MAKING MEASUREMENTS OF FOOD AND ALCOHOL INTAKE

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ABSTRACT

The stages in the planning, execution and analysis of studies involving dietary assessment are identified and discussed. Appendices provide additional information on methods, food composition tables and equipment required for dietary studies.

KEY WORDS: Dietary surveys, dietary methods, dietary analysis, food, alcohol.

INTRODUCTION

This guide on how to measure food and beverage intake is set out as far as possible in the sequence in which questions need to be answered and decisions made in planning a study which calls for dietary assessment. However, since it is helpful at the outset to have a clear idea of all the areas which need to be considered we have also summarised the process as a flow-chart diagram in Figure 1.

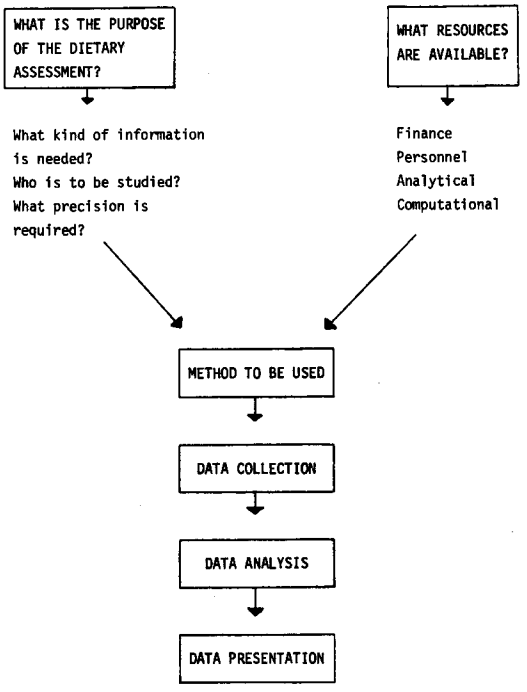

Figure 1: Planning a dietary study.

Two basic questions are:

1. What is the purpose of the dietary measurements to be made i.e., how is the information to be used and what questions do they seek to answer? Clear answers to these questions will indicate the data needed (total diet which includes alcohol intake, specific foods or nutrients), whose diet is to be measured (volunteers, a representative sample, which age, sex or occupational group), and how much data is required (sample size and days of information)?
2. What resources are available? These include finance, trained personnel and the means for handling the dietary data i.e., food composition tables or analytical facilities as well as coding and computational resources.

Having answered these two basic questions it is then possible to decide how to collect the dietary data, and then plan the data collection, analysis and presentation phases of the project.

The assessment of dietary intake usually involves *not* measurement of a *single* variable but the measurement of a number of variables with different characteristics. Thus using exactly the same approach to measure all the components of a diet, be they foods or nutrients, may not be appropriate.

Often although data collection is well planned, analysis and presentation of the data are not. This leads to inadequate use of the data collected and could even mean that the study objective is not achieved.

DECIDING ON A METHOD

The three most common uses of dietary data illustrate the principles of choosing an appropriate method of dietary assessment for most situations. Before discussing the choice of method we review the ways in which dietary data may be obtained.

National Dietary Data

In Australia, dietary data at the national and household levels, to monitor trends in food availability and consumption patterns, are generally collected by government departments rather than individual research workers. Before using such data individual research workers should read two helpful critical reviews, of the Australian data by English (1981) and Cashel (1981) in Volume 3 of these Transactions.

Individual Dietary Data

These are collected in two ways:

1. records of concurrent food intake;
2. recalls of past food intake.

Variations of these two approaches arise in the following ways:

1. who records the data;
2. which method is used to record the data;
3. which method is used to quantitate the data;
4. the interval over which the data are collected.

Table 1(a) illustrates the most common variations used in recording methods and Table 1(b) provides similar data for recall methods.

