Development and testing of a quantitative food frequency questionnaire for use in Gujarat, India

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Submitted 10 April 1998: Accepted 17 September 1998

Abstract

Objective: To develop and test a quantitative, interviewer-administered food frequency questionnaire (FFQ) to ascertain nutrient intakes of individuals in northern India.

Design: A 92-item FFQ was developed based on food use and market surveys of the study area. A validation study was conducted consisting of 24-h diet recalls (24HR) administered on 6 randomly selected days over 1 year. Two FFQs were administered, one each at the beginning and end of the 1-year period. FFQ and 24HR-derived nutrient scores were compared using correlation and regression analyses and by computing differences between nutrient intakes estimated by the two methods.

Setting: Rural villages in Bhavnagar District, Gujarat, North India.

Subjects: 60 individuals who agreed to provide all necessary data.

Results: Pearson (parametric) correlation coefficients averaged 0.69 in comparing nutrient scores derived from the 24HR with those from the first FFQ and 0.72 in comparing the second FFQ ($P < 0.0001$). Spearman correlation coefficients were virtually identical to the Pearson correlations, averaging 0.68 and 0.72, respectively. In regression analyses, most coefficients were close to 1.0 (perfect linear association). Nutrient scores were significantly and consistently higher on both FFQs relative to the 24HR.

Conclusions: This FFQ produces results broadly comparable, and superior in some respects, to those commonly used in the West. Higher than average measures of association indicate its suitability for comparing exposures within this study population in reference to health-related endpoints.

Keywords
Human nutrition
Food frequency questionnaire
Dietary assessment methods
Gujarat, India

The food frequency questionnaire (FFQ) has become the method of choice for dietary assessment in most large-scale epidemiological studies[1]. Despite limitations of structured questionnaires of this type[2,3], a major advantage of the FFQ is its feasibility for establishing long-term habitual dietary intake[1].

FFQs are used widely in epidemiological studies in the West[1,4,5]. Observational epidemiological studies of diet or nutrition reported from India have relied on dietary assessment consisting of check lists for different foods and food categories[6–8]. Based on a complete search of the literature (using Medline medical subject headings and textwords), it appears that with the exception of a similar instrument that we developed for use in Kerala (southern India[9]), there has been no instrument of this type developed for use in India. Therefore, no epidemiological study employing a validated FFQ has been reported from India.

The FFQ approach may be particularly appropriate for studies in India because of: relatively large inter-relative to intra-person (mainly day-to-day) variability[10]; a shorter questionnaire (under 100 food items) could make querying respondents easier[11,12]; and a smaller chance of response bias due to prior knowledge of diet–disease relationships. Also, it appears that these rural Indians may be relatively adept at estimating food portion sizes. In a separate study[13] comparing the abilities of rural Indians (including these subjects) and middle-class Americans from Massachusetts to estimate weights and volumes of common food items we observed that the differences between the Indians' estimates of food portion size and the actual values were significantly closer to zero than the differences observed in Americans. Across all three Indian study sites, relative differences for small (~ 50 g) and large (~ 300 g) items averaged 0.30 (i.e. 30% too high) and –0.004, respectively; whereas the corresponding values for subjects from Massachusetts were

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https://doi.org/10.1017/S1368980099000051 Published online by Cambridge University Press

1.50 and 0.59, respectively. Values in Gujarat were even better than the Indian average; 0.15 and 0.04, respectively. Besides the average difference being closer to the ideal of zero, the distribution of the errors was narrower. That is, the average standard deviations (SD) for the Indian locations were 1.30 and 0.49 (0.46 and 0.30 for Gujarat), respectively, for the two weights; versus 1.47 and 0.73, respectively, for Massachusetts.

As a part of the on-going study of oral cancer and precancer[14], this study was conducted in the same three areas of India: Ernakulam district in Kerala, Srikakulam district in Andhra Pradesh, and Bhavnagar district in Gujarat. There being major differences in foods eaten in different parts of India, it was necessary to develop a separate FFQ for each region. This article describes the development of the FFQ in Bhavnagar district, Gujarat state, for a variety of nutrients that plausibly could be related to oral cancer and precancer (and a variety of other health-related outcomes) and a validation study to test the FFQ.

Methods

Some prior information was available for developing an FFQ in this population. This consisted of a database with 592 food items commonly consumed in India including most of the food items consumed in the target area. It provided values of 30 nutrients including macronutrients and some micronutrients[15]. In addition, we had access to a report on a number of diet surveys[12].

As the first step in developing the FFQ, food lists were constructed based on interviews conducted in 36 households representing the major groups in the study area. Interviews focused on food items typically consumed, including ingredients of prepared items, condiments and spices. Cross-checking these food lists with the nutrient database[15], it was confirmed that the list of food items accounted for >95% of the intake of the target nutrients (β-carotene, ascorbic acid, thiamin, riboflavin, calcium, zinc, copper, iron and sodium). This confirmation was based on a combination of the concentrations of nutrients in the named food items and the rate at which they were eaten, based on our survey data.

