

2.3

Dietary assessment

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Key points

- A wide variety of methods are available for measuring dietary intake.
- Methods for estimating dietary intake in individuals can be retrospective measures, e.g. 24-hour recalls, diet histories or food frequency questionnaires, or current measures, e.g. weighed or estimated food records.
- The differences between methods and the impact of measurement error need to be considered when intending to use dietary methods.
- It is essential to understand the advantages and limitations of dietary assessment methods both for use in clinical practice and when reading and interpreting the scientific literature.

Dietary assessment methods are used for a variety of purposes from individual assessments in clinical situations, through to use in epidemiology. In epidemiology they are used to estimate intakes of populations and establish associations between nutrition and disease. They are also used as a basis for developing dietary guidelines and health policy, for monitoring change in intervention studies and for monitoring the effectiveness of public health interventions. Dietary assessments are traditionally used to estimate intakes of foods and nutrients, but more recent interest has arisen in estimating intake of bioactive phytochemicals, e.g. flavonoids, additives and contaminants. Ideally, assessment methods should have a low burden on respondents and investigators, and be rapid and cheap, but also result in accurate, precise data with minimal measurement error.

There are a number of dietary assessment methods for measuring food consumption at the national, household and individual level. This chapter focuses on assessment methods suitable for individual intakes. At the national level, food balance sheets can be used to assess dietary intakes. Household level methods include the food account method, inventory method, household record method and list recall methods, and further information on these methods can be found in Gibson (2005).

Table 2.3.1 describes the advantages and limitations of the main types of dietary assessment methods used for individuals. Although many methods are available for estimating dietary intake in individuals, they can mainly be divided into two types; retrospective measures of intake, such as 24-hour recalls (24 HR), diet history or food frequency questionnaires (FFQs), or current measures of

intake, such as weighed or estimated food records. Qualitative information is available from all methods, but quantitative estimates for nutrient consumption are possible only if data for weighed or estimated portion weights are available.

Weighed records, estimated food records, 24 HR and dietary histories are the most intensive methods. The quantity of food consumed may be weighed directly or estimated using household measures such as cups and spoons, photographs, standard units or average portions (Food Standards Agency, 2001; Nelson *et al.*, 1997). Data for portion sizes should be derived from weighed intakes, government surveys and research groups in populations similar to the one to be studied. Food models/replicas (three dimensional models representing foods) can also be used, particularly in clinical practice.

More recently, methods are being developed that utilise photographs of portion size recorded with mobile phone or digital camera technology (Penn *et al.*, 2010). For all methods the amount consumed can be measured or described either including or excluding wastage material usually discarded during food preparation, e.g., outer leaves and peel from vegetables or bones from cuts of meat. A number of newer methods for recording food intake are being developed involving online methods.

Number of days of recording

The number of days of report required for adequate measures of nutrients using 24 HRs, weighed or estimated records varies depending on the day to day variability of nutrient consumption (Nelson *et al.*, 1989;

Table 2.3.1 Characteristics of dietary assessment methods

Method	Advantages	Limitations
Retrospective methods		
24-hour recall (24 HR) (single or multiple days)	Not reliant on long term memory; interview length 20–45 minutes	Single 24 HRs can be used for group assessments but not for estimating intake of individuals
Diet history	Respondent literacy not required	Report of past intake is influenced by current diet; trained interviewers required
Food frequency questionnaire (FFQ) (if portion estimates included, termed semiquantitative FFQ)	Useful for large sample sizes; relatively straightforward to complete	Need to be developed for specific population group to ensure important food items are covered and requires updating to accommodate changes to supply of foods; responses governed by cognitive, numeric, and literacy abilities of respondents, also by length and complexity of the food list Not easy to develop for clinical practice since specific computer programs need to be developed
Short frequency questionnaires	Targeted to specific food types, administration simpler and easier than long questionnaires	Need to be developed for specific population group to ensure questions are relevant
Current methods		
Weighed food record (weighed inventory technique)	No requirement for memory retrieval as it records current intake; food intake weighed so estimates of quantity consumed not required	Literate, cooperative respondents required as burden is high; possible that respondents change usual eating patterns to simplify the record; high data entry costs
Food record with estimated weights	No requirement for memory retrieval as it records current intake	Literate, cooperative respondents required as burden is high; possible that respondents change usual eating patterns to simplify the record
Duplicate analysis	Greater accuracy	Very labour intensive; requires laboratory to do food composition analysis
Records using electronic equipment, e.g. mobile phones, digital cameras	Visual records of foods Avoids need for paper records Data can be sent to investigators electronically	Currently involves labour intensive programs to convert to usable data, i.e. quantities and types of foods, although systems are in development to deal with this limited use in older people who experience difficulties with using newer technology

