on the meal of the day. More important factors conditioning the food intake environment include the number of young children in the family and the "style of life" developed by the family.

**Summary**

In summary we feel that knowledge of social, cultural, and psychological information about individuals may well aid in the assessment and pre-
diction of the amount and kind of food intake. The studies reviewed here show that short term patterns are related to cultural, social and psychological factors. Long term food patterns may well be (in a gross manner) related to broad cultural, social, and psychological factors. For example, knowledge of age, income, activity level, education, ethnicity, role in the family, and other similar factors may allow for good long term food intake pattern classification.

As the social sciences increase their understanding of social life, new variables should become available for investigation with respect to diet. Preferably, these should be considered within the system within which they originate by means of models, such as those mentioned concerning food preferences, which should be integrated with statistical models as presented in Chapter IV.
Chapter VII
PROBLEMS ARISING OUT OF COMBINED NEEDS

The complexity of some of the problems of dietary survey methodology will be reconsidered now as they are related to need for surveys, information to be sought in surveys, and the survey research process for obtaining information.

The need for dietary surveys is in the area of epidemiology. Epidemiology has been defined as "the study of disease in populations" and Stamler (1959) indicates that "its concern is not with sick individuals but with populations, patterns of disease in populations, and the factors responsible for those patterns. . . . For its part, epidemiology seeks to account for observed patterns of disease occurrence by studying the role of multiple factors that possibly may be operative; for example, income, occupation, place of residence, housing conditions, diet, physical activity, smoking, climate, mores, tensions, stresses, antecedent diseases, race, ethnic origin, heredity, and genetics. In assessing these variables, several of which may play a significant etiologic role, epidemiology seeks to determine which one, if any, is decisive in the process of causation by virtue of its relation to occupation, or habitual physical activity of work, or nutritional status. Similarly, race may be significant, not only because of inherited genetic factors but also because of associated socioeconomic conditions."

Since diet is one of many factors for investigation of disease, it is important that it be coordinated with other factors of possible importance. The twenty year study that began in Framingham, Massachusetts in 1948 is a
large population study in which diet is being considered as one of the
multiple possible causative factors in the epidemiology of arterioscle-
rotic heart disease. (Dawber et al. 1957)

The information to be sought in dietary surveys encompasses another
group of problems. In the past, much consideration has been given to
problems of dietary deficiencies. The consideration of excesses and
imbalance of nutrients has been given less consideration in dietary
survey work. It has now become necessary to consider a great variety of
possibilities in the areas of excesses and imbalances. Wiehl and Reed
(1959) pointed out this fact when they stated that "suggestions concerning
the possible association between diet and the development of arterial-
sclerosis do not relate to deficiencies of any specific nutrients, but to
possible excessive consumption of some foods or food factors, either alone
or in proportion to other foods." This increase in scope for study and
the change of emphasis in dietary surveys involves additional problems.
In learning about certain deficiency diseases, only certain foods and food
groups may be involved, while it appears at present that more nearly total
knowledge is needed to learn about excesses and imbalances of nutrients.
Nutrients, such as fats, are widespread in many kinds of foods and in most
methods of food preparation. However, there may be "key" food combinations
or predictors of other entirely different types, including likes and dis-
likes, that may be used to obtain the information needed. Possible predic-
tors of dietary intake will be discussed later.

In addition to the problems arising out of combined needs of the
dietary and related information desired and those of determining the signif-
icant information regarding eating, foods, and nutrients there are a vast
number of problems in the survey research process. Metzner has summarized
the phases, purposes, roles, techniques and results of the survey research process (Table 9). The techniques required for the process indicate the wide variety of problems that can arise from combined needs. The diversity of roles required to apply these techniques suggest other problems. Although it is possible for individuals to have the qualities and abilities that permit them to function well in particular roles, these same characteristics may make them unable to assume other roles well that are incompatible. The consideration of attributes of those from whom the information is obtained is basic to securing valid information.

The survey research process is being used in large scale, long term studies in content areas other than nutrition; for example, the Survey Research Center of the University of Michigan has been studying consumer finances for a period of 14 years (1946-1959).

Ohlson et al (1953) have used the continuous consumer panel that is maintained by agricultural economists as a source of data for food consumption study. The data were collected from families by food records. The "participating families were not aware that records supplied would be examined for the nutritional implications of their food habits."