A prototype FFQ developed from this food list was pilot tested by visiting family units representative of the target population. The objective was to determine completeness of the list and to collect recipes for prepared items included in the FFQ. It is known that the concentration of ingredients in certain preparations varies by differences in religious and economic status[16,17]. Therefore, for final construction of the recipe database for the FFQ, representative recipes were collected for each prepared food according to prevailing definitions of caste/social status which represents a combination of religious affiliation (e.g. Brahmin or Jain) and occupation (e.g. teacher or farmer). For classification of economic status, objective data on family wealth and income were unavailable. Therefore, the three categories of economic status were defined as follows.

- High status: possessing a concrete or tiled house; owning a farm employing servants; having a successful business or shop; or being a government officer.
- Middle status: low-level government job; primary school teacher; small shop owner; owning a house plastered with mud or even cow dung; or owning a small-scale farm.
- Low status: those marginally employed or unemployed individuals who could neither afford to live in their own house nor own their own business.

Description and administration of the FFQ

The FFQ contained 92 food items, of which 56 were prepared from two or more ingredients. Nine of these food items represented categories rather than a specific food item, differing primarily on the main ingredient (e.g. green gram curry and red gram curry). These preparations were similar in terms of nutrient content and method of preparation, and they represented similar dietary choices. Therefore, these items were further classified as specific food items according to the main ingredients and given subcodes. There were 35 subcodes for these nine items. The general form of the questions used in the FFQ and the entire list of 92 items are shown in Appendix 1. For purposes of comparison, also shown is the list of 81 items used for the FFQ in Kerala[9].

For each food item on the FFQ, the average frequency of consumption over the past year and the normal portion size typically eaten by the respondent was ascertained. In instances where the items subsumed under a certain category (e.g. leafy vegetable preparations) did not represent an exhaustive (or nearly complete) list of such items, the average amount overall was ascertained. This allowed the subject to report the amounts of specific foods that were available only seasonally while reporting the overall consumption of foods in that category. In pilot tests of the instrument, it was found that subjects could respond easily both to the total overall category amount and to specific, seasonally available foods but had difficulty in cumulating food-specific averages of seasonally available foods towards an overall category average.

Unlike self-administered questionnaires used in the West, in which the frequency must conform to ordinal response formats, frequency responses on this instrument were entered onto the form as integer amounts by the dietitian. For items that were available only seasonally, such as fruits and certain vegetables, the frequency of consumption was recorded only for the season in which it was consumed. This obviated the need for the respondent or the interviewer to undertake the tedious and error-prone exercise of computing the yearly average intake for seasonal items.

During the year of the validation study, data were collected to establish seasonal availability of food items and to standardize weight equivalence for volume, diameter size and piece designations. For a seasonally available item, the proportion of the year that it was available became a multiplier in the algorithm for computing nutrient scores.

Portion size estimation was undertaken using volume measures, circular measures, numbers and linear measures. A set of 12 metal vessels ranging in size from 1520 to 60 cm^3 was used as an aid to estimating volumes. In addition, two spoons were used to estimate very small volumes (10 and 5 cm^3). Similar vessels were reported to have been used in earlier studies[17,18]. For approximately circular items such as chappati or puri, a set of nine circular models was developed ranging from 24 to 4 cm in diameter. Some items such as bread slices and salty snacks were recorded as integer multiples of standard portion sizes. Most fruits were recorded in three sizes: small, medium or large. Volumetric estimation was based on the three-dimensional measurements associated with the food's length, diameter or surface area as ascertained in surveys of local food vendors and eating establishments.

In the study region, 30 households were selected to represent the nine specific economic and caste groupings. In each household, the male head of household and female food preparer were enrolled. To be eligible, the male had to be a tobacco user (because that was the target group for the epidemiological study in which the FFQ was to be used) and both the male and female had to have no dietary restrictions, be compos mentis, be permanent residents of the area and be available over the entire next 1 year for interviewing (no absences planned). The FFQ was administered twice, once at the beginning and again at the end of the 1-year validation study period.

The 24-h diet recall interview

Normally, nutrient intakes estimated from an FFQ are compared to those derived from multiple days of food diaries or 24-h diet recall interviews (24HR)[1,19]. Because a part of the study population was illiterate, keeping food diaries was not an available option. Also, total variability (and, therefore, total measurement error) appears to be lowest for the 24HR in comparison to diet records or histories[20,21]. Therefore, we chose the 24HR as the reference standard for validating this FFQ.

The 24HR was an open-ended, prompted interview conducted by a qualified research dietitian. The reference period for the 24HR was the day prior to the day of the interview. The 24HRs were administered on 6 randomly selected days, but avoiding days immediately following important religious and social festivals. To account for variations in diet, intake days were selected to represent the three main seasons of the year and weekdays as well as weekends. Interviews were conducted so as to take the respondent through the recall process in direct chronological order from the first food encounter of the day to the last.

When the respondent was female and the food was a home-made item, recipe information was collected from her. If the selected female respondent to the 24HR had not prepared the food, the recipe was obtained from the person in the same household who had. Thus, recipe information was collected for each food item reportedly consumed in each of six 24HR, even if the food item was prepared more than once. An attempt was made to alter the order of interviewing the male and female within a household during successive administrations of the 24HR. In all instances, the interview was held only with the interviewee, with no one else present.

