

## Review Article

# Quantitative food frequency questionnaire and assessment of dietary intake

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### ABSTRACT

India is a land of varied foods and food habits. This makes the task of collecting dietary and nutrient intake data difficult. Methods need to be devised to improve the accuracy in reporting intakes by various population subgroups. There is an urgent need to develop a questionnaire that is simple enough to be administered on a large sample and whose validity and reproducibility has been quantified. Regional differences in food habits and availability will have to be taken into account in the questionnaire design. Packaging of food items with definite portion sizes is not a common practice in Indian markets and labels on food products are neither very informative nor descriptive.

Epidemiologists addressing the effects of diet have generally used questionnaires that enquire about the frequency of specified foods consumed and sometimes also attempt to quantify usual portion sizes. A number of investigators have conveyed, apparently independently, that the food frequency questionnaire (FFQ) as a method of dietary assessment is best suited for most epidemiological applications. A food frequency list can form the basis for nutrition education and allows the dietician and the patient to relate individual eating patterns to specific foods. Other advantages of the FFQ are that it is independent of the ability or inclination of an individual to maintain a diary and also provides immediate feedback to patients, physicians and counsellors.

Natl Med J India 1998;11:268-75

### INTRODUCTION

Accurate assessment of the diet of any population is important for policy-making and planning of health promotion and disease prevention activities. This information is critical for monitoring the dietary and nutritional status of the general population and subgroups at nutritional risk. The selection and correct use of dietary methods to measure intake and the appropriate interpretation of dietary data are central to the assessment of the population's dietary intake. Also, to investigate relationships between nutrient or food intake and disease, a description of dietary intake over time is needed.

Increasing recognition of the potential importance of diet in the aetiology of various diseases such as coronary heart disease

and cancer has brought up the need for methods to measure individual dietary intake. These methods need to be simple enough to be used in large epidemiological studies and their reproducibility and accuracy quantified.<sup>1</sup> Collection of nutrient data by methods requiring weighing and laboratory analysis is impractical. Dietary history, recall and recording of food intake have, therefore, been used most frequently.<sup>2</sup> The diet history method quantitatively measures the usual dietary intake of an individual over a specified period of time. Assessment of food intake by recall, frequency, or diet-diary is part of the diet history. Generally, information regarding the socio-economic environment, medical history and details of dietary practices is included. In retrospective studies of diet and disease, in which the past rather than the current diet is of greater interest for its role in the causation of disease, a diet history has been the preferred instrument for dietary assessment and has been used in numerous studies.<sup>3-7</sup> Several modifications and brief versions of this method have been developed which are suitable for estimating a limited number of specific nutrients or foods of interest. A detailed diet history is considered more appropriate for a complete profile of an individual's diet.<sup>8-10</sup> The cost and time required for the latter, however, becomes a limiting factor in its selection.<sup>11</sup>

### DIET RECORDS

The diet record is generally used for collecting individual dietary data.<sup>12-14</sup> This written record of all foods and beverages consumed by the respondent is related to nutrient intake. Because dietary recording is performed by the respondent, this method can only be used by literate persons. Also, it is inappropriate when symptoms or treatment of a condition affect the diet. Moreover, the act of recording may increase awareness to the point of altering the respondent's eating behaviour.<sup>15</sup> In dietary intervention programmes, however, this heightened awareness can be used to advantage.

Diet records are frequently used as a teaching device. The shortest time required for the diet record to have validity is covering 7 consecutive days or 20 consecutive meals.<sup>16-18</sup> If this is impractical, 3 days is the minimum time required to get a correct picture of food intake.<sup>19</sup> However, the number of days of recording of diet largely depends on both the degree of accuracy desired and the variability of intake of the nutrient in question. For example, for dietary fat assessment 3-4 days will provide a fair estimate, but for antioxidant vitamin intake a longer time period will be required.

### DIET RECALL INTERVIEW

In this method, food consumption over a specific period of time is recalled in as much detail as possible. The recall period may

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vary from one day to weeks, although longer time would result in less accuracy of recall. Unlike diet recordings where the individual records the diet himself, 24-hour recalls are collected via a structured interview. The 24-hour recall pioneered by McHenry,<sup>20</sup> Kruse *et al.*<sup>21</sup> and Burke<sup>22</sup> is the most widely used method for dietary assessment. The Health and Nutrition Examination Surveys (HANES),<sup>23,24</sup> Nationwide Food Consumption Surveys (NFCS)<sup>25</sup> and other large studies, such as the Multiple Risk Factor Intervention Trial (MRFIT),<sup>26</sup> have used it as the primary dietary assessment method, either alone or in combination with other methods. This method is attractive as it is rapid, requiring only 10–20 minutes for trained interviewers. The success of 24-hour recall depends on the memory, cooperation, and communication ability of the subject and the skill of the interviewer.