Recognition of the many problems that arise from the many combined needs of dietary surveys point out the necessity for--clearly defined purposes for any study, a clearly defined universe for study, and well planned designs. To develop suitable methods there needs to be careful pre-testing and pilot studies. These are needed to

(1) Measure reliability, validity, and objectivity at the collecting, analyzing, and processing phases.

(2) Deal with the time dimension, including "usual diet."

(3) Determine the feasibility of using personnel of various training and ability.
(4) Deal with the possibility of developing gross categorization techniques for long term studies.

(5) Collate information of predictor and ultimate dependent variables with the dietary variables.

Making the comparisons of all types and determining the degrees of error necessarily involve proper statistical handling.
<table>
<thead>
<tr>
<th>Phases</th>
<th>Purpose</th>
<th>Roles</th>
<th>Techniques</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Planning</td>
<td>Ascertain problem Conceptualize (Transform: social problem into conceptual problem)</td>
<td>Client public</td>
<td>Social science Content science or practice</td>
<td>Design: objectives sample</td>
</tr>
<tr>
<td>B. Collecting</td>
<td>Obtain necessary information (Transform: conceptual problem to folk language)</td>
<td>Questionnaire technician</td>
<td>Social or clinical psychology</td>
<td>Questionnaire Interviews</td>
</tr>
<tr>
<td>C. Analyzing</td>
<td>Put information in form for processing and application to problem (Transform: folk language to card punches)</td>
<td>Editor Coders Coding supervisor</td>
<td>Logic Psychology Information theory</td>
<td>Code Code sheets</td>
</tr>
<tr>
<td>D. Processing</td>
<td>Application of information to problem (Transform: card punches to attributes of the conceptual problem)</td>
<td>Machine technician Statistician</td>
<td>Machine tabulation Building tables Making inferences Hypothesis testing</td>
<td>Punched cards Tables</td>
</tr>
<tr>
<td>E. Utilizing</td>
<td>Feedback to solve problem (Transform: answers to conceptual problems to solution of the problems)</td>
<td>Journalist Group discussion leader</td>
<td>Verbal communication Printing Group dynamics</td>
<td>Reports Action</td>
</tr>
</tbody>
</table>
Chapter VIII

PERSPECTIVE

The purpose of this literature review was to study the reported methods in dietary methodology with a particular focus on epidemiological requirements. We have had in mind a pattern of relationships and their interrelationships, our interest having been to determine whether or not any method of obtaining dietary histories presently described incorporates the criteria we believe essential for its use in the epidemiological study of chronic disease.

These criteria require:

1. The provision of a basis for determining the position of an individual on a scale of consumption of important foodstuffs and/or nutrients.

2. The delineation of long-term patterns, i.e., those existing over at least one year's time.

3. Applicability to studies of large populations. This implies that:

a) the methods must be such that they can be administered by trained lay interviewers;

b) the methods must permit the collection of data within reasonable time expenditures in order to minimize interviewer cost, and time demands on the respondent.

4. The validation of methods internally with respect to interviewer and respondent errors and externally with respect to alternative methods of assessment.

In reviewing the literature, we have chosen studies that document variations of methodology. We have not cited every study describing essentially the same methodology. However, we have attempted to cover the reports which:
1. Include any method that actually measures, purports to measure, or gives promise of measuring food intake or food habits over a long period—28 days or longer.

2. Include tests of reliability, validity and/or consideration of objectivity problems.

3. Include studies of methods of collecting information.

4. Include tests of memory ability for food and food quantities.

5. Include representative studies which have been done for epidemiological investigation.

6. Give particular consideration to social factors.

The review documents the fact that individual workers have made serious efforts to satisfy one or more of the criteria suggested for epidemiological studies; in fact, the total contributions in the field of dietary methodology are impressive when one considers the relatively short span of time during which interest in this area of research has evolved. However, the literature has not supplied us with a description of any methods that will fulfill all of the criteria we believe essential components of a method useful in the epidemiological study of chronic disease.