TABLE 1(a)

PRINCIPAL VARIATIONS IN METHODS WHICH RELY ON RECORDING

1. WHO records data	— subject; — relative or other care provider; trained observer.
2. HOW is data recorded	— written; — tape-recorded; — photographed; — duplicate food collection.
3. QUANTITY description of data	— weight; — volume (household measures/models); — standard serves; — frequency.
4. TIME for which data is recorded	— 24 hours; — 3–4 days; — 7 days

TABLE 1(b)

PRINCIPAL VARIATIONS IN METHODS WHICH RELY ON RECALL

1. WHO recalls data	— subject; — relative or other care provider.
2. HOW is data recalled	— mailed proforma; — telephone interview; — interview outside the home; — home interview.
3. FORMAT of recall	— 'open' e.g. recall of all food and drink consumed; — 'closed' e.g. food list of questionnaire.
4. QUANTITY description of data	— standard serves; — household measures; — frequency.
5. TIME period of recall	— previous day or 24 hours; — 'usual' diet at present or at some specific time in the past.

(i) RECORDS

The principal ADVANTAGES of recording concurrent food intake are:

1. The amounts of food can be measured directly either by weight or volume and it is not necessary to rely on subjects' estimates of portion size which can be one of the greatest sources of error in dietary studies (Young et al., 1952).
2. It is not necessary to rely on the subjects' ability to remember the types of foods consumed.
3. Records when used as food 'diaries' to record food intake in menu form only, i.e. without quantities, can provide accurate information on food habits or on the frequency of consumption of specific food items over extended periods of time (Rutishauser et al., 1979).

The principal DISADVANTAGES are:

1. Records make much greater demands on the subjects and therefore generally have lower response rates (35–75%) than recall methods (45–95%) (Marr, 1971). To date, modern technology (digital scales, tape-recorders and auto-focus cameras) has been little used to simplify and speed up recording but may increase response rates in future.
2. Recording of food intake can lead to changes in the subjects' dietary pattern. Thus although records may accurately measure what is actually eaten this may not reflect the subjects' usual intakes.
3. Recording can usually be used for no longer than seven days at a time.
4. Records require regular supervision by the investigator(s) and therefore are costly in trained personnel and time, usually requiring home visits.

(ii) RECALLS

The principal ADVANTAGES of recalls are:

1. The demands on subjects are less than with records with higher response rates.
2. The method itself cannot influence dietary intake as may occur with concurrent records.
3. Data collection in recall methods is less costly both in trained personnel and time than with records.
4. By questionnaire and interview it is possible to obtain information on the 'usual' longer term intake of subjects.
5. Using recall techniques information can be obtained on diet at various times in the past.

The principal DISADVANTAGES are:

1. Food portion size is difficult to estimate.
2. With 24-hour recalls, under-estimation is more frequent than over-estimation whereas with extended (dietary histories) of usual intake over-estimation is more common when the data is compared with records (Bazzarre and Myers, 1979). Very little is known about the ability of individuals to recall accurately diets eaten in the distant past (Byers et al., 1983; Van Leeuwen et al., 1983).

All methods of assessing individual dietary intake are time consuming and without previous experience it is not easy when planning a survey to make a realistic estimate of the number of persons/days which can be studied in a given period of time. Black (1982) has summarised the logistic aspects of dietary surveys and provided detailed information on the time requirements of dietary studies from the planning through to the data analysis stage.

USES OF DIETARY DATA

Comparison of two or more groups

This is usually done to establish whether there are significant differences in either nutrient or food intake, between the groups. The most important considerations in such a study are:

1. The individuals selected for study are representative.
2. The dietary data obtained are comparable for the groups. This means that in practice it is less important which dietary method is used than that the same method is used for all the groups. But if, for example, dietary differences preclude the use of the same questionnaire or if relatively little is known about the dietary pattern of the groups being studied, then an 'open' recall approach rather than a 'closed' questionnaire approach may be more appropriate.

   Alternatively if the groups differ in age, sex, occupational or socio-economic status the method of choice will be the method which is likely to elicit the most comparable responses from all groups. This will usually be the method which makes fewest demands on the subjects, that is the 24-hour recall. Campbell and Dodds (1967) have reported that this method may not be appropriate for direct use with elderly people with failing memory. However, as with young children, the respondent does not need to be the subject but can be the person responsible for his or her care.
3. The amount of information obtained should be adequate to detect with the desired level of confidence specified differences in mean intake, between the groups, for the dietary variables of interest. To ensure this it is necessary to have some preliminary information on both the inter- and intra- individual variation of the dietary parameters in question since both influence the confidence limits of the mean. Beaton et al.