The most important limitation of this method is the highly variable daily dietary intake. Any given 24-hour period is usually not typical or representative of long term intake and may misrepresent the actual intake of an individual.<sup>27,28</sup> When thousands of subjects are involved, as in large epidemiological studies, this method is considered to be indicative of the dietary pattern characteristic to the group.<sup>27</sup> Multiple 24-hour recalls can provide good estimates of individual dietary intake but require ample time and effort from the interviewer as well as the respondent.

#### QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

Epidemiologists addressing the effects of diet have generally used questionnaires that enquire about the frequency of specified foods consumed and sometimes also attempt to quantify usual portion sizes. This approach is attractive because the data are simple to collect and process, and in theory represent intake over an extended period, which is the usual period of interest for chronic diseases.<sup>29</sup> Burke<sup>22</sup> developed a dietary history interview that included 24-hour recall, 3-day food record and a checklist of foods consumed over the preceding month. This checklist was the forerunner of the more structured dietary questionnaires in use today. During the 1950s, Stefanik and Trulson,<sup>30</sup> Heady,<sup>31</sup> Wiehl and Reed,<sup>32</sup> and Marr<sup>33</sup> developed food frequency questionnaires (FFQ) and evaluated their role in dietary assessment.

Interest in the FFQ waned during the early 1970s but has increased recently. Many investigators have used the FFQ for dietary assessment and have found it best suited for most epidemiological applications. During recent years, substantial refinement, modification, and evaluation of these questionnaires have occurred, so that data derived from them are more interpretable. Frequency data have been used in several studies investigating possible associations between diet and health and in nutritional programmes to search for individuals likely to require more detailed dietary investigation.<sup>2</sup> An FFQ allows patients to report their customary intake of selected nutrients. This tool is more reflective of long term intake. A food frequency list can form the basis for nutrition education, allowing the dietician and the patient to relate individual eating patterns to specific foods or food groupings. The other advantages of an FFQ are that it is independent of the subject's ability or inclination to maintain a diary and provides immediate feedback to patients, physicians and counsellors.<sup>34</sup>

#### Designing of FFQs

Food frequency questionnaires are an attractive method for rapid estimation of the usual dietary intake over a long period. However, accurate quantitative questionnaires are difficult to develop and verify.<sup>35–40</sup> Some FFQs have been designed for categorizing

diets according to macro-nutrient<sup>41</sup> or energy intake.<sup>36</sup> Others have been developed to assess the dietary intake of cholesterol<sup>37</sup> or for predicting serum lipid values.<sup>42</sup> FFQs consist of the following components:

**Food list.** Before designing an FFQ, it is essential to first define its purpose and then the nutrients of interest. The FFQ includes an extensive list of foods that are commonly consumed by respondents and those that contain appreciable amounts of nutrients of interest. Here again, when deciding how many foods are 'sufficient' for an FFQ, it is important to consider the purpose of dietary assessment. If the purpose is to generate a point estimate of the actual level of intake of a number of foods or nutrients, then the list of foods included in the questionnaire will need to be extensive. If, as in epidemiological studies, the researcher's need is simply to represent variance among study subjects with regard to intake of a nutrient, the required number of foods will be considerably smaller. A pilot test is helpful in eliminating infrequently used items. It is better not to eliminate a food item that significantly contributes to the intake of any selected nutrient even if it is consumed infrequently or in small amounts.

**Portion size.** Whether or not to collect data on portion size has been debated for long. Several options exist. The first is to collect no information on portion size (a simple frequency questionnaire). The second is to specify a portion size as part of the question on frequency, for example, to ask how often a glass of milk is consumed rather than only how often milk is consumed (a semi-quantitative FFQ). Food items available in natural units (e.g. a slice of bread, one egg, one fruit) add clarity to the question. However, this is less clear for foods that do not come in typical units (e.g. rice, meat). Here it is possible to specify a typical portion, e.g. a half cup of rice or 100 g of meat. This can be done with the assistance of a trained dietician. The third alternative is to include an additional item for each food to describe the usual portion size. A realistic food model or a simple shape as a unit of reference may be used. The respondents may be asked to describe their usual portion as a multiple of the specified portion.