Specifically, no method is now known which provides:

1. Measures of reliability (error) on the position of an individual on a scale or scales of consumption;

2. Measures of reliability (error) on data concerning a long-term (year) period;

3. Procedures of known reliability and low cost for large populations.

Only limited rather than comprehensive studies have been made of standard errors of measurement; proportion of variance absorbed by measures covering long-term periods are unknown; and current procedures entail lengthy use of high cost personnel. It appears important to attempt to develop objective interviewing procedures that may be used by personnel of less than professional dietetic training, and to ascertain the measurement error with respect to individuals over long time periods.
APPENDIX A

Using the classifications of the aspects of validity and reliability given in Chapter I, we can categorize the information obtained in some of the studies from the literature.

Content or Representative Validity

Wait and Roberts (1932 a and b) in their early study were aware of the problem when they attempted to see if one and four days data would give comparable information. They concluded a week is to be preferred over the shorter period. Koehne (1935) was also aware of the problem in the limited study of five subjects. Her findings show that one week is sufficiently representative of the period covered for the five subjects on the same menu. Widdowson (1947) reports that in studying four children, age 16 to 18, who weighed their intake for two weeks at intervals of about one year, it is evident that in every case the second week was not very different from the first and either measurement could have been taken as a measure of the girls' intakes. This group was more representative of persons having completed growth than the children studied. Widdowson also concludes that a fair estimate of a person's intake is obtained from a study lasting for one week. Velat et al. (1951) conclude that food consumption for seven days tends to be representative of an individual's diet in a given season. In dealing with the same kind of problem, Young et al. (1952 a) after years of experience concluded that collection periods should be for seven days to get a useful picture of a given person's diet.
On the other hand, Young et al. (1952 A) in a further study in the Northeastern Regional group of studies found that the weekly average deviated considerably from the 28 day averages (approximately 50 percent of the individuals had weekly averages that varied ± 10 percent). There were considerable weekly variations in calories and in nutrients. Widdowson and McCance (1945) in a study of 34 girls found that the caloric intake findings for a 7 day period were not consistent and the question is raised again as to whether one week is typical for an individual. To further cloud the picture, Hames and Robertson (1954) concluded after a study of 136 families that a one week period does not give a reliable picture of a particular family's eating habits. Since we would expect less variation in the food eaten by a family than by individuals within it, these data point to extending the period of time to be covered.

In order to determine dietary intake over longer time periods, Strom (no date) found that a two week period represented approximately 60% of the food repertoire. Clearly the problem of representativeness of the technique is made more difficult as the time dimension is extended. It is more difficult to obtain representative information for a year than a week.

The representative validity problem has been more explored of the time dimension than of the content of the diet dimension. Can we shorten the amount of information collected at a point in time to represent a larger fund of substantive information? Do we need to know all the food that has been eaten or can we have a representative dietary measure which would be just as adequate for our purposes?
Concurrent Validity

There are several studies which may be categorized as dealing in whole or in part with what we have called concurrent validity problems. The usual consideration of this problem in the field of data collection methodology has been for the investigator to compare two methods of collection on the assumption that one is more accurate (valid) than the other. In most cases the weighed diet subjected to chemical analysis is taken as approximating actuality, with other techniques, such as a history, a record or a twenty-four hour recall, used as the other measure to be compared to the weighed diet. Thomson (1958) and Morrison et al. (1949) have both found differences between these techniques. Assuming that the weighed diet is correct, they have pointed out errors in the findings given by the other methods. In doing this, they have been trying to validate a simpler, less expensive technique with a more accepted technique applied concurrently. This kind of approach has been used by Young et al. (1952 c) and Chamberlain and Pyke (1948) as well as Carroll et al. (1952), where a less accepted technique is compared to a more accepted technique in order to determine whether there is sufficient concurrent agreement between techniques. Eppright et al. (1952) attempting to find further evidence that the dietary record in terms of estimated servings and household measures was a satisfactory means of collecting data, compared the calculated ascorbic acid content of the diet with the blood ascorbic acid concentration for their sample of 63 children and found a correlation between these two measures of \( r = .50 \).

More important tests of concurrent validity (though gross) have been made by such comparisons as the use by Epstein, Carol and Simpson (1956)
of Boothby et al.'s nomogram (1936) to compare the calculated caloric intake with the nomogram which makes allowances for age, sex, weight, and height and assumes that weight is neither lost nor gained.

