Short Communication

Development and evaluation of a semi-quantitative food frequency questionnaire for use in urban and rural India

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The objective of this study was to develop and evaluate a semi-quantitative food frequency questionnaire (FFQ) for use in urban and rural India. A single FFQ was developed for use in cities and rural areas of four regions of India. To assess validity, the FFQ was administered to 530 factory workers and rural dwellers, and subsequently three 24 hour recalls were administered on different days. Nutrient and food group intake calculated from these two methods were compared using medians, kappa statistics, Spearman's correlation coefficients and Bland-Altman plots. Dietary intake was overestimated by the FFQ compared to the 24 hour recalls (mean difference in energy intake = 1743 kJ), with kappa statistics ranging from 0.07 (egg) to 0.51 (carbohydrate). The results showed acceptable validity for measuring intakes of groups, and demonstrated that it is feasible to measure dietary intake in diverse regions of India with a single FFQ.

Key Words: dietary assessment, food frequency questionnaire, validity, India, dietary intake

INTRODUCTION

In low and middle-income countries the burden of chronic diseases is increasing.[1] Diet contributes to the epidemiological transition, and monitoring changes that occur with rapid urbanisation may help in developing strategies for dietary interventions to improve health. Food frequency questionnaires (FFQs) are a common method for measuring usual dietary intake, particularly in large epidemiological studies.[2] Many have been validated and are widely used in studies in high-income countries, but less work has been done in countries with more heterogeneous diets and lower levels of literacy. It is important to evaluate how well an FFQ measures diet in such populations so that data can be interpreted appropriately.

The Indian Migration Study (IMS) was designed to look at the effect of rural-urban migration on obesity and diabetes risk in India.[3] Migrant participants were recruited from factories in Lucknow, Nagpur, Hyderabad and Bangalore, and their non-migrant rural siblings travelled from rural areas to participate. Rural or urban residence was self-defined by participants, with reference to the Indian Census 2001 definitions if required.[4] Comparisons of differences in dietary intake between rural, migrant, and urban participants was a major objective of the study but 24 hour recalls were not considered viable as all the rural participants had had to travel in the 24 hours prior to assessment, which would be likely to affect what they ate. Diaries were not possible because many people in the population were not literate. An FFQ was considered the only feasible method to use in this population.

When the study was being designed, a small number of FFQs had been developed for specific regions of India,[5-8] but none was available to cover north, central and south India where the IMS was based. A single FFQ to cover the different regions of the study was developed, firstly because the migrant population could have come from many different areas; secondly because there is an increasing availability of regional foods in different areas; and thirdly because it was preferable to have a standard questionnaire to use across the four regions of study. This paper describes the development of the FFQ, and evaluation of its validity.

MATERIALS AND METHODS

Development of the FFQ

A single semi-quantitative FFQ was developed to cover the four study sites (Lucknow, Nagpur, Hyderabad, and Bangalore, plus rural areas). A total of 400 individuals (men and women, aged 18-60 years) from the four regions were interviewed to obtain a single 24 hour recall and a questionnaire about seasonal and festival food habits. A food list was generated from this. Inclusion and exclusion of foods was done according to the following

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principles used elsewhere: retaining items that were consumed by a large proportion of people; combining similar foods consumed by few people and that had similar portion sizes and nutrient content (eg, mutton biriyani and chicken biriyani); retaining items where the content of a particular nutrient of interest was high; eliminating foods that did not contribute to any nutrients of interest (eg, coconut water). [9]

The final food list contained 184 items. The reference period for the FFQ was the preceding year. To obtain an estimate of portion size, subjects were shown common household portions (bowl, ladle, tablespoon, teaspoon, glass) and were asked to report portion sizes in relation to this standard. For each food item the average portion size and the frequency of consumption (number of times consumed per day, week, month or year) were documented. For seasonal fruit and vegetables, participants were asked about consumption when the item was in season. Due to levels of illiteracy in the population, the questionnaire was designed to be interviewer-administered.