Samet *et al.*<sup>43</sup> and Pickle *et al.*<sup>44</sup> compared the variation in frequency of intake of food items with variation in portion sizes among the same individuals and found that frequency of use varies more than portion sizes over a period of time. Hunter *et al.*<sup>45</sup> on the other hand, compared variation in portion sizes in one individual over time with variation in portion sizes in persons of similar age and sex, and found that portion sizes varied considerably more within a person over time than within individuals of similar age and sex. Samet *et al.*<sup>43</sup> considered frequency data to be much more important than portion size data while Hunter *et al.*<sup>45</sup> felt that portion size is an inherently complex concept and often reported imprecisely.

**Frequency method.** The other component of the FFQ is the frequency response section, in which subjects report how often each food was eaten. For most epidemiological purposes, dietary intake over a number of years is the exposure of conceptual interest. Because diets tend to be reasonably correlated from year to year, Willett *et al.*<sup>29</sup> and most others asked subjects to describe their frequency of using foods in reference to the preceding year. This provides a full cycle of seasons so that, in theory, the responses should be independent of the time of the year. For other purposes, the time-frame could be in reference to a period of 5 years previously (such as in a case-control study of colon cancer), the first 2 months of pregnancy (in a study of congenital malformations), or the preceding month (in a study of plasma HDL-cholesterol).

Response formats to frequency questions may appear to be a simple issue; however, there can be serious pitfalls. Many investigators have provided a multiple choice response format, with the number of options usually ranging from five to ten. Five choices are likely to be too few and will result in serious loss of information if the same options are used for all food questions. Broadening the response categories to reduce their number would decrease the discrimination capacity of questions. There may be many possible responses ranging from never to 6 or more times a day. For example, in a study carried out to assess the dietary calcium intake of premenopausal women<sup>46</sup> three options were offered for the number of servings—daily, weekly and monthly. In another study, eight categories were used—none in the past year, 1–11 times last year, about 1–3 times a month, about 1–2 times a week, about 3–4 times a week, about 5–6 times a week, once a day, and more than once a day.<sup>47</sup> Another approach is to use an open-ended format and provide respondents the option to answer in terms of frequency per day, week or month.<sup>48</sup> This may provide for enhanced precision in reporting as the frequency of use is truly a continuous rather than a categorical variable.<sup>49</sup> Illustrations of FFQ from three well known studies are depicted in Figs. 1–3.<sup>50–52</sup>

**ADMINISTRATION OF FFQ**

The FFQ may be self-administered or obtained in an interview format by a trained dietician or nutritionist. Administration of an FFQ may be facilitated by using standardized food models made of plastic, wood or papier mache. Simple pictures of different portion sizes may also be used. These help in increasing the speed and accuracy of quantifying serving sizes. Measuring cups, spoons, bowls and rulers may also be used. The basic principles of survey

During the past year or so how often did you usually [eat/drink]	How Often ?	Was it a small, medium or large portion?
10. Green Salad ?	Times per <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Less than 6 a year or never	<input type="checkbox"/> Small <input type="checkbox"/> Medium (1 medium bowl) <input type="checkbox"/> Large
25. Fried Chicken ?	Times per <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Less than 6 a year or never	A medium serving is 2 small or 1 large piece <input type="checkbox"/> Small <input type="checkbox"/> Medium (2 small or 1 large) <input type="checkbox"/> Large
33. Eggs ?	Times per <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Less than 6 year or never	How many eggs ? Number
49. Doughnuts, Cookies, Cake or pastry?	Times per <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Less than 6 a year or never	A medium serving is 1 small or 3 cookies <input type="checkbox"/> Small <input type="checkbox"/> Medium (1 piece or 3 cookies) <input type="checkbox"/> Large
53. 2% milk or drinks made with 2% milk, not including any cereal?	Times per <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Less than 6 a year or never	<input type="checkbox"/> Small <input type="checkbox"/> Medium (8 or glass) <input type="checkbox"/> Large

Fig 1. Selected questions from the Block/NCI 60-item FFQ administered in the 1987 US National Health Interview Survey<sup>50</sup>