When a respondent was not able to identify a prepared food item by name, only the main ingredients and the type of preparation (e.g. curry or dry) were identified. An appropriate name was then assigned to the preparation by the interviewer.

Computing nutrient scores

Computation of nutrient scores on the basis of food items consumed required recipes with a listing of ingredients and relative quantities. As stated earlier, there could be large differences in relative quantities of ingredients for the same food item, therefore recipes were categorized according to each of three caste and economic groups, totalling nine groups. To obtain good representation, the target was to obtain three recipes from each of the nine groups. Some food items were rarely consumed by certain groups, resulting in fewer than three recipes per group. Therefore there were on average, 21 (rather than 27) recipes for each of the 47 items that were without subcodes. Nine items with subcodes had, on average, 22 recipes per subcode. On the whole there were 1753 recipes in the recipe database, each recipe containing, on average, eight ingredients.

For all items listed as raw ingredients in the recipe records, the edible portion of each was weighed separately on a balance whose minimum capacity was 5 g. Proper calibration was assured by using cup measures in excess of 200 g, so as to minimize error. Thus the weight equivalences of all ingredients estimated as volumes were established and, from this, the proportional weight of each raw ingredient in each preparation was derived. For items reported in circular sizes, three samples of the size (diameter) typically eaten were weighed and the average taken. For items reported in numbers, the weight of the item was averaged, again from three samples. For fruits, equivalent gram weights were computed from either cup measures or relative sizes based on the standard definitions of small, medium or large.

To derive nutrient data from the 24HR, the gram weight equivalent estimated from portion size information was multiplied directly by the nutrient values in the nutrient database (National Institute of Nutrition, 1993)[15]. For computing nutrient scores from prepared items on the 24HR, the procedure was to use, in order of availability:

1 the recipe corresponding to the household;
2 the average recipe for the religion-economic class groups; or
3 the average recipe for the entire study population if the item was prepared outside the home.

As for whole foods, food items comprising a recipe were multiplied directly by the corresponding nutrient value in the nutrient database.

Computing nutrient scores from the FFQ was more complex, because several recipes could be available for a single food item. Therefore the most appropriate recipe according to caste and economic classification was used. If a recipe for an appropriate socioeconomic category was not available, then the average recipe for the validation study population was used. For 47 items with no subcodes, the simple arithmetic average of the recipes was used. For items with subcodes, recipes were weighted by the rate that foods comprising the subcode were consumed in the target population. The recipes formed the main database for linking the foods listed on the FFQ to the nutrients listed in the National Institute of Nutrition database. Appropriate adjustments were made for seasonally available food items and for specific ingredients in a recipe.

Statistical methods

Simple univariate statistics of nutrient scores derived from both the multiple 24HR and the FFQ were computed to identify out-of-range responses and to examine adherence in testing the statistical assumptions involved in testing concordance between the two sets of nutrient scores. Pearson (parametric) and Spearman (rank order) correlation coefficients were computed, as is the standard practice in studies of dietary assessment methods[1,4,22]. De-attenuation of the correlation coefficients was done for correcting within-person variability by using standard methods[23,24]. Motivation for this procedure derives from the premise that, because of day-to-day variation in diet within any given individual, the observed correlation coefficient is lower than what would be obtained if there were a very large number of recalls. This presumes that there is no correlated error across the methods.

Simple linear regression was used to assess the linear agreement between the FFQ-derived nutrient scores and arithmetic average of those obtained from the 6 days of 24HR. If for each unit change in the nutrient score obtained from the 24HR there was a one unit change in the nutrient score derived from the FFQ, the slope of the regression line would be 1.0. Because there could be a bias between the measures that neither the regression nor correlation coefficient are adequate to describe, the differences between an individual's FFQ and 24HR-derived nutrient scores were also examined. These differences were plotted against the mean of the two methods for total dietary energy intake, according to the method recommended by Bland and Altman[25]. Because women and men were sampled in pairs, the intraclass correlation coefficient was computed by household to determine to what extent their responses were correlated.

Results

No data collected were deemed to represent outliers. Therefore, all data shown and discussed here include every response from each individual enrolled in the study. Descriptive statistics of the study population are shown in Table 1. Nutrition data shown are based on the average of the 6 days of 24HR. Women consumed diets with lower overall energy content (about 70% that of men). Women weighed, on average, about 84% that of men. Consumption of all nutrients was roughly proportional to the ratio of energy intake among men and women.

Difference scores, obtained by subtracting the FFQ-derived scores from the 24HR-derived score are shown in Table 2. Also shown are the 95% confidence intervals around the point estimates of these differences. All nutrient exposures were underestimated by the average of the six 24HR relative to either of the two FFQs. The two FFQs produced a consistent overestimate. Plots of the difference between energy derived from the 24HR and the first FFQ versus the average of the two measures are shown in Fig. 1.

Table 3 shows the Pearson (parametric) and Spearman (rank order) correlation coefficients. The Pearson coefficients are shown with de-attenuation, so as to give the reader a feel for the influence of this procedure on results. De-attenuation exerted a large influence for some nutrients, owing to the relatively large intra-person (day-to-day and other sources) variability in consumption of some nutrients.