In the main body of the text we mentioned the study by Reed and Burke (1954) which, though limited (n is small), is the only study we have found that has attempted to concurrently validate the method of collecting dietary information over any extended time period. We hope that future studies will provide more information indicating how well dietary methods give valid information over time.

**Predictive Validity**

The basic problem to be dealt with here is whether or not the various techniques used for collecting dietary information are sufficiently valid so that they may be able to predict factors to which dietary information should logically be related.

A simple illustration of this kind of problem deals with one aspect of the effect of seasons. One would expect that an individual's food intake would change somewhat from season to season. The problem develops as to how well data collected at one time is able to predict to a future period of the same individual's intake. Eppright et al. (1952) and Chappell (1955) have found some differences in their results related to seasonality. Young et al. (1951 a) found no significant differences in intakes of the majority of nutrients when they compared data for fall and spring in several communities. The data from these studies are only predictive validity information of a rather gross nature, since all that is shown is that the method of assessment used at one point in time can
predict to results obtained by the same or similar methods at a later point in time.

We know that amount of fat in the diet is generally correlated with total calories in the diet. If we found that in a subsequent study the amount of fat intake in the diet was correlated with the total calories in the diet, this would be some information on the validity of the fat intake measurements in the study. This kind of information reflects on the value of the method of dietary assessment. A further kind of data which tends to validate the method of dietary assessment is the type of finding reported by Boek (1956). She found that dietary intake to be related to level of living.

We have given some gross examples of how information on predictive validity can help to validate the dietary assessment method used. There are more specific possibilities of getting detailed predictive validity information especially if long term studies of dietary intake are going to be undertaken. If aspects of disease development are related to long term dietary intake, they should be predictable from reliable food intake information.

**Construct Validity**

Construct validity is not an aspect of validity which is mutually exclusive of the other types of validity discussed above. In reference to a measuring device, construct validity refers to the ability of the technique used to measure the actual variability in the concept or physical matter measured.
In attempting to develop the construct validity of measuring devices one must define the construct under investigation, e.g. total calories, animal fat or salt intake. This variable, then, becomes the postulated attribute to be reflected by the score obtained on the measuring device or by the measurement technique. There are several techniques for obtaining construct validation for a given measure of a given attribute. First, does this attribute when measured by several different techniques of measurement show agreement between the methods of measurement? — agreement, that is, besides common error or bias effects. Secondly, do measures of this attribute co-vary with measures of correlated attributes to which the construct is related theoretically?

Attempts to establish the construct validity of given concepts and their measurement can be seen in the work of Huenemann and Turner (1942), Young et al. (1952 c) and Trulson (1954). While these investigators did not think in these terms, their attempts were to find how the various techniques agreed with each other in measuring the various attributes under consideration (calories, fat, protein, riboflavin, etc.). The basic conclusion of these studies was that at the individual level of analysis, the techniques of measurement very often did not agree with each other, but that on the group level of analysis there was more agreement between methods of assessment for the nutrients measured.

The second aspect of construct validity is similar to the aspects of concurrent and predictive validity discussed above. We should expect that groups varying markedly in activity level should also vary, other things being equal, in caloric intake, so that, in this case, the
assessment of caloric intake should correlate with physical activity. If, for example, two techniques of measurement were used, an interview and a 7 day record, and average calories were computed by both techniques, one would expect that the technique which correlated most highly with a general activity level measure was the technique which showed construct validity.

A considerable number of studies fall into the above kinds of categories once these two aspects of construct validity are clearly defined. The more we are able to collate such information, the surer we will be of the techniques of measurement which we are using. It should be noted here that no long term tests of construct validity of techniques are presently available unless the minimal data from the Reed and Burke study (1954) can be used.

**Reliability**

We have defined the reliability of a measurement device as the ability of the technique to give the same results given the same situation (reproducibility). It was indicated further that only estimates of reliability of measurements are possible. Marr et al. (1959) report that in two surveys of the same persons (n = 25) six months apart, the following were the results using a seven day weighed diet:

<table>
<thead>
<tr>
<th>Bank officers, males, 40-55 years inclusive</th>
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</thead>
<tbody>
<tr>
<td><img src="https://example.com/table.png" alt="Table" /></td>
</tr>
</tbody>
</table>
These data show that for the attributes measured for this select group, the reliability estimates were on the average \( r = 0.80 \). Some of the lack of reproducibility should be attributed to the actual changes in the diets of the subjects at the different times of the year, since it is known that individual diets do change over time. The data of Trulson and McCann (1959) are clear on this point. Trulson and McCann further point out that no one technique of evaluating food intake that is practical for field conditions gives a completely reliable pattern of intake for the individual. Here, they were concerned about short term assessments. The above is more clearly the case for assessment techniques which are used for longer periods of time.