Because nutrient values for cooked Indian foods are unavailable, weighed recipes (using digital scales accurate to 1g) were obtained from participants who regularly prepared these foods, under the supervision of a nutritionist. Because of variation in food preparation, recipes were collected for the four regions and rural and urban areas separately. Cooking-oil specific databases were also created, to account for the marked differences in fat composition of cooking oils used in India. Recipes were checked for face validity with nutritionists and other study participants. The Indian food composition tables were then used to estimate the nutrient content of a single portion of each food item.[10] Where nutrient values were unavailable from the Indian food composition table, the United States Department of Agriculture nutrient database (USDA, Release No 14)[11] or McCance and Widdowsons Composition of Foods were used.[12] For foods for which none of the above food composition tables provided nutrient values, estimated values from a similar food, or average of multiple foods was used. In the absence of information about the micronutrient losses during food preparation and cooking for Indian foods, losses during food preparation were not taken into account while developing the nutrient database. Databases for food group content of each item included in the FFQ were also developed from the recipes.

To link information from the FFQ to the nutrient databases, programs were written in STATA statistical software, and gave an output of average nutrient and food group consumption per day.

Validity study

The validation study used three 24 hour recalls as a reference measure - two of which were collected during the week and one at the weekend, over a period of 1-2 months for each participant. The validity study sample was recruited from volunteer participants in the IMS. It was not considered practical to recruit rural people from the IMS because they had come from many different locations and often travelled long distances. Rural participants were selected from villages nearby the IMS factory sites in Lucknow, Nagpur, Hyderabad and Bangalore who had not been involved in the IMS previously. Participants completed the interviewer-administered FFQ first and then at least one week later completed their first 24 hour recall by interview and then completed two further 24 hour recalls by interview at weekly intervals to avoid days of correlated food consumption. An average of intake in the three recalls was taken, and nutrient and food group intake derived. Information on age, sex, occupation, and education was collected.

Statistical methods

All data were checked for outliers and normality. Median nutrients and food group intakes from the FFQ and 24 hour recalls, and median differences (FFQ- 24 hour recalls) were calculated, due to the non-normal distribution of some variables. Percentage differences were also calculated ((FFQ- 24 hour recalls)/FFQ*100) to compare validity of nutrients and food groups on different scales of intake. Wilcoxon sign-rank tests were used to statistically assess differences. For variables for which the mean and standard deviation of differences was the same throughout the range of measurements, limits of agreement were calculated and Bland-Altman plots drawn (mean difference ±1.96*SD).[13] Non-normal variables were transformed to the natural log scale before drawing Bland Altman plots if appropriate. Spearman correlation coefficients were calculated. Energy adjusted correlations for nutrients were calculated using the residuals method to calculate energy-adjusted intake. Deattenuated correlation coefficients were also calculated in order to account for random within-person variation in the 24 hour recalls.[2]

Because nutrient analyses often use categorized data, participants were also split into tertiles and their tertile grouping from the FFQ and 24 hour recall intake compared and Cohen's kappa statistic calculated, using weightings of 1 for complete agreement; 0.5 for partial disagreement (participants classified in adjacent tertiles by the two FFQs); 0 for complete disagreement (participants classified into opposite tertiles by the two methods).[14] Kappa statistics give a measure of how closely the two methods categorise individuals, with a statistic of 1.00 indicating perfect agreement, and a statistic of 0 indicating no better agreement than chance. For values in between 0 and 1: <0.20 indicates poor agreement; 0.21-0.40 fair; 0.41-0.60 moderate; 0.61-0.80 good; 0.81-1.00 very good.[15]

Stratification by sex, rural/urban residence, and education was considered to assess whether validity varied by subgroup. Differences in nutrients and food groups obtained by FFQ and 24 hour recall were statistically tested by fitting linear regression models and performing Wald tests on model parameters (for normally distributed variables), and by using Wilcoxon rank sum tests (for the non-normally distributed variables).

All analyses were conducted with STATA 11 statistical software (StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP).