(1979) have used the following formula to calculate the 95% confidence limits, expressed as the percentage deviation (D) of the mean for a group of subjects (g) from the true, but unknown, mean for the population.

$$D = 2\sqrt{\frac{(CV_1)^2}{g} + \frac{(CV_0)^2}{gn}}$$

Where CV_1 is the coefficient of inter-individual variation, CV_0 is the coefficient of intra-individual (residual or day-to-day) variation and n is the number of independent days information for each subject. D can be reduced both by increasing sample size (g) or the number of days information for each subject (n). This is particularly important in the design of large surveys where cost considerations play a major role. Whether it is more cost-effective to increase sample size or the number of observations will depend on the relative cost of recruiting a subject (CR) and the cost of conducting and analysing a single day's information for the subject (CI). For a fixed total cost the most effective number of repeated interviews (n) is given by:

$$n = R\sqrt{\frac{CR}{CI}}$$

Where R represents the ratio of the intra- to inter-individual coefficients of variation. Table 2 indicates that values of R for most nutrient variables fall between 1 and 2.2 but may be as high as 5.0. Thus in most cases, that is for values of R 2.2, if the cost of interviewing is at least five times the cost of recruiting, it is more cost-effective to use a single interview and to increase the reliability of the mean by increasing sample size.

TABLE 2

RATIOS OF INTRA- TO INTER-INDIVIDUAL VARIATION CALCULATED FROM DATA FOR 14 AUSTRALIAN FEMALES STUDIED OVER 14 DAYS, COMPARED WITH SIMILAR DATA FROM BEATON ET AL. (1979 TO 1983)

Nutrient	*Group (age in years)*	
	Australian (19–21)	*Canadian (25–44)*
Energy MJ/day	1.9	1.2
Protein g	2.2	1.2
Fat g	2.2	1.3
Carbohydrate g	1.7	1.2
Calcium mg	1.2	1.0
Iron mg	2.1	1.6
Vitamin A (total) µg	3.5	4.9
Thiamin mg	1.7	2.1
Riboflavin mg	2.3	1.5
Cholesterol mg	—	2.0

TABLE 3

NINETY-FIVE PERCENT CONFIDENCE LIMITS OF SAMPLE MEAN EXPRESSED AS PERCENTAGE DEVIATION FROM POPULATION MEAN DERIVED FROM SINGLE 1-DAY OBSERVATIONS IN INDIVIDUALS

Nutrient	*Sample size*					
	5	15	25	50	100	200
	Percentage deviation					
Energy	±32	±18	±14	±10	±7	±5
Cholesterol	±53	±31	±24	±17	±12	±8

Source: Beaton et al., 1979.

Table 3 illustrates data from Beaton et al. (1979) of the effect of sample size on the 95% confidence limits of the mean for energy and cholesterol intake. Clearly, for the same level of confidence, sample size is directly proportional to the magnitude of the coefficient of variation of the nutrient variable.

Evaluation of nutrient adequacy

Since the nutrient requirements of different age and sex groups vary it is often necessary to express the intake of a group or an individual relative to some reference level of intake e.g. the Dietary Allowances for

Australia. For example if it is desired to compare the adequacy of the nutrient intake of two groups of different age and sex structure this cannot be appropriately done by simply comparing the actual mean intakes of both groups. It requires that each mean value be expressed as a proportion or percentage of the calculated average requirement for each group.

Collection of dietary information for comparison of group mean values in this way is subject to the same considerations as already discussed above. However, if it is also desired to estimate the *proportion of individuals* in the group with intakes at different levels of the reference value, i.e. in different categories of 'risk', then the following additional considerations also apply:

1. From the previous discussion it is already clear that there is considerable day-to-day variation in the nutrient intake of individuals and consequently that the precision of the estimate of an individual's usual intake, obtained from a single days observation, is low. Thus if single one-day records or recalls of diet are used to describe the proportion of the population which falls above or below specified intake levels there will be gross overestimation of the proportion of individuals regarded as being 'at risk'. For this purpose it is necessary to obtain a more valid estimate of 'usual' intake than can be obtained from a single one-day observation. This may be done either by repeated one-day observations at suitable intervals or by using the diet history or a quantitative food frequency questionnaire.
2. If repeated one-day observations are chosen to measure 'usual' intake of different nutrients more days observations will be required for some nutrients than for others.