The Spearman and Pearson correlation coefficients were virtually identical in comparing the 24HR-derived

Table 1 Descriptive data for the food frequency questionnaire validation study, Bhavnagar District, Gujarat, India, 1993–94

	Males ($n = 30$)	Females ($n = 30$)
Age*	36.1 (9.7)	31.4 (7.7)
Education†		
illiterate	30.0%	66.7%
primary	56.7%	30.0%
middle	0.0%	0.0%
high	10.0%	0.0%
college	3.3%	3.3%
Caste†		
forward	43.3%	43.3%
backward	36.7%	36.7%
schedule	20.0%	20.0%
Status		
high	20.0%	20.0%
middle	56.7%	56.7%
low	23.3%	23.3%
Occupation†		
business/professionals	33.3	0.0
farming/merchandise	10.0	–
skilled labour	10.0	6.7
secretarial/clerical	36.7	–
unskilled/self-employed	3.3	3.3
householder	6.7	90.0
Nutritional variables*‡		
total energy (kJ day^{-1})	9464 (4385)	7874 (2263)
total energy (kcal day^{-1})	2662 (1048)	1822 (541)
total fat (g day^{-1})	105.8 (57.4)	70.3 (32.4)
fat (% energy)	34.2 (7.4)	33.4 (8.1)
fibre (g day^{-1})	7.7 (2.3)	6.2 (1.9)*
iron (mg day^{-1})	29.7 (8.9)	22.0 (7.0)
sodium (mg day^{-1})	360 (253)	232 (158)
copper (mg day^{-1})	3.8 (1.2)	2.8 (0.9)
zinc (mg day^{-1})	11.3 (3.4)	8.5 (2.6)
calcium (mg day^{-1})	789 (439)	548 (310)
ascorbic acid (mg day^{-1})§	41.0 (19.7)	34.7 (17.7)
β-carotene (μg day^{-1})§	2143 (1282)	1422 (863)
thiamin (mg day^{-1})	1.79 (0.59)	1.29 (0.34)
riboflavin (mg day^{-1})	1.73 (0.77)	1.22 (0.50)
Other variables		
height (cm)	163.5 (7.1)	149.7 (5.0)
weight (kg)	54.6 (12.8)	46.2 (8.6)
BMI (kg m^{-2})	20.3 (3.9)	20.6 (3.6)

* Values are mean and (standard deviation).
† Values are percentage of sample with the attribute.
‡ Nutritional variables are based on the average of 6 days of 24HR diet recalls.
§ The distributions of vitamin C and β-carotene are non-normal.

values with both the pre-FFQ (where the average coefficient values were 0.68 and 0.69, respectively) and the post-FFQ (where the average coefficient values were both 0.72). Analyses stratified by gender revealed that both Pearson and Spearman correlation coefficients were higher for men compared to women. The (Pearson) intraclass correlation coefficients by household were high, averaging 0.70 for the baseline FFQ, 0.73 for the 1-year FFQ, and 0.75 for the average of the six 24HR. Spearman coefficients were slightly lower: on average 0.51, 0.50 and 0.77, respectively.

Table 4 shows the results of the linear regression model obtained by regressing nutrient scores derived from the FFQ at baseline and the FFQ after 1 year with those derived from the six 24HR. There was no clear pattern by gender (results not shown). In general, there was a strong linear relationship between the FFQ- and 24HR-derived macronutrient scores and for the B vitamins. Unlike for the correlation analyses, the post-FFQ comparisons provided slightly better agreement than did the pre-FFQ comparisons.

Discussion

This article is the first from a population in North India to provide quantitative assessment of nutrient exposures for use in an epidemiological study. Of the three areas where we worked and developed an FFQ for study purposes in India, Kerala and Gujarat were the two extremes. Kerala is firmly in the rice growing/eating South and Gujarat is in the wheat/millet North[12,26]. Also, the group with which we worked in Gujarat was nearly completely vegetarian. The food list was different and slightly longer (92 items versus the 81 in Kerala; see Appendix 1).

In designing the dietary assessment methodology for this study of diet and oral precancerous lesions in India, it was hypothesized that the FFQ would be most appropriate for this purpose. Compared to our studies in the USA[22], relatively few foods constituted the vast majority of total dietary intake. Because of this, there might be relatively less bias in recall due to cognitive or memory-related problems[27–30]. As noted above, subjects in this population appeared to be skilled in estimating the weights and volumes of commonly used foods. Usually, FFQs in the West are self-administered and semi-quantitative in terms of estimation of usual portion size[1,4,5]. Because about half of the study population was illiterate, this FFQ was interviewer administered. The interviewer also obtained quantitative estimates of the weight or volume of the food item consumed.