RESULTS

Five hundred and thirty people agreed to participate in the study, and completed the FFQ and at least one 24 hour recall. Of these, 417 participants completed three recalls,

Table 1. Characteristics of the Indian Migration Study FFQ validity study population

Characteristic	Men (n=285)	Women (n=245)	Total (n=530)
Age, years			
<30	65 (23)	48 (20)	113 (21)
30-39	59 (21)	56 (23)	115 (22)
40-49	73 (26)	68 (28)	141 (27)
50+	88 (21)	73 (30)	161 (30)
Education			
No formal education	54 (19)	62 (25)	116 (22)
Primary	37 (13)	44 (18)	81 (15)
Secondary	132 (46)	97 (40)	229 (43)
Beyond secondary	62 (22)	42 (17)	104 (20)
Region			
Lucknow	77 (27)	83 (34)	160 (30)
Nagpur	44 (15)	21 (9)	65 (12)
Hyderabad	90 (32)	84 (34)	174 (33)
Bangalore	74 (26)	57 (23)	131 (25)
Occupation			
No employment	55 (19)	170 (69)	225 (42)
Manual	180 (63)	44 (18)	224 (42)
Non-manual	50 (18)	31 (13)	81 (15)

Table 2. Validity of the Indian Migration Study FFQ: median reported absolute nutrient intake levels as estimated by 24-hr recalls and FFQ, median difference (FFQ-24-hr recalls), and Spearman's correlation coefficients

Variable	Median intake FFQ	Median intake 24-hr recalls	Median paired difference (%)	*p*-value	Spearmans correlation coefficient		
					Observed	Deattenuated	Energy-adjusted
Macronutrients							
Energy (kJ)	9365	7769	1710 [19]	<0.001	0.62	0.71	
Energy (kcal)	2238	1857	409 [19]	<0.001	0.62	0.71	
Protein (g)	65	56	8 [14]	<0.001	0.61	0.87	0.50
Fat (g)	59	46	15 [26]	<0.001	0.42	0.57	0.52
Carbohydrate (g)	349	287	60 [16]	<0.001	0.69	0.76	0.52
Saturated fat (g)	17	13	5 [26]	<0.001	0.57	0.75	0.52
Fibre (g)	11	8	2 [24]	<0.001	0.57	0.72	0.43
Food groups							
Cereals (g)	302	261	35 [11]	<0.001	0.72		0.58
Legumes (g)	52	49	4 [10]	<0.001	0.54		0.48
Vegetables (g)	155	103	54 [36]	<0.001	0.29		0.24
GLV (g)	19	3	7 [72]	<0.001	0.33		0.30
Fruits/juices (g)	99	25	60 [82]	<0.001	0.26		0.27
Roots (g)	26	15	10 [58]	<0.001	0.67		0.63
Nuts (g)	8	4	2 [43]	<0.001	0.59		0.64
Fats and oils (g)	34	23	10 [29]	<0.001	0.31		0.55
Spices (g)	16	12	3 [20]	<0.001	0.26		0.33
Sugars (g)	29	20	8 [31]	<0.001	0.55		0.45
Egg (g)	4	0	2 [100]	<0.001	0.25		
Dairy (g)	236	172	34 [18]	<0.001	0.63		0.59
Fish (g)	1	0	0 [100]	<0.001	0.26		
Meat (g)	17	0	0 [100]	<0.001	0.48		
Tea/coffee	3	2	0 [0]	<0.001	0.59		
Beverages (g)	7	0	1 [100]	<0.001	0.35		
Salt (g)	8	6	1 [18]	<0.001	0.52		0.52

4 participants completed two recalls, and 109 participants completed one recall. Two hundred and fifty-five people had two weekdays and one weekend recall as per the protocol; analyses showed no evidence of difference between intake from the weekday and weekend recalls, so those without a weekend recall were not excluded. Of the participants, 54% were male, and over half had secondary education (Table 1).

Reported intake from the FFQ was higher than reported intake from the 24 hour recalls (Table 2). Median differences ranged from 0% (tea/coffee) to 100% (egg, fish, meat, beverages), and observed Spearman's rank correlation coefficients ranged from 0.25 (egg) to 0.72 (cereals). Energy adjustment did not improve correlation coefficients, with the exceptions of fat, nuts, fats and oils, and spices (Table 3). Deattenuation (possible only for nutrients because of the inability to transform the 24 hour recall intake data for food groups) improved all correlation coefficients. Kappa statistics ranged from 0.07 (egg) to 0.51 (carbohydrate, roots).