   Table 4 from James et al. (1980) shows the number of days required to classify 80% of the population studied, into their appropriate tertiles, with 95% confidence for different nutrients. Categorising individuals according to Vitamin A intake requires many more days information than categorising them for sucrose intake.

TABLE 4

NUMBER OF DAYS REQUIRED TO CLASSIFY 80% OF THE POPULATION INTO THEIR APPROPRIATE TERTILES WITH 95% CONFIDENCE

Nutrient	*Men*	*Women*
Energy	5	4
Fat	9	6
Protein	5	5
Carbohydrate	3	2
Sucrose	2	3
Fibre	10	5
Vitamin A	46	64
Vitamin C	6	6
Thiamin	6	9
Riboflavin	10	12
Sodium	11	7
Calcium	4	4
Iron	12	19
Nutrient/MJ energy		
Fat	18	7
Protein	10	11
Carbohydrate	7	5
Fibre	11	4
Vitamin C	14	3
Sucrose	3	3

Source: James et al., 1980.

Correlation between dietary and physiological variables

Epidemiological studies are frequently concerned with detecting and describing relationships between dietary and physiological variables by means of correlation and regression analysis. In such studies large intra-individual variation in the data for the independent variable under consideration e.g., dietary variable, may mask correlations or bias towards zero the estimate of regression slopes. In either case there is the possibility of erroneous conclusions that biologically important relationships do not exist. Beaton et al. (1979) have described how knowledge of the ratio of intra- to inter-individual variation for both variables can be used to improve estimates of both regression slopes and correlation coefficients. However, steps can also be taken to reduce the intra-individual variation for the variables in question in the design of the study.

1. Is the object to investigate short or long term relationships? In short term relationships intra-individual variation in nutrient intake is less important but it is still necessary to determine the optimum period of

data collection in each case. For example, when urinary nitrogen excretion is used as a measure of dietary nitrogen intake, in individuals, it is important to remember it lags behind intake. Better correlation is achieved between input and output over three-day rather than one-day observation periods.

2. For longer term relationships information on 'usual' intake for the nutrient(s) in question is essential to reduce the effect of intra-individual variation.

Validity and reliability of dietary methods

The problems of assessing the validity and reliability of dietary methods have been reviewed in detail by Marr (1971) and Block (1982). Standardised terminology would reduce confusion as stressed in a recent report of the European Community Concerted Action Project on Nutrition (Hautvast and Klaver, 1982).

To date most reliability and validity studies of dietary assessment have concentrated on comparison of one dietary intake method with another. Emphasis needs also to be given to the use of independent markers for different dietary components. Biological markers such as urinary nitrogen for protein intake, provide one possibility but will be applicable only to a limited number of dietary components. An alternative approach may be to combine a number of simple indicators of food habits and practices. For example a score based on a number of practices which reflect important contributions to total fat intake such as the frequency of use of fried foods, the addition of separated fats to foods and the treatment of visible fats on meat might be used as an alternative independent measure of total fat intake. In this paper we point to ways in which error in dietary studies can be reduced, so improving both validity and reliability.

IMPROVING DATA COLLECTION

Records

Records impose considerable demands on the subjects, and demands reduce co-operation rates. So it is always worthwhile looking for ways of lessening the demands and improving rapport with subjects. This can be achieved in several ways.

1. Alter the study schedules wherever possible to suit the subjects.
2. Provide concise, simple and unambiguous instructions for data recording and designing record sheets for easy use not only by the investigators but also by the subjects.
3. Provide easy-to-use scales (digital if possible) with automatic taring facility or household measures as appropriate. For protein intake, Todd et al. (1983) reported smaller coefficients of inter-individual variation, from weighed records than from records in household measures in the same individuals.
4. Utilise other aspects of modern technology such as miniature tape-recorders and auto-focus cameras to simplify recording.
5. Provide regular support and feedback of information to participants.

Recalls

In recall studies good rapport with the subject is also crucial in maintaining data quality but other considerations are also important.