INSTRUCTIONS : Carefully estimate your intake of the following foods. These may be listed as daily or weekly amounts.			REGISTERED DIETICIAN'S USE ONLY			
Dairy Products : How many do you eat or drink	Day	Week	OTHER KCALS	CHOL	TOTAL FAT	SAT FAT
Cups of milk or yogurt. Is this :						
Butter Milk ?				X 1	X 4	X 3
Whole Milk ?			X 80	X 3	X 15	X 10
2% Fat milk ?				X 2	X 10	X 6
1% Fat milk ?				X 1	X 6	X 3
Skim				X 0	X 0	X 0
Milk Shakes (Cups)	C	C	X 200	X 3	X 15	X 7
Cups of egg nos.	C	C	X 180	X 15	X 40	X 20
Cups of Ice Cream	C	C	X 160	X 6	X 30	X 20
Cups of Ice Milk or other frozen dessert	C	C	X 160	X 2	X 10	X 7
Cups of Cottage Cheese. Is This Creamed ?	C	C	X 130	X 3	X 10	X 6
Low Fat ?	C	C	X 130	X 2	X 4	X 3
Ounces of Mozzarella, American, or Ricotta Cheese	OZ	OZ	X 25	X 2	X 15	X 8
Ounces of Parmesan or Cheddar Cheese	OZ	OZ	X 40	X 2	X 20	X 10

Fig 2. Items from FFQ to assess dietary fat, saturated fat, cholesterol and energy<sup>51</sup>

	INSTRUCTION : For each food item listed below, mark as "X" in the column which best describes how often you ate each food last week (7 day period).					
	NEVER	NOT LAST WEEK	ONCE OR TWICE LAST WEEK	3-6 TIMES LAST WEEK	ONCE OR TWICE A DAY	3 OR MORE TIMES A DAY
	1	2	3	4	5	6
Margarine (all brands like Pan, Chiffon etc.)	( )	( )	( )	( )	( )	( )
Butter (all brands)	( )	( )	( )	( )	( )	( )
Larde, Vegetable fat (white)	( )	( )	( )	( )	( )	( )
Beef or pork drippings	( )	( )	( )	( )	( )	( )
Vegetable oil	( )	( )	( )	( )	( )	( )
Mayonnaise	( )	( )	( )	( )	( )	( )
Salad dressing (French, oil & vinegar, etc.)	( )	( )	( )	( )	( )	( )
Gravy (Pork, chicken, beef, tomato, etc.)	( )	( )	( )	( )	( )	( )

Fig 3. Food groups section of FFQ. Nine food groups each contain six to twelve food items. The foods were identified by scanning more than one thousand 24-hour dietary recalls from the Bogalusa Heart Study<sup>52</sup>

research<sup>53–55</sup> should be applied to the collection of food frequency data. Accuracy in collection of dietary data requires motivation, thus emphasizing the scientific importance of the information and assuring confidentiality. Clarity in instructions is essential. If the FFQ is obtained in an interview format, standardized procedures are essential. Longer questions may be helpful in an interview as this gives the respondents longer time to think.<sup>56</sup> Memory aids and

prompts may be useful. The data obtained from questionnaires are then coded and analysed for nutrient/food intakes. A nutrient database and analysis programme must be compiled to calculate these intakes. In constructing the database, a value for each nutrient being computed must be assigned to each food. The total intake of a nutrient can be calculated as the sum of the products of the frequency weight and the nutrient content for each food.

#### QUANTITATIVE FFQ: THE CURRENT STATUS

FFQs have been used in various diet surveys including the NHIS (National Health Interview Survey) 1987, NHANES III (National Health and Nutrition Examination Survey) conducted by NCHS

(1989–94), Hispanic HANES (1982–84), Scottish Heart Health Study (1989), Nurses Health Study (1980), and Coronary Artery Risk Development in Young Adults Prospective Study (CARDIA 1991).<sup>49</sup> Detailed studies have been carried out to assess the reproducibility and validity of FFQs. A few of these studies based on dietary intakes of adults and adolescents are discussed below (Table I).

#### *Studies supporting the use of FFQ*

The validity of FFQ has been examined in a number of studies. In several early investigations, usually based on a relatively small number of subjects, a high correlation for food and nutrients was

TABLE I. Validity of nutrient intake measured by food frequency questionnaire<sup>49</sup>