Descriptive statistics based on the 6 days of 24HR are consistent with the relatively young age of the population. As would be expected, the total energy and fat intake were higher in Gujarat than in Kerala[12,26]. The percentage of energy as fat in Gujarat as approximately what is observed currently in the USA[31]. By contrast, the levels observed in Kerala were at about the Indian average. Based on results of correlation analyses, the results from this study indicate a relatively high level of agreement between the nutrient scores derived from the FFQ and the six 24HR. Regression coefficients were closer to 1.0 in the analyses comparing the 24HR-derived scores with those derived from the 1-year FFQ. In those comparisons, excluding fat as a proportion of energy (which is a derived variable), only three variables (fat, zinc and β-carotene) had coefficients which were significantly different from 1.0. In the regression analyses based on the baseline FFQ seven variables had coefficients

https://doi.org/10.1017/S1368980099000051 Published online by Cambridge University Press

Table 2 Difference scores – food frequency questionnaire validation study, Bhavnagar District, Gujarat, India, 1993–94*

	Baseline FFQ		1-year FFQ	
Nutritional variables	Average 24HR FFQ	95% CI†	Average 24HR FFQ	95% CI†
Total energy (kJ day^{-1})	−3423	(−4282, −2564)	−3109	(−3841, −2375)
Total energy (kcal day^{-1})	−818	(−1024, −612)	−743	(−917, −569)
Total fat (g day^{-1})	−46.3	(−58.5, −34.1)	−34.9	(−45.9, −23.9)
Fat (% energy)	−4.4	(−6.2, −2.6)	−2.8	(−4.6, −1.0)
Fibre (g day^{-1}	−5.7	(−7.1, −4.3)	−5.7	(−7.1, −4.3)
Iron (mg day^{-1})	−8.2	(−10.7, −5.7)	−8.4	(−10.6, −6.2)
Sodium (mg day^{-1})	−66	(−91, −41)	−77	(−108, −46)
Copper (mg day^{-1})	−0.8	(−1.2, −0.4)	−0.8	(−1.0, 0.6)
Zinc (mg day^{-1})	−2.3	(−3.2, −1.4)	−2.4	(−3.1, −1.7)
Calcium (mg day^{-1})	−197	(−261, −133)	−225	(−297, −153)
Ascorbic acid (mg day^{-1})‡	−0.9	(−1.0, −0.8)	−0.9	(−1.1, −0.7)
β-carotene (μg day^{-1})‡	−0.7	(−0.8, −0.6)	−0.7	(−0.8, −0.6)
Thiamin (mg day^{-1})	−0.50	(−0.66, −0.34)	−0.56	(−0.70, −0.42)
Riboflavin (mg day^{-1})	−0.36	(−0.48, −0.24)	−0.37	(00.49, −0.25)

* The average difference obtained in subtracting each individual's FFQ-derived score from the average of that person's six 24HR.
† Also shown is the 95% confidence interval around the point estimate of the difference.
‡ Based on log-transformed values of the nutrient.

that were different from 1.0. However, for three (iron, copper and calcium) the coefficients were only slightly greater than two SE_b units from 1.0.

Except for regression coefficients adhering slightly better to $H_0: \beta = 1.0$ in the post-FFQ, there was remarkable consistency between the results obtained for the FFQ at baseline and the one administered after 1 year. This is in contrast to other studies conducted by us in the USA[22]. Given the similarity between the results based on the two FFQs, it appears that there was minimal effect of training. De-attenuation of the correlation coefficients in some instances produced large increases in the size of the coefficients.

In analyses of these data, the Spearman rank correlation coefficients were, on average, virtually identical to the Pearson correlations, indicating that this FFQ was very good at rank ordering individuals, the normal use of such data in most epidemiological studies. The fact that the nutrient scores derived from the FFQ administered at the beginning of the interval agreed with the 24HR-derived scores about as well as did the post-FFQ scores is encouraging because it is only the first FFQ to which the typical epidemiological study normally would have access.

An implicit assumption of any assessment of habitual dietary intake is that the basic nature of an individual's

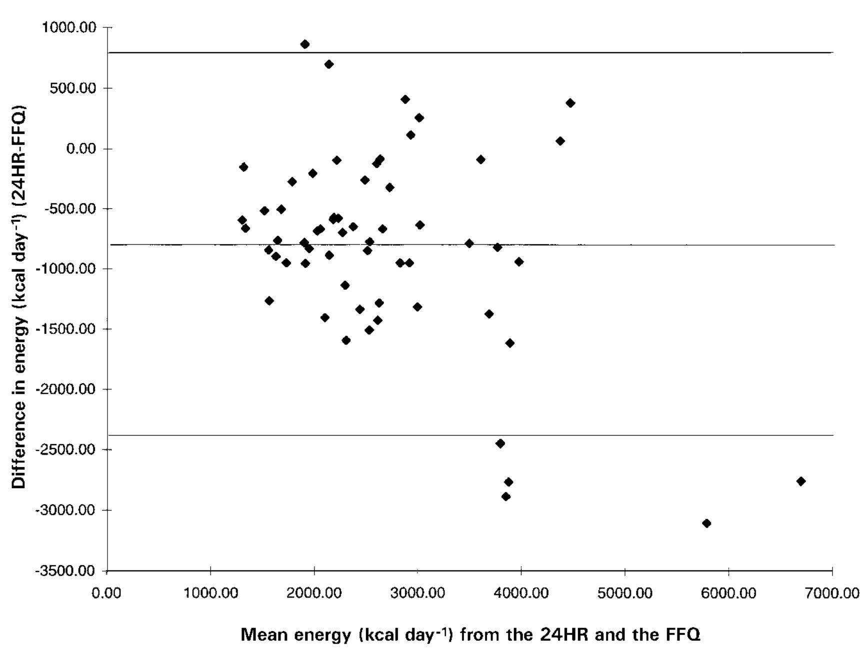

Fig. 1 Plots showing the difference between energy derived from the 24HR and the first FFQ versus the average of the two measures

https://doi.org/10.1017/S1368980099000051 Published online by Cambridge University Press