**Objectivity**

In large scale studies, it is important to have a technique which is objective, at least, to some minimum degree. The technique should minimize differences in observation, recording and scoring, and it should be communicable with a high degree of accuracy to the large number of persons who will use it to collect data and to the scientific community who may try to understand the procedures used or try to replicate the results. A further requirement of objectivity is that the technique be such that there is a minimization of variation in the conditions of its use and in the stimulus which the technique gives to the respondent.

Relatively little empirical research in this field has been reported on these kinds of problems. Work has been done on differences between interviewers by Church et al. (1954) and Taylor (1955). Some work has been done on the problem of differences in scoring techniques and results of different scorers. More work has been done on the similarity
and differences in comparative techniques of processing data. This area was recently reviewed by Whiting and Leverton (1959). In terms of processing the data, machine data processing of information would be expected to increase the objectivity of this aspect of data analysis, but it should be remembered that sufficient flexibility should be built into the programs used in order to account for regional and local differences in the food content due to such things as geographic area grown, food preparation, etc. Objectivity achieved by arbitrary uniformity of procedure may reduce validity. Objectivity becomes particularly important in those situations in which large numbers of people participate in data collection. We might conclude that selected aspects of the considerations in the area of objectivity are important considerations for the development of a technique for the assessment of dietary intake of large numbers of individuals for a long period of time.

Addendum

We have not reported or discussed the detailed nutrition survey technique used by the U. S. Army Medical Nutrition Laboratory (Consolazio, 1956) and the Interdepartmental Committee on Nutrition for National Defense (1957) for several reasons. The first reason is that it has been discussed and described in the many reports of these two groups, and further, the technique has not been compared with other methods in any studies which we could find. We also feel that this technique would be too expensive for large scale, long term use and require many more than the supply of trained personnel available. It should also be
noted that the technique must be used with populations under relatively controlled conditions; that is, populations such that all foods can be weighed and the subjects' intakes can be at least observed at all times. For these reasons we feel that this technique is not appropriate for our purposes.
Appendix B

MULTI-METHOD, MULTI-NUTRIENT EXAMPLE

As an example of the utility of the procedures of Campbell and Fiske (1959) we have applied these to some data reported in the classic work on comparison of methods by Huenemann and Turner (1942). This study reports nutrient data obtained by the dietary history method and compares this with data obtained by dietary records for 21 children. This is a very small number of individuals, but it will serve for illustrative purposes.

We have chosen to reanalyze their data using the multitrait-multi-method correlation matrix to illustrate its applicability to the problem of validity. For our purposes, nutrients correspond to traits and the several methods will be: a dietary history as method I; a food record as method II; and a second food record as method III. We are interested in convergent and discriminant validity (as defined below) of various methods in their attempt to measure the "usual" nutrient intake of individuals over a period of time. Convergent validity indicates whether separate methods which are reasonably independent from each other agree in their measurement of a given nutrient. Here we have two methods which are quite different: the history and the records as well as two diet record methods which are similar. The two similar methods, though, are used over different time periods. The variations found between the methods can be attributed to actual time differences and actual food intake differences. However, these differences need not be a function of the validity of two similar methods, but a function of the "methods co-variance" within the two methods. On the other hand, if all of the methods give about the same level of correlation between their attempts to measure the same nutrients, then we are able to develop a given amount of convergent validity from this information.
for the methods considered. A second and equally important form of validity — discriminant validity — aims at showing whether particular methods are able to discriminate sufficiently between nutrients. Following Campbell and Fiske (1959), we have developed measures of convergent and discriminant validity for our purposes.