1. For studies involving diet histories a skilled interviewer is essential not only for careful dietary questioning, but also for identifying subjects who cannot provide the necessary data, and managing the interview in such a way that the subject's interest is maintained throughout. In studies where more than one interviewer is involved check that differences in interview technique are minimised by interviewer training and follow-up testing.
2. The type of aid used to assist the subjects in providing quantitative data e.g., household measures, food models or photographs, also influences the variance in the data and therefore their reliability. In our experience (Rutishauser, 1982) food models and photographs are associated with smaller coefficients of inter-individual variation than are household measures.
3. Questionnaires need to be pre-tested. This should be done not only with colleagues but also with individuals from the group to be studied. Questionnaires need to be tested not only for comprehension but also for completion time. All unnecessary questions should be excluded. If the questionnaire is still tedious, it may then be better to sub-divide it so that it can be completed in parts.
4. Quantitative estimates in self-administered dietary questionnaires are limited to information in terms of 'standard' serving sizes. Baghurst and Baghurst (1981) using such a questionnaire have reported excellent agreement for protein intake, both at the group and individual level, with multiple urinary nitrogen determinations. However, Jain et al. (1982) who attached scaled black and white photographs of vegetables, steak and chicken to their questionnaire, found that the good agreement between questionnaire and interview data for protein did not extend to the other nutrients they studied. Allowing the subject to provide a drawing of the usual portion size, at least for the more commonly eaten foods, might be helpful in improving quantitative data in self-administered questionnaires but appears not to have been tried.

IMPROVING DATA ANALYSIS

In most dietary studies, nutrient information is derived from standard tables of food composition and not by direct chemical analysis of the food eaten. Conversion of food intake to nutrient data thus requires not only careful checking of the raw data but also coding for nutrient analysis.

1. Scrutiny of the raw data for errors, omissions and ambiguities must be done by someone who is thoroughly familiar with dietary information. It should be carried out as soon as possible after collection of the data so that any necessary additional information can be sought without delay.
2. Before coding the data for nutrient analysis it is necessary to decide which table of food composition is to be used. This choice is governed to some extent by the nutrients which are of particular interest. For example, the Australian Commonwealth Department of Health publication, 'Metric Tables of Composition of Australian Foods' (Thomas and Corden, 1977) does not contain information about the dietary fibre, zinc or pyridoxine content of foods while this information is available in British (Paul and Southgate, 1978) and American (USDA, 1976) tables of food composition.

   Does it matter which table is used? The literature indicates that the best agreement between calculated and analysed values is obtained when the food composition table is composed largely of analytical data from local foods (Pekkarinen, 1977; Marr, 1971). In this context it is important to note that the existing Australian tables (Thomas and Corden, 1977) are largely derived from data obtained outside Australia. A comparison of the nutrient content of Australian, British and American tables of food composition (Bagu and Rutishauser, 1984) found better agreement at the group level between Australian and British tables than between Australian and American tables for those nutrients which could be compared.
3. Appropriate coding of food items, that is choosing a food item in the composition table to match the item recorded, can only be done if the foods have been adequately described. It is necessary to determine the required level of description for the study at the planning stage. For example, in a study which involves assessment of the fibre content of the diet, fibre containing foods require more detailed description than other foods e.g. variety, brand name (if applicable), method of preparation and parts eaten. Allowance may need to be made in some cases for the addition of vitamins and minerals to foods. In Australia such additions are governed by legislation and the relevant information is usually indicated on the packaging. Losses of nutrients as a result of preparation, preservation, storage and cooking are very variable and can only be allowed for in general terms in tables of food composition, but cannot be allowed for at all if not adequately recorded in the food intake data.

   It often happens that a given food item is not listed in the food composition table being used. What can be done in this case? If ingredient information is available it is highly likely that an item of similar composition can be found in the table and used instead. In making such a substitution of a comparable water content is very important.

IMPROVING DATA PRESENTATION

This aspect of dietary studies often receives little attention in the planning stage. Most frequently the data are reported only as means and standard errors for the intake of relevant nutrients.

1. Information on the foods from which the nutrients come is rarely provided. It is difficult to present data on foods, rather than nutrients, in a concise and informative way, but methods are available for doing so (Margetts et al., 1981; Schwerin et al., 1981 and 1982) and others need to be developed. Figure 2 illustrates one way which might be used to describe the pattern of food use in a community in a simple yet informative way.