Table 3 Results of correlation analyses – food frequency questionnaire validation study. Bhavnagar District, Gujarat, India, 1993–94*

	Correlation coefficients					
	Pearson†					
	Pre-		Post-		Spearman rank‡	
Nutritional variables	Observed	Corrected	Observed	Corrected	Pre-	Post-
Total energy (kJ day^{-1})	0.77	0.86	0.80	0.90	0.75	0.75
Total fat (g day^{-1})	0.76	0.85	0.69	0.77	0.79	0.69
Fat (% energy)	0.55	0.61	0.46	0.51	0.59	0.46
Fibre (g day^{-1})	0.44	0.61	0.52	0.72	0.53	0.55
Iron (mg day^{-1})	0.56	0.59	0.69	0.73	0.52	0.71
Sodium (mg day^{-1})	0.94	1.00§	0.91	1.00§	0.90	0.90
Copper (mg day^{-1})	0.54	0.58	0.67	0.72	0.50	0.73
Zinc (mg day^{-1})	0.54	0.58	0.67	0.72	0.50	0.72
Calcium (mg day^{-1})	0.89	1.00§	0.86	1.00§	0.86	0.89
Ascorbic acid (mg day^{-1})‖	0.49	0.55	0.47	0.53	0.44	0.45
β-carotene (μg day^{-1})‖	0.80	0.90	0.72	0.81	0.83	0.72
Thiamin (mg day^{-1})	0.67	0.77	0.74	0.85	0.67	0.70
Riboflavin (mg day^{-1})	0.87	0.99	0.88	1.00	0.82	0.84

* In all instances $P < 0.05$ if $|r| > 0.25$.
† This is the parametric coefficient obtained in correlating the FFQ-derived nutrient score with the equivalent 24HR-derived nutrient score.
‡ This is based on the rank order (non-parametric) correlation.
§ With de-attenuation the corrected coefficient is estimated to be >1.00.
‖ Values for this nutrient have been log-transformed (ln) to normalize the distribution.

diet does not vary, even over relatively long periods of time. Therefore, multiple administrations of the FFQ, say a year or more apart, ought to yield the same results for most subjects. This assumption appears to be reasonable in this instance.

Measures of association between the 24HR- and FFQ-derived nutrients were generally higher in Gujarat than Kerala[9] (i.e. both the correlation and regression coefficients were closer to 1.0). However, the FFQ-derived nutrient scores were uniformly larger than those derived from the multiple 24HR (in marked contrast to Kerala where the 1-year FFQ average was similar to the 24HR average) and they did not change over the 1-year study period. Also, the differences in Kerala appeared to be uniform across all food sources while those in Gujarat reflected an over-reporting of fat (an overestimate of 4.4% energy as fat on the FFQ in Gujarat versus an underestimate of 2.2% in Kerala). Though the bias was relatively large, in both the baseline and 1-year comparisons, the 95% confidence interval of the difference was fairly narrow, around half of the point estimate of the difference. This may point to bias, such as due to social desirability (the defensive tendency of an individual to convey an image in keeping with social norms and to avoid criticism in a 'testing' situation[32]) or social approval (the tendency for an individual to seek a positive response[33–36]) that has been detected and reported in data from the USA[3,37]. It is well known that in India beliefs about relationships between food habits and health are widely held[16]. These response sets represent an interaction between the tendency of the respondent to seek approval or act defensively in a testing situation and the societal value attached to a particular response. Questionnaires such as the FFQ, which ask the respondent to report on behaviour as though it is a trait (i.e. a reflection on one's being rather than a state, as reflected by a single 24HR) are theoretically most susceptible to these biases. For these reasons, it is plausible that such biases could explain at least some of the overestimation on the FFQ relative to the 24HR. Future work in India should investigate the nature of the bias, especially as it was observed in data from Kerala as well[9].

In epidemiological studies, generally the intent is to estimate relative risk between levels of exposure and

Table 4 Results of the linear regression models – food frequency questionnaire validation study, Bhavnagar District, Gujarat, India, 1993–94

	Baseline FFQ		1-year FFQ	
Nutritional variables	*h**	Se_b†	*b*	Se_b†
Total energy (kJ day^{-1})	1.06	0.11	0.95	0.10
Total fat (g day^{-1})	1.12	0.13	0.74‖	0.11
Fat (% energy)	0.47‖	0.09	0.30‖	0.08
Fibre (g day^{-1})	1.22	0.33	1.34	0.30
Iron (mg day^{-1})	0.71‖	0.14	0.88	0.12
Sodium (mg day^{-1})	1.18‖	0.06	1.10	0.07
Copper (mg day^{-1})	0.61‖	0.12	0.79	0.12
Zinc (mg day^{-1})	0.62‖	0.13	0.76‖	0.11
Calcium (mg day^{-1})	1.18‖	0.08	1.13	0.09
Ascorbic acid (mg day^{-1})§	0.59‖	0.14	0.68	0.17
β-carotene (μg day^{-1})§	0.67‖	0.07	0.54‖	0.07
Thiamin (mg day^{-1})	0.98	0.14	1.05	0.13
Riboflavin (mg day^{-1})	1.18	0.09	1.14	0.09

* The regression coefficient is obtained in regressing the specified FFQ-derived nutrient score onto the 24HR-derived nutrient score.
† This is the standard error of the regression coefficient.
‖ The regression coefficient is inconsistent with $H_0: \beta = 1.0$; i.e. that the two sets of measures have perfect linear association.
§ This is based on the log-transformed values of these nutrients in order to meet the assumption of normality.