Table 10 shows the multi-method multi-nutrient matrix as applied to the Huenemann and Turner (1942) data. We may describe the layout of the table as follows: The first twelve variables are the various nutrients as measured by the dietary history method. The second twelve variables are the various nutrients as measured by the first dietary record, and the third twelve variables are the various nutrients as measured by the second dietary record. The triangles enclosed by a solid line show the inter-correlation coefficients for the set of twelve nutrients for the same method. These triangles will be referred to as the mono-method, hetero-nutrient triangles. The triangles enclosed by a broken line show the inter-correlation coefficients between different nutrients using different methods of measurement. We shall call these triangles the hetero-nutrient, hetero-method triangles. The entries in the blocked diagonals will be called the validity entries.

In order to more easily facilitate use of this table, we will quote how Campbell and Fiske (1959, pp. 82, 83) state it should be used:

"In the first place, the entries in the validity diagonal should be significantly different from zero and sufficiently large to encourage further examination of validity. This requirement is evidence of convergent validity. Second, a validity diagonal value should be higher than the values lying in its column and row in the heterotrait-heteromethod triangles."
That is, a validity value for a variable should be higher than the correlations obtained between that variable and any other variable having neither trait nor method in common. This requirement may seem so minimal and so obvious as to not need stating, yet an inspection of the literature shows that it is frequently not met, and may not be met even when the validity coefficients are of substantial size.

"In Table II, below, all of the validity values meet this requirement. A third common-sense desideratum is that a variable correlate higher with an independent effort to measure the same trait than with measures designed to get at different traits which happen to employ the same method. For a given variable, this involves comparing its values in the validity diagonals with its values in the heterotrait-monomethod triangles. For variables A₁, B₁, and C₁, this requirement is met to some degree. For the other variables, A₂, A₃ etc., it is not met and this is probably typical of the usual case in individual differences research, as will be discussed in what follows."

Let us now see how measures in Table 10 compare using this method of analysis.

1. Evidence of convergence validity.

   a. Initially we note that in terms of convergent validity, that 28 of the 36 validity coefficients are significantly different from zero at the p .05 level or less.

   b. Of the three sets of inter-correlations, methods I and methods II inter-correlations show 10 of the 12 validity inter-correlations as significantly different from zero at the p .05 level or less. Method II and Method III show 9 of the 12 validity inter-correlations as significantly different from zero at the p .05 level or less. Method I and Method III show 9 of the 12 validity inter-correlations as significantly different from zero of the p .05 level or less.

   c. If we look at how each of the nutrients fared we find that of the three possible convergent validity coefficients only five nutrients found all three coefficients significantly different from zero.
Table 11 - A Synthetic Multitrait-Multimethod Matrix

<table>
<thead>
<tr>
<th>Traits</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A₁</td>
<td>B₁</td>
<td>C₁</td>
</tr>
<tr>
<td>A₁</td>
<td>(.89)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₁</td>
<td></td>
<td>-</td>
<td>(.89)</td>
</tr>
<tr>
<td>C₁</td>
<td></td>
<td>.38</td>
<td>.37</td>
</tr>
<tr>
<td>A₂</td>
<td></td>
<td>.57</td>
<td>-</td>
</tr>
<tr>
<td>B₂</td>
<td></td>
<td>.22</td>
<td>.57</td>
</tr>
<tr>
<td>C₂</td>
<td></td>
<td>.11</td>
<td>.17</td>
</tr>
<tr>
<td>A₃</td>
<td></td>
<td>.56</td>
<td>.22</td>
</tr>
<tr>
<td>B₃</td>
<td></td>
<td>.23</td>
<td>.58</td>
</tr>
<tr>
<td>C₃</td>
<td></td>
<td>.11</td>
<td>.11</td>
</tr>
</tbody>
</table>

Note: The validity diagonals are the three sets of italicized (underlined) values. The reliability diagonals are the three sets of values in parentheses. Each heterotrait-monomethod triangle is enclosed by a solid line. Each heterotrait-heteromethod triangle is enclosed by a broken line.