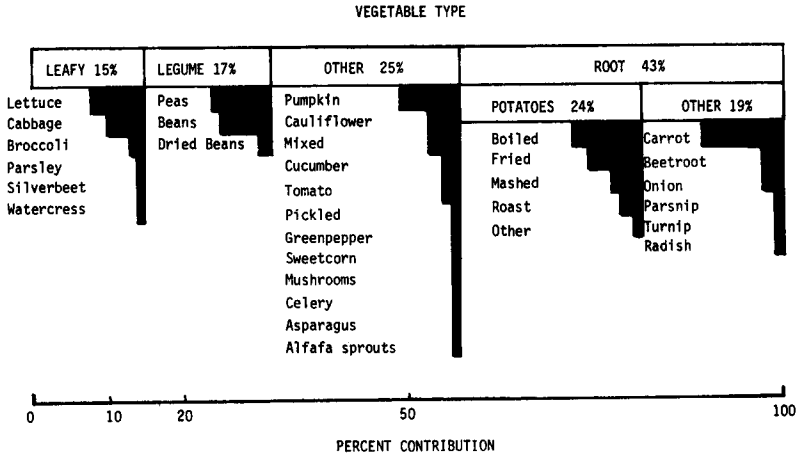

Figure 2: Contribution of different vegetables to vegetable consumption in an urban population of 300 adult Australians.

2. Useful information is provided if nutrient intake data are presented as a distribution (Darke et al., 1980). Not all nutrients have a normal distribution of intake (Figure 3) and this needs to be known if the data are to be interpreted appropriately.

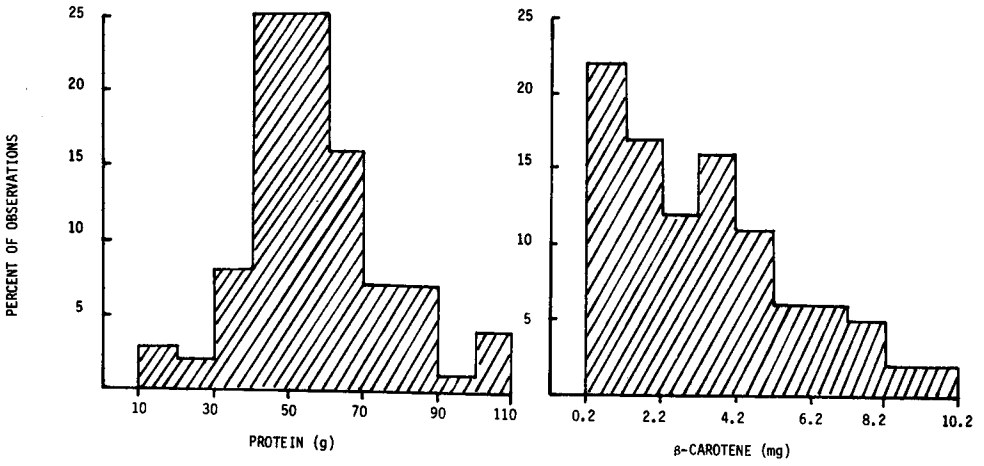

Figure 3: Distribution of protein and B-carotene intake from 195 days observations in Australian university students.

3. When diets of groups with differing energy intakes are compared, e.g. dieters v non-dieters, it is usually desirable to standardise for the level of energy intake by presenting nutrient data per unit of energy intake. This procedure also enables comparison of the nutrient concentration of the diet (nutrient density) across different age and sex groups in childhood.
4. It is often important not merely to identify differences in nutrient intake but also to identify differences in nutrient sources. For example in the case of iron the source and the conditions under which it is consumed may be more important than the amount. Similar considerations apply in the case of other nutrients which occur in different forms of varying bioavailability.

ALCOHOL INTAKE

The general approach to the assessment of alcohol intake is similar to that for food and other beverages, but there are particular problems. These relate to under-reporting for reasons such as:

(a) subject's concern about moral or medical judgment;

(b) circumstances of consumption which may lead to less awareness of intake (e.g. eating out);

(c) episodic nature of consumption;

(d) effect of alcohol on memory;

(e) subjects under legal drinking age (18 years).