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health-related endpoints within the study group. Therefore, good linear agreement and, more importantly, rank order agreement (because the data usually are expressed as quantiles of exposure) is required. The fact that there was an upward bias in estimation on the FFQ relative to the 24HR would be of greater concern in circumstances where the intent is to make specific recommendations regarding actual (and not relative) nutrient exposures in individuals. Because there was good linear and rank order agreement between nutrient scores derived from this FFQ and those derived from the 24HR, it is concluded that it is well suited for the purposes of estimating risk in epidemiological studies in this population.

Though Kerala and Gujarat are distinct enough to be different countries, they share one common feature: a very high rate of out-migration. So, not only are the findings of this study and the one in Kerala[9] important for study within India *per se*, there are large expatriate Malayali and Gujarati communities (in the English Midlands and USA for example) for which these FFQ focusing on traditional diet would be appropriate for use (at least in the first generation, possibly beyond). Because of the tremendous interest in studies of migrants, especially as their disease experience may relate to diet, both of these instruments have important public health implications beyond the use for which they were developed initially.

Acknowledgements

This work was supported by the Special Foreign Currency Program of the Fogarty International Center (National Institutes of Health) through Indo-US Fund grant number N-406-645 and a USIA Fulbright Senior Research Fellowship to Dr James R Hebert for the 1997–98 academic year through the US Educational Foundation in India. The authors acknowledge the help of Dr VS Pawar, an examining dentist in the field.

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Appendix 1

General form of the questions and list of the foods queried in the food frequency questionnaire validation studies, Bhavnagar District, Gujarat, India, and Ernakulam District, Kerala, India, 1993–94.

Sample question

Over the past year, how often have you eaten [specific food item] and what was the average portion size that you consumed [prompting from models and standard portion sizes]? [Based on the response from the participant, the interviewer filled in the number of times the food was consumed per unit time, and the average portion size (as noted in the text) in the following format.]

Responses were recorded in the following format

Item	Per day	Per week	Per month	Never	Usual portion size*
Tea/coffee with milk					C
Rotla					F

* Portion size is noted as standard measures of volume (C) or diameter (F); as small (S), medium (M) or large (L) (e.g. for fruit); as a number of normal average size pieces; or in terms of weight, as described in the text.

Food list for the FFQ Bhavnagar (Gujarat)

Item	Usual portion size
Tea/coffee with milk	C
Lime water with sugar	C
Baked/fried wheat/grain bread	
Rotla (thick, flat, round millet bread made on skillet)	F
Bhakhari (thick flat round, whole wheat bread)	F
Chapati (roti) (thin flat round, whole wheat bread cooked on skillet)	F
Puri (deep fried round whole wheat bread)	F
Rice preparations	
Khichadi (rice and lentils cooked together)	C
Rice (boiled)	C
Pulse preparations	
Black gram dal (udad dal), moth beans (muth), horse gram (kalathi)	C
Red gram dal (tur dal), green gram (mag), peas (vatana)	C
Ghanthi vegetable (fried gram noodles prepared in curd)	C
Leafy vegetable preparations	
Fenugreek leaves (methi bhaji)	C
Tanjalia bhaji (amaranth leaves)	C
Spinach (palak bhaji)	C
Cabbage (kobi)	C
Average amount overall	C
Roots and tubers preparations	
Elephant yam (suran)	C
Potato (batata)	C
Sweet potato (sakkaria)	C