Mennen *et al.*, 2002; Lanigan *et al.*, 2004). The number of days is partly dependent on the variation in nutrient concentration in foodstuffs. The concentration of macronutrients such as protein and carbohydrate in foods varies less than that of micronutrients such as vitamin C or iron. The number of days required to classify adult individuals into the correct third of the percentage distribution for usual intake for 80% of individuals has been calculated (Nelson *et al.*, 1989; Mennen *et al.*, 2002). Up to 7 days of recall are required for energy, protein, sugars and calcium. Nutrients with greater variability, including alcohol, vitamin C, riboflavin, and iron, require between 4 and 14 days of records. Fewer days of data collection are required to capture habitual diet in children (Lanigan *et al.*, 2004). More recent estimates of the number of days to estimate energy intake (using the doubly labelled water technique) suggest that 3 days of record are optimal of which 1 day should be a weekend day (Ma *et al.*, 2009).

Dietary assessment methods

24-hour recalls

Twenty-four-hour recalls determine intake during the preceding 24 hours and can be recorded on paper or using

interactive computerised software (Slimani *et al.*, 1999). Day to day variability in nutrient intake is large and a single day will not categorise individuals correctly within a distribution of intake. Particular issues are the capture of episodic (infrequently eaten) foods such as fish and liver; therefore, single 24 HRs are better used for group assessments than estimates for individuals. However, multiple 24 HRs can be used to overcome this problem. Newer methods of online recording of 24 HRs are under development. The 24 HR method is useful for assessment in clinical situations, but the difficulty with assessment and accurately reporting intake due to the variation in nutrient concentration of foodstuffs needs consideration. This will affect the number of days required to obtain adequate measures of nutrient intakes.

Diet history

The diet history consists either of an interview administered 24 HR or establishing usual eating pattern over a 1-week period, followed by a frequency questionnaire to provide additional information. The dietary history provides a representative pattern of usual intake and is interview administered only. Diet histories are traditionally

used in clinical practice and may take up to 1.5 hours to complete.

Food frequency questionnaires

Food frequency questionnaires (FFQs) consist of a list of specific foods or food types associated with frequency of consumption to record average consumption over the previous month or year. They are termed semiquantitative if portions are included. Food frequency questionnaires are thought to provide estimates of habitual intake and are widely used in nutritional epidemiology (Welch *et al.*, 2005; Cade *et al.* 2004). They need to be specific to a population group to ensure coverage of important foods and the population must be literate and numerate, as some mathematical ability is necessary to calculate relative frequencies (Smith, 1993). Factors influencing response to FFQs are the length and complexity of the food list and current diet (Smith, 1993). For clinical use it is necessary to develop specific software and databases to obtain nutrients and therefore record methods are likely to be preferable (Welch *et al.*, 2005).

Short frequency questionnaires

Short frequency questionnaires have been developed to estimate intakes of specific foods or nutrients and can be useful in clinical practice to determine where eating habits require change; examples are the Dietary Instrument for Nutrition Education (DINE) and the 5 A DAY Community Evaluation Tool (FACET) questionnaires (Roe *et al.*, 1994; Ashfield-Watt *et al.*, 2007; Welch *et al.*, 2006).

Weighed food record inventory and estimated food record

For weighed food records (WRs) all food and drink consumed over a period is weighed and recorded on forms or in booklets, with details of food type and method of preparation, to obtain consumption over a period of days. Portable scales need to be supplied. Leftover food should be weighed and deducted. The recommended time period for records is 4–7 days or more, although the number of days depends on the nutrient of interest, study population and objectives of the study. As some populations have different eating habits at weekends, weekend days should be included proportionately. For estimated food records all foods consumed over a period of days are recorded with details of food type, method of preparation and estimated portion sizes. If recorded over 7 days, this is often called a 7-day diary.

Both these methods have a high respondent burden and need cooperative, literate respondents. Respondents require training in the level of detail needed to describe foods. It is also possible that respondents may change usual eating patterns to simplify the process of the record and may also find this method tedious. It is also beneficial to include a review of weighed records during the period of recording either after the first day or at the end.

Duplicate sample technique

Duplicate samples of all foods consumed are made and the nutrient content analysed chemically. This method is used for metabolic studies and, though providing greater accuracy than other methods, its use is only feasible for certain purposes. Studies are conducted in hospital metabolic units or research centres; they are expensive, time consuming and require considerable technical support.