Source	Population	FFQ design	Time to complete FFQ (minutes)	Method used for comparison	Range of correlation
Willett <i>et al.</i> <sup>29</sup>	Registered nurses 34–59 years, <i>n</i> =194	61 items, 9 response categories, standard portions, mailed, focus on nutrients related to cancer	15	Diet records	0.36 with vitamin A 0.75 with vitamin C
Willett <i>et al.</i> <sup>57</sup>	Registered nurses 39–63 years, <i>n</i> =150	116 items, 9 response categories, standard portions, mailed, focus on nutrients related to cancer	25	4 one-week diet records	0.28 with iron, 0.61 with carbohydrate, 0.50 or greater with others
Musgrave <i>et al.</i> <sup>46</sup>	Peri-menopausal women participants in longitudinal osteoporosis study, <i>n</i> =26	53 items, 2 response categories, standard portions, self-administered, focus on calcium intake	<5	4-day food records	0.73 with calcium in winter and 0.83 in summer
Smith <i>et al.</i> <sup>58</sup>	Men born between 1938 and 1947 in Aberdeen <i>n</i> =450	50 questions, 3 response categories, standard portions, focus on nutrients related to heart disease	–	Serum vitamin concentrations	Assigned >70% subjects correctly to upper or lower tertiles of serum vitamin values except for $\beta$ -carotene in smokers
McDonald <i>et al.</i> <sup>59</sup>	White and black men aged 18–30 years enrolled for CARDIA study, <i>n</i> =128	20 food groups (700 items), 3 response categories, visual cards and food models used for portion sizes, interview	45	7 randomly scheduled 24-hour recalls	0.50 for all nutrients in whites but lower values in blacks
Block and Subar <sup>50</sup>	Representative sample of American adults, 18–99 years of age <i>n</i> =22 000	60 items, standard portions, age- and sex-specific portions used, interview, focus on a wide range of nutrients	17	Compared with data from other dietary surveys, (NHANES and NFCS)	Intake of nutrients as proportion of energy consistent with other surveys
Rimm <i>et al.</i> <sup>60</sup>	Sub-sample of male health professionals follow up study, <i>n</i> =127	131 items, 9 response categories, standard portions, mailed, focus on nutrients related to heart disease and cancer	–	Two one-week diet records	0.28 for iron to 0.86 for vitamin C (mean <i>r</i> =0.59)
Frank <i>et al.</i> <sup>52</sup>	Adolescents participating in the Bogalusa Heart Study, <i>n</i> =1108	64 items in 9 food groups, 6 response categories, standard portions, self-administered, focus on eating patterns not nutrient intake	–	Seven consecutive 24-hour recalls for frequently consumed foods	90% or more for infrequently consumed foods, 26%–40% agreement
Curtis <i>et al.</i> <sup>51</sup>	American men and women 23–65 years of age, <i>n</i> =29	78 items, 2 response categories, standard portions, self-administered, focus on fat, saturated fat and energy	10–15	4-day diet records	0.65 for cholesterol, 0.63 for saturated fat and 0.53 for fat and energy
Peters <i>et al.</i> <sup>61</sup>	Blue- and white-collar employees of a corporation, both sexes <i>n</i> =436	2 sections including 23 questions, 4 response categories, standard portions, self-administered, focus on fat and cholesterol	11	4-day food records	0.55 to 0.56 for foods rich in cholesterol and fat

observed between simple dietary questionnaires and diet history.<sup>62-65</sup> Stefanik and Trulson<sup>30</sup> found that a simple FFQ could reasonably characterize cultural differences in eating habits between Irish-born and Italian-born American men. Nutrient intake data have been reported from a 60-item FFQ administered in the 1987 NCHS to a representative sample of American adults 18-99 years of age ( $n=22\ 080$ ).<sup>50</sup> These data provided, for the first time, an estimate of the distribution of usual nutrient intakes in a national probability sample. The questionnaire used in this study produced nutrient estimates fairly close to those of the reference data used in the study.

Willett *et al.*<sup>29</sup> evaluated the reproducibility and validity of a 61-item semi-quantitative FFQ used in a large prospective study among women (Nurses Health Study). The form was administered twice at an interval of about a year, and 4 one-week diet records were collected during that period from 173 participants. Intra-class correlation coefficients for nutrient intakes estimated by the one-week diet records were similar to those computed from the questionnaire; indicating that these methods were comparable with respect to reproducibility. Later, the same authors<sup>49</sup> revised and expanded the FFQ to include 116 items and worded the questionnaire to ask about food intakes 3-4 years earlier. Thus, mean nutrient intakes assessed by the revised questionnaire were similar to those measured by the diet record and also yielded a similar degree of validity as the earlier version. The data provide evidence that the semi-quantitative FFQ method can measure dietary intake several years previously, as would be done in a case-control study.