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Item	Usual portion size
Average amount overall	C
Other vegetable preparations	
Tomato	C
Onion (kando)	C
Kantola (momordica dioica)	C
Parwar (trichosanthes dioica)	C
Pink beans (valore/cowpea)	C
Brinjal (ringna)	C
Gourds of all types	C
Kovai (tindora)	C
Cluster bean (gavar)	C
Ladies finger (bhinda, okra)	C
Cauliflower (phul gobi)	C
Chibhada (musk melon)	C
Drumstick (saragova)	C
Average amount overall	C
Vegetables eaten in raw form	
Onion (kando)	C
Carrot (gajar)	C
Cabbage (kobi)	C
Chillies (marcha)	C
Salad	C
Tomato	C
Radish (mula)	C
Cucumber (kakdi)	C
Flesh food preparation	
Meat curry (mutton)	C
Chutneys	
Coriander leaf (kothmer)	C
Onion (kando)	C
Garlic (lasan)	C
Other	C
Pickles	
Gunda	C
Kerada	C
Mango (sweet) (keri)	C
Mango (hot) (keri)	C
Carrot (gajar)	C
Ash ground (bhiri kohlu)	C
Amla	C
Chillie (marcha)	C
Milk and milk products	
Milk (dud)	C
Buttermilk (chas)	C
Curd (dahi)	C
Ghee (clarified butter)	C
Butter (mankhan)	C
Sweet kadhi (sweet buttermilk curry)	C
Sour kadhi (sour buttermilk curry)	C
Miscellaneous	
Moramba (mango jam)	C
Jaggery (gol.)	C
Ganthia (fried gram flour noodles)	G
Chivda (fried mixture of puffed rice, ground nuts, grams, coconut, etc. with spices)	G
Bhajia (deep fried chopped vegetables dipped in gram flour paste)	G
Fried snacks (all types)	
Papad (crisp lentil wafer)	SML
Solid milk-sweet preparations (e.g. ladva, burfee)	N
Thick fluid sweet preparations (e.g. shira, kheer)	C
Sponge-type preparations (e.g. dhokala) (lentil preparations using fermentation or yeast)	C
Fried preparations (e.g. dhebra) (fried flat round preparations commonly made of whole wheat)	F
Fried preparations (e.g. pataravel) (fried snacks weighed in grams)	G
Groundnut (bhoising) eaten as such	C
Fruits (eaten as such)	Indicate S, M, L or other size as appropriate
Apple (safarjan)	SML
Banana (kela)	SML
Guava (jamphal)	SML

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Item	Usual portion size
Custard apple (sitaphal)	SML
Orange (santra)	SML
Grapes (draksha)	C
Pomegranate (dalamb)	SML
Mango (keri)	SML
Dates (dried) (khajur)	SML
Sapota (chikoo)	SML
Zyziphus (kashibor)	SML
Papaiya	SML
Sugarcane (sherdi)	SML
Pineapple (ananas)	SML
Tender coconut (nariyal)	C
Sweet lemon (musambi)	SML
Jamun	C
Other fruits	Filled in as needed

Food list for the FFQ Ernakulam (Kerala)

Food item	Usual portion size
Tea or coffee with milk	C
Tea or coffee without milk	C
Rice preparations	
Kanji (rice gruel)	C
Appam (rice pancakes)	F
Pathri (thin rice pancakes)	F
Puttu (steamed rice and coconut cake)	C
Idli (steamed rice cakes)	F
Idiapam (rice noodles)	F
Dosai (rice and lentil pancake)	F
Boiled rice (parboiled)	C
Preparations made with pulses	
Sambar/puling curry (spicy lentil gravy)	C
Other pulse curries	C
Other dry pulse preparations	C
Leafy vegetables	
Chekkur manis/drumstick leaves (shukra mani cheera)/muringa ela	C
Amaranth (mullan-cheera)	C
Colacasia leaves (chembu ela)	C
Cabbage	C
Average amount overall	C
Roots and tubers	
Carrot: curry	C
Carrot: dry preparation	C
Elephant yam (Chena): curry	C
Elephant yam (chena): dry preparation	C
Tapioca	C
Average root/tuber: curry	C
Average root/tuber: dry	C
Other vegetables	
Bitter gourd (pavakka): curry	C
Bitter gourd (pavakka): dry	C
All other gourds: curry	C
All other gourds: dry	C
All beans: curry	C
All beans: dry	C
Tomatoes	C
Onions	C
Avial (mixed vegetables prepared in curd and coconut)	C
Average amount overall: curry	C
Average amount overall: dry	C
Flesh food preparations	
Mammalian meat: curry	C
Mammalian meat: dry	C
All birds: curry	C
All birds: dry	C
Fresh fish: curry	C
Fresh fish: dry	F
Dried fish: curry	C
Dried fish: dry	F

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Food item	Usual portion size
Eggs: curry	C
Eggs: dry	N
Chutneys	
Coconut with tamarind	C
Coconut with mango	C
Onion/other	C
Pickles	
Mango	C
Lime	C
Amla	C
Other pickles	C
Milk and milk products	
Milk	C
Curd	C
Butter milk: plain	C
Butter milk: curry	C
Miscellaneous	
Pappad/pappadavada	F
Wheat preparations, non-fried (e.g. wheat payasam, a sweet soup-like preparation)	C
Wheat preparations, non-fried (e.g. wheat dosai or chappathi)	F
Fried wheat preparations (e.g. puri)	F
Slice of bread or bun	N
Uppuma (salty semolina dish)	C
Sweet rice preparations (e.g. rice payasam)	C
Sweet rice preparations that are eaten whole-piece (e.g. neyappam, kozhikotta)	N
All other sweets	N
Groundnuts	C
Fried salty snacks eaten in large numbers (e.g. banana chips)	C
Fried salty snacks eaten as few whole pieces (e.g. parip vada)	N
Fruits (eaten as such)	Indicate S, M, L or other size as appropriate
Banana (pazham)	SML
Jackfruit (chakka chola)	C
Mango (mampazham)	SML
Orange	SML
Papaya (omakai)	SML
Pineapple (kayitha chakka)	SML
Guava (perakka)	SML
Grapes (mundringa)	C
Amla (nellikai)	C
Pummelos (bombilimas)	SML
Other fruits	Filled in as needed
Alcoholic beverage	
Toddy	C