Table 12 — Convergent Validity of the Various Methods of Measurement of the Various Nutrients.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Method I with Method II</th>
<th>Method I with Method III</th>
<th>Method II with Method III</th>
<th>Total Signif. Diff. from 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>.599</td>
<td>.604</td>
<td>.699</td>
<td>3</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>.520</td>
<td>.567</td>
<td>.754</td>
<td>3</td>
</tr>
<tr>
<td>Iron</td>
<td>.410</td>
<td>.163</td>
<td>.752</td>
<td>1</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>.506</td>
<td>.524</td>
<td>.042</td>
<td>2</td>
</tr>
<tr>
<td>Thiamine</td>
<td>.571</td>
<td>.359</td>
<td>.658</td>
<td>2</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>.796</td>
<td>.660</td>
<td>.737</td>
<td>3</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>.652</td>
<td>.786</td>
<td>.267</td>
<td>2</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>.779</td>
<td>.715</td>
<td>.726</td>
<td>3</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>.588</td>
<td>.189</td>
<td>.364</td>
<td>2</td>
</tr>
<tr>
<td>Protein</td>
<td>.679</td>
<td>.526</td>
<td>.798</td>
<td>3</td>
</tr>
<tr>
<td>Fat</td>
<td>.403</td>
<td>.444</td>
<td>.825</td>
<td>2</td>
</tr>
<tr>
<td>Calories</td>
<td>.555</td>
<td>.382</td>
<td>.676</td>
<td>2</td>
</tr>
</tbody>
</table>

The nutrients are calcium, phosphorus, ascorbic acid, riboflavin and protein. The nutrient that shows the poorest convergent validity is iron. We may further note that none of the methods used for all nutrients fulfills the convergent validity requirements, Table 12.

2. Let us now turn to the assessment of the discriminant validity of the methods.

a. The initial test for discriminant validity is determining the number of correlations for each nutrient in which there are correlations which are higher between the nutrient and any other variable having neither the nutrient
nor both methods in common and the correlation of two measures of the same nutrient.

---

Table 13 — Discriminant Validity - Aspect 2a

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Method I with Method II (1)</th>
<th>Method I with Method III (2)</th>
<th>Method II with Method III (3)</th>
<th>Total for Nutrients (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Iron</td>
<td>9</td>
<td>20</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1</td>
<td>2</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Thiamine</td>
<td>5</td>
<td>15</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Protein</td>
<td>2</td>
<td>1,5</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Fat</td>
<td>11</td>
<td>14</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Calories</td>
<td>7</td>
<td>13</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Totals for Methods</td>
<td>53</td>
<td>96</td>
<td>35</td>
<td>184</td>
</tr>
</tbody>
</table>

There are 22 comparisons for each table entry except for the marginal totals.

---

Table 13 shows the comparisons between the main validity diagonal coefficients and the heterotrait heteromethod blocks coefficients for a given method or nutrient in Table 10. For example, the validity coefficient for calcium as measured by methods I and II has seven coefficients higher than it in the hetero-nutrient hetero-method blocks that do not have both of the same methods used for the coefficient obtained in the main validity diagonal. Zero entries in the table are, of course, the most desirable.
As can be seen only the ascorbic acid measures fulfill this requirement. Others that come close are measures of riboflavin and carbohydrate. One can also see that no one method of measuring all the nutrients sufficiently fulfills the requirements of this aspect of discriminant validity.

b. How these methods compare to the second discriminant validity criterion can be illustrated in Table 14.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Method I</th>
<th>Method II</th>
<th>Method III</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Iron</td>
<td>9</td>
<td>11</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Thiamine</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Protein</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Fat</td>
<td>8</td>
<td>8</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Calories</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>53</strong></td>
<td><strong>60</strong></td>
<td><strong>56</strong></td>
<td><strong>169</strong></td>
</tr>
</tbody>
</table>

This table shows that none of the methods is completely within the limits of this requirement of discriminant validity and only ascorbic acid as a nutrient fulfills the requirement as a validly discriminated nutrient. Vitamin D and carbohydrate measures also come close to fitting this requirement.
In summarizing the overall findings from this example of the application of the multi-nutrient multi-method matrix to these data reported by Huenemann and Turner (1942), we accept the fact that we are basing our information on a very limited sample of only 21 children, ages 6 to 14 years, who gave, however, highly "dependable" data to Huenemann and Turner (1942). We have found that the analysis of the data using this statistical technique shows that the methods of measurement are deficient in their ability to accomplish the rather lenient requirements of convergent and discriminant validation. In general, the three methods: the dietary history, the first two week record, and the second two week record — do not fulfill the requirements. There may be several reasons for this finding. The initial possibility is that the idea of "usual" diet is not a really meaningful concept. That is to say, there is so much variability in dietary intake from time to time that one cannot take a two week time slice and expect adequate comparative agreement between measurements at two periods of time at the individual level of analysis. There are some data at the group level of analysis to suggest that there is little significant seasonal variation in intake as reported by Young et al. (1951) and Young and Filcher (1950b). Information on six young women indicate weekly variations of such magnitude that dietary surveys extending over seven days cannot be considered to give accurate average intakes of calories or nutrients by individuals (Yudkin, 1951). Young et al. (1952a) following 18 individuals over four consecutive weekly periods state that:
On the group basis, there would not appear to be sufficient variation from week to week to warrant more than a seven-day record. However, to study the intake of an individual, it would appear that more than a one-week record would be desirable for some individuals.