The Bland-Altman plot for energy showed a mean difference of 1734 kJ, indicating substantial overestimation of intake in the FFQ compared to the recalls (Figure 1). There was consistency in the differences seen across the

Table 3. Kappa statistics for agreement between FFQ and 24-hr recalls when dietary variables are categorised into tertiles

Variable	Kappa statistic	
	Unadjusted	Energy adjusted
Macronutrients		
Energy (kJ)	0.45	
Energy (kcal)	0.45	
Protein (g)	0.44	0.34
Fat (g)	0.29	0.37
Carbohydrate (g)	0.51	0.37
Saturated fat (g)	0.39	0.38
Fibre (g)	0.39	0.27
Food groups		
Cereals (g)	0.49	0.41
Legumes (g)	0.39	0.37
Vegetables (g)	0.21	0.17
GLV (g)	0.22	0.19
Fruits/juices (g)	0.21	0.17
Roots (g)	0.51	0.46
Nuts (g)	0.41	0.45
Fats and oils (g)	0.21	0.38
Spices (g)	0.21	0.22
Sugars (g)	0.39	0.30
Egg (g)	0.07	
Dairy (g)	0.46	0.45
Fish (g)	0.09	
Meat (g)	0.33	
Tea/coffee	0.32	
Beverages (g)	0.15	
Salt (g)	0.36	0.35

range of measurements, but the limits of agreement were wide (-3400 to 6906 kJ). Bland-Altman plots for the other nutrients showed similar trends. Bland-Altman plots for all food group intakes (except cereals and legumes) showed an increase in variability of differences as the magnitude of the measurement increased.

Differences in validity by certain subgroups were also explored, although results should be interpreted with caution because the study was not designed to assess effect modification. Very few differences between men and women were found, with the exception of beverages, which men overestimated more than women. The FFQ overestimated nutrients and food groups in both urban and rural people, but the magnitude of this difference was greater in urban participants for some variables, most notably fat (11 g mean difference in rural; 18 g mean difference in urban, p=0.003) and vegetables (33 g median difference in rural; 75 g median difference in urban, p<0.001). Validity did not differ by educational status, with the exception of vegetables, which was over-reported more in participants with secondary or higher education than those with less education (77 g median difference vs 47 g median difference, (p=0.03)).

DISCUSSION

The present study demonstrates that it is possible to use a single FFQ to measure diet across multiple regions of India, with reasonable validity. Previous studies have considered only FFQs developed for specific regions of India. There was overestimation of overall energy intake and consumption of all food groups and macronutrients, but the kappa statistics showed that the ranking of individuals was acceptable, and ranking will be the main use of this FFQ. For rarely consumed food groups (fish, egg, meat, and beverages), there were very low kappa statistics and high percentage difference between the FFQ and recalls, but these are likely to be underestimates of validity because of the differences in reference period of the FFQ and 24 hour recalls. Infrequently consumed foods that are reported in the FFQ may not have been consumed on any of the recall days for which data were collected. Daily intake of such food groups is therefore likely to be better estimated by the FFQ than the 24 hour recalls. There are some design features of the FFQ that might be considered as explanations for the overall over-estimation bias seen in the FFQ. In order to have one FFQ that captured the diets of four different regions of India and both rural and urban areas, a large number of foods were included (n=184). Some work has shown that asking more questions may lead to overestimation once intake is summed