Use of methods in clinical practice versus research

Dietary methodology for clinical practice requires rapid assessments of nutritional intake in order to prescribe dietary change or to improve nutritional status. Traditionally, 24 HRs of usual intake or diet histories have been used for this purpose. Food frequency questionnaires and weighed or estimated food records are not generally used due to the more intensive burden on respondents and on the resources required for coding and processing the data. For research purposes a number of methods may be used from FFQs to multiple 24 HRs. When designing a study, it is advisable to obtain expert advice to decide on the optimum method.

Recall of remote diet – current intake biases recall of past diet

When designing studies or reading the literature, dietitians need to be aware that recall of diet in the remote past is heavily influenced by current dietary habit. Studies have found that the correlations between recalled past diet and current diet are higher than the correlations between actual past diet and recall of past diet (Willett, 1998). The onset of diseases such as cancer may affect appetite and dietary assessment, as recall of remote diet is strongly related to current diet. Therefore, studies where diet was measured prior to the onset of disease are less likely to suffer from bias than, for instance, case-control studies in which the diet of cases with disease is compared with controls.

Use of data and conversion of reported intake to nutrients and food types

Qualitative data

Dietary method data can be used qualitatively, e.g. during the process of reviewing nutritional intake for the purpose of dietary treatment, as in clinical practice. However, the majority of uses of dietary methods are targeted towards quantitative analyses.

Quantitative data

Food composition databases, data entry and nutrient calculation systems

The data collected by dietary methods are converted into food and nutrient consumption by calculating the amount

of food eaten and linking this to a database with values for the nutrient composition of foods. The governments of many countries provide the databases of nutrient composition of foods. The UK National Nutrient Database consists of *McCance and Widdowson's The Composition of Foods* (2002) and its supplements. It is essential to read the information distributed with the printed or electronic versions of databases to determine the uses and limitations of the data (see Chapter 2.4).

Nutrient databases vary in the coverage and comprehensiveness of the foods and nutrients, and in the conversion factors used for certain nutrients. Care should be taken when comparing values from different sets of food tables because the definition and expression of nutrients may not always be the same. Different conversion factors may have been used to prepare the values, e.g. to calculate protein from nitrogen or to convert the major nutrients to energy. The same nutrient may be quoted in different ways, e.g. carbohydrate may be expressed as monosaccharide equivalents, actual weights or by difference. In the UK food tables, carbohydrate is expressed as monosaccharide equivalents but for food labelling purposes carbohydrate should be provided as actual weight.

The nutrient values provided in food tables are generally averages of representative samples of foods or selected values from literature surveys. However, like any other biological material, the composition of food can vary considerably and so the values in food tables are only representative of the true biological range of values and should not be considered as having the accuracy of atomic weights. Values in nutrient composition databases are expressed as either per 100g of food or per common household measure. Most up to date information in the UK, European, US and international nutrient databases can be found at the Food Standards Agency (FSA) (www.food.gov.uk), European Food Information Resource Network (EuroFIR) (www.eurofir.org), USA Department of Agriculture <http://ndb.nal.usda.gov> and the Food and Agriculture Organization of the United Nations (www.fao.org/infoods).

Several steps are involved in calculating nutrient intake (also known as coding or processing). The first is to choose the item in the database that corresponds most closely with the food consumed. If the food consumed is not in the database, a suitable alternative can be chosen by considering food type, general characteristics and likely nutrient profile. Once the food has been chosen, the nutrient composition of the food quoted in the database is multiplied by the amount of food eaten. To calculate daily intake for an individual, the contribution of each food is calculated and all the foods for a day summated. If more than one day's data have been collected, it is usual to calculate the average for the number of days recorded. Although it is possible to compute intake by hand, using a calculator and a printed copy of a nutrient database, this is very labour intensive and in practice, has been superseded by computerisation for most purposes. A number of computerised data entry systems and nutrient calculation programs exist to calculate nutrient intakes (Welch *et al.*, 2001). Prior to purchasing a new

entry system, it is important to know on which version or food composition database it is based.

Dietitians should be aware that the UK food tables are not adequate for estimating salt intake because the nutrient intakes for recipe or composite dishes do not include salt and therefore calculations are systematic underestimates.

Estimated food quantities

To obtain quantitative information for nutrients or food groups, actual or estimated food weights are used. For methods using estimated food weights, values also need to be found for the foods described, such as standard units, average portions or household measures. Sources of data are national publications, surveys of weighed dietary assessments, and food manufacturers. Data may also be included in nutrient calculation programs.

Additional sources of nutrients

Proprietary medicines may contain sources of nutrients, and vitamin and mineral supplements can contain considerable amounts of nutrients. Therefore, they should be taken into account when assessing total nutrient intakes (Lentjes *et al.*, 2010). Current estimates of prevalence of supplement intakes are around 40% in the UK population aged over 40 years (Lentjes *et al.*, 2010).