In 1992, Rimm *et al.*<sup>60</sup> assessed the validity of an expanded 131-item semi-quantitative FFQ developed by them in a prospective study among 51 529 men (male health professionals). The form was administered twice at an interval of one year as in the above study and during this interval, men completed 2 one-week diet records spaced approximately 6 months apart. The mean values for intake of most nutrients assessed by the two methods were found to be similar. This questionnaire provided reasonably reproducible measurements for individuals over a period of one year. The degree of validation in nutrient intake and validity of the questionnaire indicated that important associations between diet and disease can be quantified in a large cohort of men. FFQs have also been used for time periods of less than a year. A self-administered questionnaire was developed and used in the Bogalusa Heart Study to indicate weekly consumption of 64 foods.<sup>52</sup> The reliability and validity pattern were determined. Frequency of foods obtained from 7 consecutive 24-hour recalls was compared with frequency obtained from the FFQ. A mean 50% agreement for both frequency and quantity of foods was noted in 55% or more FFQs; but the recalls reported higher frequencies and quantities of foods than FFQs. This suggested that FFQs might have a potential for selective bias or under-reporting of frequency. It was opined that the ability of FFQ to characterize an individual's eating pattern might improve with a larger listing of single foods. In addition, the study suggested that an FFQ, repeated after 2 weeks may not be appropriate for evaluating the reliability of this instrument; however, it might identify certain commonly eaten foods.<sup>52</sup>

The amount of calcium consumed daily by a group of perimenopausal women, who were participants in a longitudinal osteoporosis study, was assessed using a quantitative FFQ designed by Musgrave *et al.*<sup>46</sup> Subjects filled out an FFQ and in the next week completed 4-day food intake records according to instructions from the researchers. The calcium level estimated

from the questionnaire correlated significantly with the estimated amount from 4-day records ( $r=0.73$  in winter and  $r=0.84$  in summer). There was no significant difference between the means derived by the 2 methods. It appeared that the brief time (<5 minutes by a dietician) required to calculate the amount of calcium consumed daily from the FFQ could make an important clinical tool. It was found to be useful as an educational tool in diet counselling and for prescribing calcium supplements.

FFQs have been validated and compared with numerous other diet assessment methods,<sup>60</sup> all of which are susceptible to reporting bias.<sup>66</sup> Biochemical markers may offer independent validation of nutrient intake. Although suitable markers are not available for many nutrients, serum values for several vitamins are reported to reflect intake in controlled studies,<sup>67</sup> despite the inevitable variability caused by absorption, availability and post-absorptive metabolism of the vitamins.

Smith *et al.*<sup>58</sup> carried out the task of comparing dietary data obtained from an FFQ with serum vitamin concentrations (vitamin E and C, carotene, retinol) and also serum total cholesterol and triglycerides. The questionnaire validated was the Medical Research Council-Caerphilly questionnaire<sup>68</sup> used in both the Scottish Heart Health Study<sup>58,69</sup> and the Scottish MONICA Study<sup>70</sup> originally designed to assess macro-nutrient and fibre intake. Its suitability for determining vitamin intake needed to be assessed. The questionnaire assigned >70% of the subjects correctly into the upper or lower and adjacent tertiles of serum vitamin concentrations, with the exception of beta-carotene and total vitamin A for smokers. Thus FFQ appeared to be an adequate tool for assigning individuals into tertiles of serum antioxidant vitamins.<sup>66</sup> Curtis *et al.*<sup>51</sup> developed and pilot-tested an FFQ that rapidly and accurately assessed intake of fat, saturated fat, cholesterol and energy. Figure 2 illustrates a part of the 78-item questionnaire. After completion of the FFQ, 4-day dietary intake was recorded by the respondents. This questionnaire attained a higher level of correlation than other questionnaires tested similarly.<sup>71,72</sup> All relationships were significantly correlated ( $p < 0.05$ ). No statistically significant differences were found between the FFQ and the 4-day dietary records for daily fat, saturated fat, cholesterol and energy intake. The authors recommended that for developing an FFQ, establishment of specific criteria for including items on the questionnaire through pilot studies is critical and the same database should be used for FFQs and dietary records.

To meet the objectives for dietary assessment in the CARDIA prospective study, McDonald *et al.*<sup>59</sup> developed a dietary history to provide accurate and reliable quantitative data on habitual individual nutrient intakes at baseline. The CARDIA dietary history was an interviewer-administered method that included a short questionnaire regarding general dietary practices followed by a comprehensive FFQ about typical intake of foods using the previous month as a reference for recall. Provision was made for reporting foods not found in the food frequency list. Visual card-prompted responses and food models assisted in estimating the usual amounts consumed. Baseline nutrient analyses from CARDIA dietary history provided estimates that agreed reasonably well with expected caloric intake for body mass index according to age- and sex-specific recommended dietary allowances, but were higher than those reported from 24-hour recalls in the NHANES II. The CARDIA dietary history can act as a comprehensive assessment tool when detailed information regarding habitual eating patterns and nutrient intakes is sought.