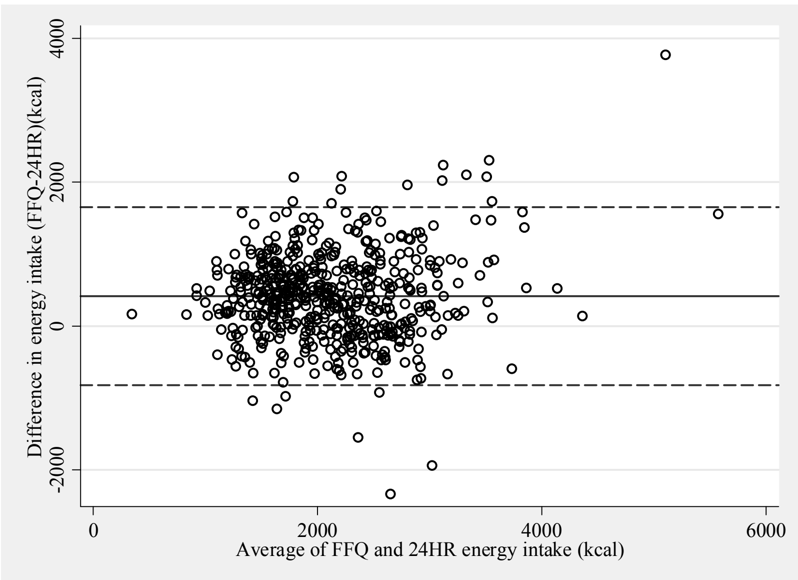

Figure 1. Bland Altman plot of differences in reported energy intake between FFQ and 24-hr recalls in the validity sample (solid line is mean difference, dotted lines are limits of agreement)

across questions.[16] The heterogeneity of the population covered by the IMS FFQ is large because a single questionnaire is used for rural and urban people of four different regions. Some authors have suggested that region and place specific questionnaires should be used,[6,9,17,18] but when looking at a migrant population it is necessary to include food items from the different regions of origin in the questionnaire. Some over-estimation and error may have arisen from people reporting items that they did not eat, but people were briefed before completing the questionnaire that there would be foods that they had not heard of, and told to report zero consumption for these foods.

Strengths of the study include the large sample size, the urban and rural and regional coverage, and inclusion of men and women across a wide range of ages, but limitations should be acknowledged. Participation was of people who were first contactable and willing to participate. Because non-random samples were collected, the participating individuals may have been more conscientious than those who did not participate. There is also an issue of generalisability because the rural population included was not (for logistical regions) the same as the rural population in the main study. Ideally, the reference method used in a validity study should not have correlated error with the method being investigated. In our setting however it was not feasible to conduct a biomarker study or 7-day food diaries or weighed dietary assessments, which are likely to have less correlated error with FFQs. In common with all dietary assessment methods there is difficulty in defining an ideal reference standard. Both FFQs and recalls can be subject to reporting bias and perception of serving sizes. However, recalls continue to be a widely used reference because they measure the specific rather than the general, rely on short-term rather than long-term memory, have a low responder burden, and can be used for populations in which illiteracy is common.

The reproducibility and validity of our FFQ gave similar results to regional FFQ studies from India.[6-8] All previously published Indian FFQs have shown overestimation of intake relative to the reference method, which is also commonly found with FFQs used in western settings.[19] The results are encouraging given that studies to date have concentrated on specific regions of India, whereas the IMS FFQ was used in diverse regions from across India. Willet describes results from western reproducibility studies giving correlations of around 0.5-0.7 for nutrient intakes measured at intervals of 1 to 10 years.[2]

The results from the assessment of this FFQ show that a single FFQ can be used to capture dietary intake information for individuals from multiple regions across India, and provide assurance that the data can be used in analyses comparing dietary intake between groups in the study, looking at both patterning of dietary intake and associations between diet and disease

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AUTHOR DISCLOSURES

The authors have no conflicts of interest to declare.

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發展適用於印度都市及鄉村地區之半定量飲食頻率問卷

本篇研究目的為發展一份半定量飲食頻率問卷，並評估此問卷是否能有效測量印度都市及鄉村地區研究對象的飲食情形。以一份簡單的飲食頻率問卷在印度四個區域的城鎮及鄉村測試。為評估問卷效度，首先以飲食頻率問卷面訪 530 位工廠工人及鄉村居民，相隔至少一周後，接續進行三次的 24 小時飲食回憶記錄。將營養素及食物類別攝取量以中位數、一致性檢定(kappa statistics)、相關性檢定(Spearman’s correlation coefficients)及 Bland-Altman plots 等方法，比較兩種飲食測量方法之相關性。與 24 小時飲食回憶記錄相比，飲食頻率問卷有高估的現象(平均能量攝取差異為 1743 kJ)；kappa 統計量之範圍為 0.07(雞蛋)至 0.51(醣類)。結果顯示，此半定量飲食頻率問卷可用來評估印度不同地區的膳食攝取，並且有足夠效度以量測食物類別的攝取。

關鍵字：飲食評估、飲食頻率問卷、效度、印度、膳食攝取