Over-reporting probably occurs less commonly, but may arise through a design to impress.

AIMS OF STUDY

These must be clear and will influence the choice of method to assess intake. They might include:

(a) relationship of risk of disease or social problem to alcohol intake;

(b) time trends in alcohol consumption;

(c) patterns of alcohol consumption in or between communities;

(d) effects of intervention programmes on alcohol abuse.

Some studies may be entirely descriptive rather than designed to test an hypothesis.

QUESTIONS ABOUT ALCOHOL INTAKE

The first question to resolve is whether community, group or individual intakes are required.

In some cases qualitative data may be satisfactory obviating the need for quantitative methods.

In other circumstances ethanol itself might not be exclusively the component of the alcoholic beverage of interest, so that data may need to be expressed as quantities of the beverage rather than of ethanol. The contribution to energy of the complete beverage or of the ethanol may also be relevant. Finally the pattern or the social context of consumption may be important.

These kinds of information could be classified as:

(a) type of alcoholic beverage, its alcohol content and other composition;

(b) duration, frequency and pattern of consumption. Pattern could include seasonal variation, day of week, with or without food;

(c) social context (alone, in hotels);

(d) quantity;

(Armstrong, McMichael and Leeder, 1978).

METHODS

There is no 'gold standard' against which alcohol intake can be assessed. It is an area where corroborative evidence or more than one method to cross-check is desirable.

RECORDS

These are sometimes applied to alcohol consumption as part of an overall food and beverage record. They suffer the same limitations.

HISTORY AND QUESTIONNAIRES

In a personalised medical history, diplomatic probing and cross-checking is possible, but standardisation and reproducibility of the method arises through combination with some kind of questionnaire. The way in which enquiry develops through the questionnaire can be critical in determining the quality of data obtained. Examples can be found in papers by Baghurst and McMichael (1978), Kamien (1978), Krupinski (1978), McCall et al. (1978), Millwood and McKay (1978) and Roe (1979).

INDICES OF DRINKING BEHAVIOUR

To take into account quantity, volume, frequency and variability in alcohol intake, various indices have been developed. Those summarised in a review by Baghurst (1978) are:

(a) QF (quantity-frequency) index;

(b) QFV (quantity-frequency-variability) index;

(c) VV (volume-variability) index;(d)

AQP (absolute alcohol:quantity pattern) index.

These indices set boundaries for different categories which require definition, make certain assumptions and possibly obscure data. Sobell et al. (1982) have compared a time-line (TL) method, in which the exact volume of each beverage type for each day is reported, with the QF method. The TL method resulted in a greater number of reported drinking days, mean g of absolute ethanol consumed per drinking day, low ethanol consumption days, heavy ethanol consumption days and excessive ethanol consumption days.

CROSS-CHECKING ALCOHOL INTAKE

To check the validity of intake data the investigator may:

(a) ascertain money spent on alcoholic beverages;

(b) ascertain work performance and nature of any absenteeism;

(c) consider relevant personal and socio-cultural information e.g., appropriateness of drinking behaviour to culture, such as wine at meals for an Italian/Australian;

(d) check with friends and relatives (ethically difficult and requires subject's permission);

(e) laboratory investigations:
   (i) blood ethanol;
   (ii) mean corpuscular volume (MCV). One study indicates that this increases 1.7 fl per 10g ethanol daily (Whitehead et al., 1978);
   (iii) liver function tests. Both gamma-glutamyl transpeptidase (GGT) and aspartate transaminase relate to increasing alcohol consumption;
   (iv) urate also relates to increasing alcohol consumption;
   (v) serum triglycerides. In the report of Whitehead et al. (1978), the highest category of alcohol intake four or more drinks each day) did not have a significantly higher serum triglyceride concentration than the lowest category (0–1 drinks per day), but for each category of drinking the triglyceride level was actually higher than the lower category, considering the four categories in all. Moreover, the recognition of hypertriglyceridaemia has been found to be a useful way of identifying alcohol abusers in an industrial setting (Stewart, 1982).

   A combination of laboratory investigations increases their predictive power for alcohol intake. One of the more useful combinations appears to be that of MCV and GGT.

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