Peters *et al.* designed an Eating Pattern Assessment Tool (EPAT)—a self-administered FFQ to assess dietary fat and cho-

lesterol intake among adults.<sup>61</sup> Reliability and validity testing were done using a repeated measures design with individuals completing the EPAT at five visits. Participants were also asked to complete a 4-day food record. Validity of EPAT was about the same as the other generally accepted instruments.<sup>48,57</sup> The test-retest reliability of EPAT (both sections) was at or above the generally accepted level ( $r=0.70$ ) for reliable detection of change for a person. Thus, EPAT is a reliable and valid substitute for more time-consuming food records. Use of EPAT has been recommended only for Midwestern American populations. However, it is being adapted for use by other ethnic groups by adding other food categories and changing the examples.<sup>61</sup>

#### *Studies favouring other methods*

While most studies support the validity and reliability of FFQs, a few researchers favour other dietary assessment methods. Briefel *et al.*<sup>73</sup> considered the FFQ too imprecise for estimating nutrient intake and opined that these data cannot be used to produce national nutrient means or distributions, and that adjustments to the data to assure mathematical fit are inappropriate. They pointed out the following limitations of FFQs for estimating nutrient intake:

1. The FFQ does not collect information for specific food items. Instead, foods are typically grouped into broad categories. For example, in the Block/NCI instrument, doughnuts, cookies, cake and pastry form a single food grouping (Fig. 1). This limitation can be overcome by including specific food items and not groups, even if it makes the questionnaire a bit lengthy. For example, in case of an FFQ based on Indian foods, all 'pulses' should be listed separately instead of listing them as a food item that includes all the varieties, e.g. green gram, black gram, red gram. The frequency of intake of each food item is different and so is its nutritive value. Data will be misleading if foods are grouped into broad categories.
2. In an FFQ, the survey respondents do not indicate what portion size they eat. Instead, broad categories of small, medium and large are asked and often only the medium portion is defined. This limitation, however, can be taken care of by using standardized cups, bowls, spoons, rulers and food models.
3. Data on exact foods eaten by respondents are also not collected by the FFQ. They list only a few mixed dishes and the respondent has to separate all others into their component foods. Food preparation, brand name, and packaging information are rarely noted. We feel that to make the data more reflective of an individual's actual intake, information on the method of food preparation, brand name, etc. should be collected wherever possible. Where nutritive value is affected much by cooking, data should be collected separately for cooked and raw food items. Thus by improving the basic design of the FFQ, the quality of information collected can be improved.

Larkin *et al.*<sup>74</sup> compared 16 days of dietary recall and records collected over 1 year for 228 respondents with a 116-item FFQ data. The mean food energy and nutrient values obtained by the FFQs were consistently and significantly higher than the mean recall/record values for all four race-sex groups (black and white, men and women), although the degree of difference varied with nutrient, food group and demographic characteristics of the respondents. In the design of this study it was assumed that mean values from the records, which depend upon recent memory, were more reliable and valid than those from FFQs which depend on long term memory. However, theoretically it is possible that FFQ

values have greater validity as they purport to represent behaviour over a longer period.

In another comparative study between an FFQ and a 3-day diet record, Bergman *et al.*<sup>75</sup> reported that FFQs consistently resulted in higher estimates for energy, carbohydrate, protein, vitamin A, vitamin C and iron. Estimates of saturated fat, cholesterol, caffeine and sodium intakes and percentage of total energy from protein, carbohydrate and fat were not significantly different between FFQs and diet records. They argued that higher nutrient value estimates obtained with FFQs might be the result of the subjects' overestimation of foods eaten. Foods eaten once a week or more frequently are remembered better than foods eaten less often. Foods consumed infrequently are often recalled with the least accuracy. However, Frank *et al.*<sup>52</sup> felt that a comparison among studies evaluating FFQs are complicated by differences in sample size, age, sex and racial composition of the study group; the design of the FFQ (such as number of food items, open or closed question design, and length of reference period of the recall); the reference or standard method used in the evaluation; and the statistical techniques used in data analysis. Each of these factors, in addition to others, may be related to the degree of agreement between methods of dietary intake assessment.

#### DISCUSSION

It is well recognized that data cannot be generalized beyond the limits inherent in the method by which the data are generated. Hence, all data need to be looked at critically with regard to the collection methodology, controls, sample selected, key underlying assumptions and processes by which the data may be manipulated.