If there were true variability from two week period to two week period, we might expect lower correlations in the validity diagonal of the matrix in Table 10, which would show this individual variability between the methods of measuring the same nutrients. We might further expect that the dietary history method which is supposed to represent a longer time period might not agree with the dietary records which cover a shorter time period because of the time representation differential. If this were so we would expect the more variable nutrients like Vitamin A, ascorbic acid, vitamin D or riboflavin to show low discriminant and convergent validity. Our findings, conversely, to this expectation, show that it is just those nutrients which show the most convergent and discriminant validity and it is the measurement of the macronutrients which show the poor validity results. This kind of information makes us consider whether the methods used in this careful investigation might not be in questionable validity according to the criteria described by Campbell and Fiske (1959).

In order to more carefully test the possibility that a picture of long range food intake is given by the history and the combined records, we further subjected these data to the following analysis. Under the assumption that the average data for the two records would more likely give results for a similar period as covered by the dietary history, we averaged the data for the two records, for each individual for each nutrient, and compared these averaged results with the data for these individuals from the dietary history. These two sets of results were then subjected to the Campbell and Fiske analysis design and the results are shown in Table 15. This table shows that
The data used as the basis for this matrix has been reported by Huenemann and Turner (1912).

A correlation of .433 is likely to occur by chance if the true correlation is 0 with the probability of one chance in twenty. A correlation of .509 is likely to occur by chance if the true correlation is 0 with the probability of one chance in one hundred.
the pattern of the results for this analysis are not essentially different from the results found in Table 10.

Evidence for convergent validity is summarized in Table 16.

(a) It is noted that 9 of the 12 validity coefficients are significantly different from zero at the \( p \leq 0.05 \) level or less. Most nutrients do not meet the minimal correlational agreement requirements between the two methods. This is especially true for iron, fat and calories.

(b) Evidence for discriminant validity is also a little less than encouraging for the methods used in this study. It can be seen in Table 16 that under the various minimal aspects of discriminant validity, the methods used meet the requirement only for ascorbic acid. This requirement is consistently not met by the results of the analysis for the measurement of iron, thiamine, protein, fat and calories. If the minimal requirements of discriminant validity were met, then there would be entries of zeros in the right hand side of Table 16.

In summary, both the earlier analysis (Table 10) and the present analysis (Table 16) show that the minimal requirements of convergent and discriminant validity, for the methods used, are found to be met by measurements of ascorbic acid only. The measurement techniques used for the other eleven nutrients do not fulfill the minimal requirements of convergent and discriminant validity.
Table 16 — Convergent and Discriminant Validity for Method I compared to combined Methods II and III.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Aspect (a) (Pearson r correlations)</th>
<th>Convergent Validity</th>
<th>Discriminant Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>.751</td>
<td></td>
<td>aspect (a)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>.673</td>
<td></td>
<td>aspect (b)</td>
</tr>
<tr>
<td>Iron</td>
<td>.419</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A</td>
<td>.497</td>
<td>.3</td>
<td>2</td>
</tr>
<tr>
<td>Thiamine</td>
<td>.566</td>
<td>.8</td>
<td>11</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>.757</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>.813</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>.604</td>
<td>.5</td>
<td>8</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>.573</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Protein</td>
<td>.608</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Fat</td>
<td>.398</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Calories</td>
<td>.362</td>
<td>12</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>111</td>
<td></td>
</tr>
</tbody>
</table>

N=21

Pearson r correlations of over .422 are significant at the p < .05 level.

There are 22 comparisons for each table entry except for the totals.
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Additions:
