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The National Cancer Institute's Dietary Assessment Primer: A Resource for Diet Research

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Abstract

This monograph describes the National Cancer Institute's (NCI) Dietary Assessment Primer, a web resource developed to help researchers choose the best available dietary assessment approach to achieve their research objective. All self-report instruments have error, but understanding the nature of that error can lead to better assessment, analysis, and interpretation of results. The Primer includes profiles of the major self-report dietary assessment instruments including guidance on the best uses of each instrument; discussion of validation and measurement error generally and with respect to each instrument; guidance for choosing a dietary assessment approach for different research questions; and additional resources such as a glossary, references, and overviews of specific/important issues in the field. This monograph also describes some future research needs in the field of dietary assessment.

Keywords

dietary assessment; diet instrument; 24-hour dietary recall; food record; food frequency questionnaire

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The purpose of this monograph is to introduce readers to National Cancer Institute's (NCI) Dietary Assessment Primer web resource. [1] This article explains the motivation for the Primer's development, describes its key features, and highlights major points outlined in its guidance. The focus of the Dietary Assessment Primer is on self-report dietary instruments, i.e. 24-hour recalls (24HR), food records, food frequency questionnaires (FFQ), and screeners, which continue to form the mainstay of diet assessment methods. The Primer was developed by an interdisciplinary team of researchers, composed of registered dietitians, nutritionists, epidemiologists, and biostatisticians, motivated to develop a resource to help researchers choose the best available dietary assessment approach for their particular needs. The Primer reflects their perspective on dietary assessment issues, which has evolved over 15 years of collaborative work aimed at understanding the particular errors inherent in dietary assessment and developing analytical methods to address these errors. The NCI has supported this work because of the central importance of accurate dietary assessment to cancer epidemiology, monitoring, and behavioral research. This work is relevant to non-communicable disease epidemiology and thus important to the missions of other institutes of the National Institutes of Health and to dietary researchers throughout the world.

Terms used in this paper and their short definitions are presented in Table 1.

GUIDING PRINCIPLES OF THE PRIMER

Measurement Error

The Primer incorporates the current understanding of measurement error, the difference between the measured value and the true value, in dietary assessment. The sources of measurement errors are many, for example, recall bias and interviewer bias.[2, 3] Understanding the nature of those errors is important: random error does not affect estimates of the mean, but systematic error, if not controlled for, does and leads to biased estimates of intake.[4] Thus, the extent and nature of measurement error in various dietary assessment methods should be a key consideration in choosing the most favorable instrument or approach for a given research question.

Combining Instruments

In recognition of different errors associated with various dietary assessment methods, the Primer explicitly considers the use of more than one instrument in a given study to exploit the advantages and minimize the weaknesses of each. Thus, the recommendations describe various dietary assessment approaches that may incorporate multiple instruments. For example, a common approach in large epidemiologic studies has been the administration of two instruments: a food frequency questionnaire (FFQ) to all respondents and 24HRs or food records in a subsample to both evaluate (or “validate”) and adjust (or “calibrate”) the FFQ. Calibration consists of adjusting the FFQ to be more like the recalls/records, thus presumably less biased.[5] Another example is administration of one or more 24HRs, which have less systematic bias and have richer detail, to the full sample as the main instrument in combination with an FFQ, a tool that better sheds light on foods that are consumed less frequently.

Research, Not Clinical, Applications

The Primer was developed for research purposes and not for clinical counseling. In research, data are collected from individuals, but are used only in making statements about the group. In clinical counseling, on the other hand, data are collected to characterize the individual, and dietary assessment may be just one component of a more extensive evaluation including biochemical, physical, and anthropometric measures.[6] This distinction between individual and group is a key tenet underlying the primer.

Organized by Research Objective

Because of the central importance of the research question to the choice of methods, the Primer uses the framework of particular research objectives to organize recommendations. Specific dietary assessment approaches may be more or less appropriate depending on the research question.

VALIDATION AND MEASUREMENT ERROR: IMPLICATIONS FOR CHOOSING A DIETARY ASSESSMENT APPROACH

Validity is the degree to which an instrument measures what it purports to measure. A key goal of validation research is to use an accurate reference measure or instrument that

captures true intake. For self-reported diet, there are few accurate, i.e. unbiased, reference measures. Known unbiased reference measures include data from feeding studies or direct observation and recovery biomarkers. Because of the difficulty and cost of conducting controlled feeding studies, this approach is not practical for large-scale validation studies. Direct observation is feasible mostly in institutional settings, such as schools.[7] Recovery biomarkers, a class of biomarkers that measure intake with little error, are few: doubly labeled water (DLW) for short-term energy expenditure, urinary nitrogen for protein, and urinary potassium and sodium for potassium and sodium.[8] If objective measures are not available or feasible, self-report dietary assessment instruments are often evaluated using as a reference another self-report instrument that still may have bias, but less bias than the instrument being evaluated.

Measurement error is a central consideration in dietary assessment since researchers typically rely on self-report instruments that measure diet with error. However, the nature of the error, whether it is random or systematic, is crucial.

Random error is an unpredictable source of error that contributes variability. An example of random error in dietary data is the day-to-day variability that affects data collected for one or a few days when what is eaten and drunk changes from day to day. Systematic error, also referred to as bias, is a source of error in which measurements consistently depart from the true value in the same direction.[4] An example of systematic error is consistent underreporting of certain foods, such as sweets or beverages.[9] Averaging data collected from many repeat administrations of an instrument with only random error results in a value that approximates the true value, whereas the same is not true for instruments which exhibit systematic error. In other words, an important distinction between the two types of error is that random error due to day–to-day variability can be adjusted for by using repeat measures and statistical modeling.[4] However, systematic error cannot be adjusted for without the availability of a reference measure that contains no error or only random error.

Data collected using different self-report instruments are affected to varying degrees by different types of error. This has implications for which tools are recommended for different research purposes.

MAJOR SELF-REPORT DIETARY ASSESSMENT INSTRUMENTS

The Primer focuses on dietary assessment instruments that rely on self-report. Thus, objective sources of data, such as biomarker data, or data gathered by observation of the subject's diet, are not discussed in detail. In addition, the Burke dietary history[10] method is excluded from discussion, because there is no common understanding of the definition of the instrument, and thus there is little comparability of the “instrument” across studies.[7] The Primer focuses on the food record, 24HR, FFQ, and screener. The following briefly describes each instrument, what is known about its measurement error structure and validity, and its most appropriate uses in population research.

Food Record/Diary

A food record, also known as a food diary, asks the respondent to record all foods and beverages consumed over a period of time, including thorough descriptions, preparation methods, and amounts consumed. Portion sizes are either estimated or measured, either by volume or weight. The record sometimes is reviewed with the respondent by a trained interviewer, close to its completion, in order to recover incomplete descriptions. Often several days of records are requested, and usually these are consecutive, and may include both weekdays and weekend days.[7]

Foods consumed may be recorded on a paper form, often structured to capture elements of interest, such as name or brand, description, preparation method, amount consumed, and time and place consumed. More recent technological advances in hand-held devices such as smart phones have enabled less burdensome information capture. Evaluation of these digital applications is currently underway. [11]

As with recalls, day-to-day variability in consumption can be modeled if at least two days of records are collected. Collecting records on non-consecutive days (i.e., two or more one-day records) may provide a better estimate of day-to-day variability since consumption on one day may affect consumption the following day. Controlling for this variability will correct that source of bias in resulting estimates.

Ideally, respondents record consumption as it occurs, thus minimizing dependence on memory. However, in practice, respondents may record consumption less often, and to the extent that this happens, a record may become more similar to a recall, but without structured probes.[7] Furthermore, since the record by design is done prospectively, a respondent may modify his “usual” diet,[12] potentially in a more socially desirable manner [13] or to simplify the recording task,[14] referred to as reactivity. Further, the burden of completing records can lead to lower quality data as the number of days increases.[15] These factors create systematic error, which will lead to bias in the resulting estimates.

Food record estimates of energy, protein, potassium, and sodium have been compared to estimates from recovery biomarkers. Generally, food records have underestimated energy and protein (4 to 37%)[16, 17] and sodium (10 to 20%),[18, 19] and have overestimated potassium (12 to 20%).[18, 19] In the largest study to date (n=450 women), the underestimates were 20% for energy and 4% for protein.[20] This study found that records compared favorably to 24HRs and especially FFQs for energy, protein, and protein density. Calibration equations using body mass index, age, and ethnicity substantially improved estimates for all instruments making them somewhat comparable.[20]

Food records can be used to describe dietary intake and to examine associations between diet and other variables such as health. Because of their potential reactivity, food records are not optimal for assessing usual diet. However, such reactivity potentially makes food records useful for supporting individuals’ ability to make recommended dietary changes.

24-Hour Dietary Recall (24HR)

A 24HR asks respondents to report everything they ate and drank over the past day. Traditionally, an interviewer records the responses, and when appropriate, probes the respondent for more detailed information such as brand name for processed foods, recipes for home-made foods, and preparation methods. In addition, the interviewer asks about foods and beverages and eating occasions such as snacks that may be initially omitted. Portion size of everything consumed is queried, often with the help of aids such as food models and pictures.[7]

The USDA has developed a structured interview system that consists of multiple and sequential layers of questioning---the Automated Multiple-Pass Method (AMPM).[21] Another frequently used system is the University of Minnesota's Nutrition Data System for Research (NDSR).[22] Both of these systems standardize the interviewing process so that there is consistency among interviewers in the type and amount of information collected. In addition, coding of reported foods and beverages is automated for those items in the food composition databases. Items not in the databases are coded manually.

The NCI has developed an automated self-reported 24HR instrument (ASA24) that uses a computer interface rather than an interviewer to query food and beverage consumption.[23] ASA24 is modeled on USDA's AMPM system, incorporates multiple passes, and uses USDA food composition databases for totally automated coding.

24HRs have been shown to be affected by both random and systematic error. Much of the variability in 24HRs is due to day-to-day variation, a form of random error that can be controlled by statistical procedures.[24] However, systematic error also is present. Studies that have used the DLW as a recovery biomarker for energy have found that 24HRs underestimate energy intake in a variety of Western populations in the range of 3 to 34%.[7] Larger studies, however, reported underestimates of 12 to 23%.[25] Compared to the recovery biomarker of urinary nitrogen, 24HRs have been found to underestimate protein by 11% to 28%.[7] The phenomenon of underreporting of total energy is common to all the self-report methods.[7] This error is reduced when nutrient/food intake is expressed as nutrient density, for example, protein as a percentage of calories.[17, 26] In large recovery biomarker studies, when compared to FFQs, multiple 24HRs had less bias in energy and protein estimates, although protein density was not substantially different.[25]

Even though there is bias in 24HRs, because food records potentially have reactivity bias, the 24HR is considered the least biased of the self-report instruments and thus the best single dietary assessment instrument for many purposes. 24HRs can be used to describe dietary intake; to examine associations between diet and other variables such as health; and to evaluate the effectiveness of an intervention study to change diet.

Food Frequency Questionnaire (FFQ)

An FFQ asks respondents to report their usual frequency of intake of a list of food and beverages over a particular time period, for example, last year or last month. Portion size of each item is usually asked, either as an additional question, or embedded within the frequency question itself (e.g. how many times did you have a slice of bread?).[7] The number

of individual items queried is usually 80 to 120. FFQs are usually self-administered, often from a website, but can be administered by interviewers if needed.

Because FFQs query usual diet over a long period of time, they are not affected by day-to-day variability. However, FFQs have systematic error due in part to not capturing the entire diet and the difficulty of the recall task.[7] When evaluated against recovery biomarkers, FFQs have underestimated energy (11 to 35%) and protein (up to 30%).[20, 27-29] Two of the largest recovery biomarker studies reported underestimates of energy of 35% and 28% and of protein of 31% and 9%.[20, 27] However, energy adjustment of protein negated the underestimate in the first study and led to a small overestimate in the second study.[20, 27]

FFQs can provide useful information about specific foods and food groups, particularly those that are consumed infrequently in the population. However, because of systematic error, the FFQ is not the best instrument to describe total absolute dietary intake. Energy adjustment and calibration procedures reduce this error[5, 20, 28] and are recommended whenever possible. FFQs are commonly used in large prospective epidemiologic studies because of ease of administration and low cost and in retrospective case-control studies because the FFQ is the only instrument that asks about diet retrospectively.

Screeners

Screeners are short instruments that assess particular aspects of diet rather than the total diet. Most query about behavior over a long period, such as the last year or last month. Some screeners assess aspects of general dietary practices, for example, “how often do you salt your food before tasting it?” [7] or query specific dietary practices, such as meat preparation behaviors to assess heterocyclic amine intake. Many screeners are short food frequency instruments.

Some target particular dietary factors, such as soy, and ask more detailed questions than a typical FFQ. Some screeners attempt to estimate absolute intake of particular aspects of the diet; many produce estimates of frequency or an index score. Screeners can be self-administered or interviewer-administered.

Very little research is available comparing screeners to recovery biomarkers, since screeners typically do not attempt to estimate total intakes of energy, protein, sodium, or potassium. Some screeners have been compared to concentration markers[30]. Frequency-type screeners have been compared to 24HR, with performance similar to FFQs.[31] Like FFQs, screeners are thought to have systematic error. A common use of screeners is in large cross-sectional studies when interview time or resources are limited [32, 33] to estimate the mean intake of a few dietary factors, such as fruits and vegetables.

A summary and comparison of features of these self-report instruments is found in Table 2.

GUIDANCE FOR RESEARCH QUESTIONS

The culmination of the information in the Dietary Assessment Primer is a set of recommendations for choosing the best possible dietary assessment approach for each of four common research questions. The recommendations include approaches using a single

or multiple instruments; because different instruments have differing strengths and weaknesses, sometimes their joint use can be advantageous.

A primary factor guiding the choice of approach recommended in the Primer is the particular research question to be addressed. Too frequently, researchers are guided not by the question but by what is feasible. While feasibility considerations do affect the choice, the first consideration should be to define the main research objective. Distinguishing between the main and secondary objectives is critical in choosing the optimal approach.

In the Primer, the research objectives considered are: 1) to describe dietary intake; 2) to examine an association between diet as an independent variable and a dependent variable (e.g. fat intake and cancer); 3) to examine an association between an independent variable and diet as a dependent variable (e.g., race/ethnicity and diet); and 4) to examine the effect of an intervention. The Primer provides recommendations and their rationales for each of these objectives.

Following is a brief summary of the Primer recommendations.

Describing Dietary Intake

The Primer recommends using the 24HR for describing a population's dietary intake because, based on the research to date, it is likely to be most accurate. To estimate the mean intake of a population, only a single 24HR is necessary.[24] However, to estimate the distribution of intakes (for example, the prevalence in the population of consuming a certain amount), at least two 24HRs are needed on at least a subsample of the population.[24] Food records may be useful if reactivity bias is minimal. If 24HRs are not feasible, FFQs or screeners may be used if they are calibrated to a more accurate instrument, such as a 24HR, and preferably within the same population[5].

Examining the Association between Diet as an Independent Variable and a Dependent Variable (e.g., Fat Intake and Breast Cancer)

For prospective and cross-sectional studies, the Primer recommends multiple 24HRs and an FFQ on all participants as the optimal approach. This approach combines the accuracy of the 24HR with additional information about less frequently consumed foods from the FFQ, and provides maximum information and flexibility for analyses. The data are combined using regression calibration.[34] Administration of four to six 24HRs provides greater statistical power than administration of a single 24HR.[34] While administration of both 24HR and FFQ instruments in the total sample is optimal, if this is infeasible, administration of the FFQ to the entire sample and administration of the 24HRs in a sub-study also is useful to calibrate the FFQ[5]. In retrospective studies querying diet from long ago, an FFQ is the only choice. In all study designs, a screener may be used for the frequency information, if interest is in one or a few specific components that are concentrated in a limited number of foods, and if there is not a need for energy adjustment.

Examining the Association between an Independent Variable and Diet as a Dependent Variable (e.g., Race/Ethnicity and Diet)

The Primer's recommendations for this objective are similar to those for the preceding objective. The crucial difference is the caution that differential response bias may be a significant problem. This is because the independent variable of interest is often one which is associated with other variables that affect dietary reporting error. For example, analysis of the research question of how race/ethnicity is associated with diet is complicated by the fact that race/ethnicity is related to BMI, and higher BMI is associated with greater response error.[35]

Evaluating the Effect of an Intervention on Diet

Differential response bias in intervention studies may arise due to the fact that the intervention group is exposed to the intervention and the control group is not. [36] Because of this, the Primer suggests the use of objective measures of diet such as biomarkers rather than self-reports of diet when evaluating the overall effect of an intervention. When this is not feasible or when additional dietary information is needed, the Primer recommends using 24HRs. If these are not feasible, an FFQ or a screener may be acceptable if they adequately capture the specific components of interest in the intervention. However, if FFQs or screeners are used, the Primer recommends that calibration sub-studies using a less biased instrument such as a 24HR be conducted within the study population, and ideally, within each experimental group and each time period of interest. The Primer suggests that food records not be used to evaluate the effects of interventions on diet because of their tendency toward reactivity in general that is likely to lead to participants in the intervention group reporting consumption consistent with the intervention.

FUTURE RESEARCH NEEDS

The aim of the Dietary Assessment Primer is to help researchers determine the best way to assess diet using self-report instruments in any population-based study. Analytical considerations, to the extent they have been elucidated, also are discussed. However, there are many important areas for which research is still needed.

Incorporation of Technology into Data Capture

An area of great interest is the development and incorporation of new technology into dietary assessment. This integration of computer technology already has led to standardized data collection, automated dietary analyses, and improved data management, thereby reducing costs for 24HRs collected using AMPM, NDSR, and ASA24, and for other dietary assessment tools. However, the use of integrated technology in dietary assessment does not necessarily obviate overall limitations of each dietary assessment tool presented in the Primer. Evaluation of measurement error and bias of new applications is needed.

Novel technologies applied to diet records such as contemporaneous recording of intake using the camera feature on smart phones are being evaluated[11]. It is possible that such mobile technology may better engage participants in the diet record process (although reactivity may still be problematic), and that images of foods and beverages may reduce

participant burden and improve portion size estimation.[37] Additionally, as data capture tools continue to advance and are able to collect multiple data layers such as time stamps, geospatial coding, images of foods/beverages before and after consumption, and texting/prompts related to behavioral factors, dietary intake can be integrated with other streams of data for a broader context for eating patterns. How these new capabilities affect dietary assessment is an active research area.

Expansion of Databases

Because the food supply changes so rapidly, food composition databases require continuous updating. With the increasing frequency of eating away from home---25% of energy intake in 2011-12 was from restaurants[38] ---expanding the databases to include more restaurant-provided food is needed. Data capture tools must be well-integrated with food, nutrient, and other dietary constituent databases and the necessary system infrastructure to yield meaningful datasets and variables. Construction, maintenance, and linkage among databases are ongoing needs. Although significant efforts and resources are allocated to the update and maintenance of food composition databases, other types of databases could enhance capabilities. For example, image databases either for food identification or portion size estimation,[39] branded foods data, and bar code databases, when easily linked to nutrient databases, may lead to greater specificity of consumed foods and additional data layers for analysis.

Data Analysis Development

As identified in the Primer, important gaps in the ability to analyze dietary data include the problems of reactivity and bias inherent in intervention studies and in studies in which diet is the outcome variable. Greater understanding of the extent and potential impact of differential response bias is needed, as well as whether it is possible to adequately control for such error either in study design or in later analysis.

Analytical methods are also needed to allow the combined use of data from multiple self-report instruments, such as 24HR and FFQs. Although the Primer focuses on self-report, the use of recovery and other types of biomarkers in combination with self-report to reduce error [40] is an active area of inquiry. While analyses of dietary data have most frequently considered a single dietary variable (e.g., fat), or included a second dietary variable (e.g., energy), there is growing recognition of the need for a more holistic framing of diet. The area of dietary patterns---how to assess and analyze---is an evolving area of research.[41]

As the scope of dietary assessment expands, with technology enabling the collection of additional layers of contextual detail about eating occasions, data analysis strategies will need to adapt to allow modeling of this complexity. These layers of detail may include, for example, timing, location, and other contextual dimensions of the eating occasions. In addition, data about time-varying dietary patterns incorporating a life course approach that consider critical windows as well as cumulative exposures could be incorporated. Currently, time-varying models are being explored to address the complexity of multiple points of dietary data capture across time.[42] A parallel need is to model the multiple levels within the

food stream that ultimately shape what people eat and drink, from the food supply through various food outlets to the individual.

Although dietary data are collected about individuals, the Primer focuses currently on the use of such information for conducting research on groups, not individuals. However, clinicians and others involved in counseling individuals need information about the usual intake of individuals; more research is needed to develop appropriate analytic methods.

Integrated Life Course Data Collection and Analysis

The capability of new technologies to capture intake data at multiple points over time, with multiple layers of data as described above, could be integrated within studies that also incorporate multiple collections of biological samples for analysis of nutritional biomarkers, metabolomics or the microbiome. More research is needed to develop and adapt "big data" analytic methods. [43] The ideal scenario for the study of associations between dietary factors and numerous health and disease outcomes would be a life course study from fetal development to later life, and collection of multiple exposures. It is now time to consider the data capture capabilities, data composition infrastructure, and analytic techniques that would be required for such studies.

CONCLUSION

The goal of the Dietary Assessment Primer is to help researchers choose the best available instruments for their research purposes and thus to advance understanding of dietary intakes among populations and relationships between diet and health. The Primer is an evolving resource; it will be updated as more is understood.

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Table 1

Glossary

Term	Definition
Accuracy	The degree of closeness of measurements of a quantity to that quantity's true value.
Associations	A dependent relationship between two or more variables. The relationship does not establish causality.
Automated self-administered 24-hour recall (ASA24)	A freely available web-based tool developed by the National Cancer Institute (NCI) that enables multiple automated self-administered 24-hour dietary recalls.
Bias (also known as systematic error)	A source of measurement error in which measurements consistently depart from the true value in the same direction; affects the sample mean as well as percentiles and can result in incorrect estimates and conclusions.
Biomarkers	A measurable substance in an organism whose presence is indicative of some phenomenon such as disease, infection, or environmental exposure (such as diet).
Body mass index (BMI)	A measure of relative weight, calculated as mass (kg)/height $(m)^2$. Standards for defining underweight, normal weight, overweight, and obesity are often defined in terms of BMI cut-points.
Calibration	The process of using equations to re-scale data obtained from a more biased, less accurate instrument based on information obtained from a less biased, more accurate instrument.
Calibration study	A study that collects data from a less biased, more accurate instrument to calibrate a more biased, less accurate instrument. These studies can be conducted using data from a subset of participants within a study or from an external study.
Case-control study (also known as a retrospective study)	A study that compares two groups of people: those with the disease or condition under study (cases) and a very similar group of people who do not have the disease or condition (controls).
Combining instruments	The analytical strategy of using information from two or more dietary assessment instruments to estimate intake.
Cross-sectional studies	A study that includes measurements on a group of individuals at a single interval in time.
Day-to-day variation	Fluctuations that occur in dietary intake from one day to the next.
Dependent variable	The response or outcome variable that is hypothesized to be affected by the independent or exposure variable.
Differential response bias (also known as differential error)	Reporting error that is different in nature or magnitude between two groups.
Doubly labeled water (DLW)	Water with identifiable isotopes of the hydrogen (2H) and oxygen (18O) that can be used as a recovery biomarker for measuring energy expenditure. DLW is assumed to be equal to energy intake in weight-stable individuals.
Energy adjustment	Adjustment of nutrient and food group intake for total energy intake.
Exposure	The explanatory variable; also referred to as the independent variable in a regression model, it is often a behavior such as diet.
Food frequency questionnaire (FFQ)	A dietary assessment instrument that asks respondents to report their usual frequency of consumption of each food in a list of foods over a specific period of time.
Food records	A dietary assessment instrument in which a respondent records the types and amounts of all foods and beverages consumed over one or more days; also called a food diary.
Independent variable	The exposure or other variable that is hypothesized to effect the dependent or outcome variable.
Intervention study	A study in which the researcher tests the effectiveness of a condition with a defined timing, dose or intensity assigned to an experimental group in comparison to the control group (i.e., the group that is not assigned the condition). For example, in dietary research, the condition can be a supplement or a program to affect dietary behaviors or intakes.
Main dietary assessment instrument	The primary dietary assessment instrument used in a study, sometimes referred to as the study instrument; may be calibrated or validated using a reference instrument.
Mean	An indicator of central tendency, derived as the average of a set of values (the sum of the values divided by the number of values in the set).
Measurement error	The difference between the observed or measured value and the true value.

Term	Definition
Nutrient density	Nutrient intake divided by total energy intake (in kilocalories), often expressed either as a percentage or as amounts per 1,000 kilocalories.
Observational study	A type of study in which individuals are observed and variables of interest are measured. No attempt is made to affect the outcome.
Outcome	The target variable; also referred to as the dependent variable in a regression model; often a health outcome, such as the occurrence of a specific disease.
Prospective study	A study that assesses exposures of interest for a group of individuals at baseline, follows them over time, and compares them for a particular outcome.
Random error	A type of measurement error that contributes variability (reduces precision) but does not influence the sample mean or median.
Reactivity	A change in behavior due to awareness that behavior is being or will be measured. If attempting to measure typical diet, reactivity may bias results.
Recovery biomarker	A type of biomarker that is directly related to intake and not subject to homeostasis or substantial inter-individual differences in metabolism; for example, doubly labeled water for energy intake and urinary nitrogen for protein intake.
Reference instrument	An instrument that is administered in a sub-study and is used to calibrate or validate the main dietary instrument. The reference instrument is assumed to provide estimates that are closer to truth than the main instrument.
Regression calibration	A statistical method for correcting estimated regression coefficients for bias due to measurement error in one or more continuous covariates. It is used to adjust relative risk estimates for measurement error in studies of the association of diet and health outcomes.
Response bias	A deviation from an accurate report that is related to a variety of factors that affect an individual as they respond to a verbal or written question.
Screener	In dietary assessment, an instrument that asks a limited number of questions in order to estimate intake of one or a few food components.
Self-reported	Intake as reported by the individual who actually consumed the dietary component; can be measured using various dietary assessment instruments or approaches.
Statistical power	The probability that a test correctly rejects the null hypothesis when the alternative hypothesis is true.
True intake	Actual intake, which usually cannot be measured among free-living individuals.
Twenty-four-hour dietary recall (24HR)	A dietary instrument that asks the respondent to remember and report all foods and beverages consumed in the preceding 24 hours or during the preceding day.
Unbiased instrument	An instrument that collects data containing no error or only random error.
Underreporting	A type of misreporting in which an individual reports less than their true intake.
Usual intake	Long-term average daily intake.
Validity	The degree to which a tool measures what it claims to measure.

Adapted from National Institutes of Health NCI. Dietary Assessment Primer. http://dietassessmentprimer.cancer.gov/.

Table 2

Comparison of Dietary Assessment Instruments

		24-Hour Recall (24HR)	Food Record (FR)	Food Frequency Questionnaire (FFQ)	Screener (SCR)
Study Design	Cross-sectional	X	X	X	X
	Retrospective			X	X
	Prospective	X	X	X	X
	Intervention	X		X	X
Scope of Interest	Total Diet	X	X	X	
	One or a few components			X	X
Captures contextual details regarding food preparation, timing of meals, location of meals, etc.	Yes	X	X		
	No			X	X
Time frame of interest	Short term	X	X		
	Long term			X	X
Can be used to query diet in distant past	Yes			X	X
	No	X	X		
Allows cross-cultural comparisons	Yes	X	X		
	No			X	X
Major type of measurement error	Random	X	X		
	Systematic			X	X
Potential for reactivity	High		X		
	Low	X		X	X
Time required to complete	<15 minutes				X
	>20 minutes	X	X	X	
Memory requirements	Specific	X			
	Generic			X	X
	Does not rely on memory		X		
Cognitive difficulty	High			X	X
	Low	X	X		

Reprinted from National Institutes of Health NCI. Dietary Assessment Primer. http://dietassessmentprimer.cancer.gov/.