Till date, controversy exists on the reliability and validity of food intake data generated using an FFQ. To resolve the controversy it is essential to prove the efficacy of FFQs in collecting dietary intake data. Usually the method in question is compared with the 'standard' method. Unfortunately, the 'standard' methods detailed diet histories, and multiple 24-hour recalls have their own drawbacks. A few recent studies indicate massive under-reporting by these methods.<sup>73</sup> There is a pressing need for objective methods that accurately assess food intake. Until the standard is redefined and assured to be accurate, the controversy will stimulate further research.

In the development of new or improved techniques to estimate nutrient intake, it is important to identify the intermediate steps that respondents employ in summarizing their food behaviour. Those that lead to mis-estimation should be identified and controlled. It is essential not only to have a good questionnaire whose reproducibility and accuracy have been established but also to have it administered in a standardized manner. In case of a questionnaire filled by the interview method, systematic errors during interviewing can introduce a significant bias in the nutrient intake results. Intensive training needs to be given to interviewers and suitable probes, standardized food models and accurate recording are other important requisites for minimizing errors.

#### THE INDIAN CONTEXT

Results from many studies have raised the question whether dietary methods shown to be accurate and reliable in one group of people, race or population are equally valid in estimating dietary intakes of other races, groups or populations. Studies on dietary assessment in Indians have generally employed methods that are based on current rather than long term intake. The National Nutrition Monitoring Bureau (NNMB) undertakes a nutrition

S.N.	Food Item	How Often ?					Average Serving	Serving Size
		Per Day	Per Week	Per Month	Per Year	Never		
27.	Kidney beans/ Rajmah	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	30g/1 katori cooked Photo A	<input type="checkbox"/> S <input type="checkbox"/> M <input type="checkbox"/> L
53.	Cauliflower/ Phool Gobhi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	100g/1 katori cooked	<input type="checkbox"/> S <input type="checkbox"/> M <input type="checkbox"/> L
92.	Apple Crow/ Juice/baked	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1 medium Photo B	<input type="checkbox"/> S <input type="checkbox"/> M <input type="checkbox"/> L
104.	Cheese (pasteurized)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	25g/1 cube small	<input type="checkbox"/> S <input type="checkbox"/> M <input type="checkbox"/> L

Fig 4. Quantitative food frequency questionnaire<sup>88</sup>

survey annually through weighment of raw food and 24-hour recall method or oral questionnaire.<sup>76</sup> Recently, many studies on diet have relied only on a single 24-hour recall,<sup>77-79</sup> while others have used it in combination with the weighment method.<sup>80,81</sup> and some have used 24-hour recall for 3 consecutive days.<sup>82-84</sup> Only a few studies investigated dietary intake with the help of a 24-hour recall and FFQ.<sup>85-87</sup>

In India, the task of collecting dietary and nutrient intake data is rather difficult as the foods eaten and food habits vary remarkably. So far, no attempt has been made to design and test FFQs based on Indian foods. There is a need to develop a questionnaire that would be simple enough to be administered on a large sample of Indians and whose validity and reproducibility have been quantified. Regional differences in food habits and food availability will have to be taken into account while designing the FFQ. An FFQ constructed for use in North India will have to be different from one for use in South India. Packaging of food items with definite portions is not a common practice in Indian markets and this makes defining portion sizes a very difficult task. Intensive research is required on dietary intake estimation methodologies. Methods need to be devised to improve the recall and accuracy in reporting intakes by various population subgroups. Using interviewers with ethnic characteristics similar to those of respondents may help improve reporting accuracy due to greater rapport and an intrinsic understanding of the dietary patterns of the respondents' ethnic group.

We are in the process of developing and designing a quantitative FFQ for use in northern India and testing its validity and reliability. The questionnaire will be administered by trained personnel. It would provide information on the past or long term intake of antioxidant vitamins, flavonoids, fats and fatty acids, cholesterol, fibre, protein, carbohydrates and calories. It includes an extensive list of foods ( $n=150$ ) that contain appreciable amounts of the above nutrients and are commonly consumed in the North Indian diet. An open-ended format is being used which provides the respondent with the option to answer in terms of frequency per day, week, month or year. The average serving size is specified for each food item and the respondent has to report whether his usual serving size is less than the average size, the same or more than that. Pictures and food models are used along with the questionnaire to help the respondent choose the usual serving size. A sample of the FFQ that we have developed is depicted in Fig. 4. This pro-forma has been used in a small epidemiological study.<sup>88</sup> The quantitative FFQ is being validated, using carefully kept

periodic food records. Food records are being maintained by participants for a total of 4 weeks spread throughout one year. The FFQ will be administered twice at an interval of approximately one year on the same individuals to check for its reliability and reproducibility.

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