Measurement error

Measurement error can be defined as the difference between the measured exposure (or measure of dietary assessment) and the true exposure; it is now known that there is measurement error associated with using dietary methods. Measurement error reduces the likelihood that true values have been measured with accuracy and in nutritional epidemiology, associations between dietary intake and disease outcomes will be affected (Schatzkin & Kipnis, 2004). As the proportion of measurement error increases, the scale of the relationship relating diet to disease status will tend towards no relationship. Overall the effect of measurement error would be to misclassify an individual within a range of intake.

The existence of measurement error also impacts on the interpretation of the scientific literature. For instance, it is known that FFQs tend to produce systematically greater estimates of fruit and vegetable intake and of vitamin C intake than record methods such as 7-day diaries (Dehghan *et al.*, 2007). As a result, fruit and vegetable intake for individuals and populations will be overestimated using an FFQ; more individuals measured with this method will appear to have sufficient intakes than if a record method had been used.

The technique of validation can be used to estimate measurement error. Although full detail of the impact, scale and detection of measurement error is beyond the scope of this chapter, an awareness of the differences between dietary methods and the potential pitfalls when using them is helpful to clinicians in interpreting the scientific literature.

2.3 Dietary assessment

Methods of detecting measurement error

There are four major methods of detecting measurement error:

1. *Comparison with other diet methods*, but this is not advisable since individuals report in the same way with all methods and the errors are correlated (Black & Cole, 2001; Kipnis *et al.*, 2003).
2. *Predictor reference methods*, such as the Goldberg equations, or percentile cut points to detect energy misreporting and potentially statistical model the effects of misreporting (Stubbs, 2002).
3. *Biomarkers* (biological markers) in blood or urine, quantitative recovery biomarkers (quantitative estimates of intake over a specific time period) and concentration biomarkers (measure relative concentrations over a distribution) are thought to be independent of errors when measuring intake (Potischman & Freudenheim, 2003). Examples of quantitative markers are urine nitrogen excretion over 24 hours (to estimate protein intake) and energy expenditure measured using the doubly labelled water technique (DLW). Examples of concentration markers are plasma concentrations of n-3 polyunsaturated fatty acids and fish consumption (Welch *et al.*, 2006).
4. *Comparison with disease risk biomarkers*, e.g. saturated fat and low density lipoprotein (LDL) cholesterol (Bingham *et al.*, 2008).

Examples of validation studies are those performed within EPIC Europe and the Observing Protein and Energy Nutrition Study (OPEN) in the US (Kipnis *et al.*, 2003; Slimani *et al.*, 2003).

Although biomarkers are useful in the detection of measurement error, it should be noted that a number of factors influence their interaction with nutrition, e.g. differences in gender or genetics and homeostatic or behavioural influences. Not all associations are linear, e.g. vitamin C concentrations in the blood plateau since additional concentrations are excreted, and smoking impacts on circulating concentrations of vitamin C.

Sources of measurement error in dietary assessment

Sources of measurement error when using dietary assessment are many. They may occur both during data collection and processing. Systematic bias, interviewer bias, recall bias and social desirability bias have been identified, but there are likely to be other sources of error. Bias can be defined as the modification of a method of measurement by a factor that influences the measurement in one or more directions. Measurement error associated with dietary methods may consist of one or more types of error.

Systematic bias is a systematic mismeasurement of data and can occur, for instance, if an interviewer consistently fails to use questions to probe for consumption of snacks and additional foods. If systematic bias is identified, it can be overcome by interviewer training and monitoring interviewers.

The behaviour of interviewers can influence the response of interviewees or clients and introduce interviewer bias. It is important to develop rapport between interviewers and respondents and for questions to be asked in an open ended, neutral manner without value judgements.

Social desirability bias can influence dietary assessment methods as respondents strive to report what they think is required, not what was actually consumed, e.g. reporting less alcohol consumption or greater consumption of foods with perceived health benefits, such as fish, fruit or vegetables. This is likely to be the cause of misreporting, under reporting or low energy reporting, which occurs in certain respondents and can affect clinical practice.

Conclusion

A wide variety of methods for measuring dietary intake exist and it is essential to understand their advantages and limitations, both for use in clinical practice and when reading and interpreting the scientific literature.

Further reading

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Internet resources

- EuroFIR Project website with information on European food composition databases www.eurofir.net
- FAO – INFOODS information for nutrient database compilers and suppliers www.fao.org
- USA Department of Agriculture (USDA) National Nutrient Database for Standard Reference Release 24 www.ars.usda.gov/Services/docs.htm?docid=8964

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