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Development and validation of a nutritional questionnaire for the Palestine population

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Abstract

Objective: Dietary habits vary widely among regions and cultural groups, and FFQ need to be designed for specific populations. The objectives of the present study were to develop and test the repeatability and relative validity of a medium-length semi-quantitative FFQ for measuring the energy and macronutrient intakes of a specific population and to contribute a methodological framework for this procedure.
Setting: Palestinian families in the Hebron area.
Design: After a preliminary survey of a subgroup of homemakers using 3 d diet recall, stepwise multiple regression analysis was used for selected nutrients to choose foods for inclusion in the FFQ.
Subjects: The FFQ was administered to a study population of 169 women representing the same number of families.
Results: The Wilcoxon test and Bland–Altman plots were used to compare the FFQ results with the mean 3 d diet recall results. A high level of concordance was found, validating the FFQ. In this population, the mean consumption of SFA was above recommendations and the intakes of vitamin D, folic acid, Ca, Fe and K were deficient.
Conclusions: The availability of diet assessment instruments designed for specific populations and cultures is of immense value to researchers and policy makers. The study describes a simple and effective method to develop and validate an FFQ for a given population of interest.

Keywords
FFQ
Palestinian families
Nutritional questionnaire validation

Semi-quantitative FFQ are used extensively in epidemiological studies to evaluate food intakes and to explore the diet and associations with specific nutritional profiles, such as the Mediterranean diet[1,2]. FFQ are relatively easy and inexpensive to administer and can be used to measure dietary intake over a prolonged time period[3,4]. However, because dietary habits vary widely among regions and cultural groups, FFQ must be tailored for use and validated in specific populations[4–6].

No gold standard instrument is available for measuring dietary intake. One approach to the validation of the FFQ is to compare its responses with 3 d diet recall results[7–10]. In these validation studies, an acceptable concordance between the instruments has generally been found for energy or macronutrient intakes but not for micronutrients that do not form part of the daily diet[11–16]. In selecting a reference measure for a validation study, the sources of error of the two instruments should be as independent as possible[11,17]. The 24 h recall is not susceptible to the possible misinterpretation of questions in the FFQ, but both instruments share some potential errors, including recall bias and variations in the perception of portion sizes. Nevertheless, multiple-day diet recall is considered an appropriate reference method in FFQ validation studies[7,18,19], and the speed and ease of its administration allow a large number of subjects to be investigated without using excessive resources. Further research is required to improve the methodological approach to this validation process.

The objectives of the present study were to develop and test the repeatability and relative validity of a medium-length semi-quantitative FFQ for measuring the energy and macronutrient intakes of a specific population (Palestinian families in the Hebron area) and to contribute a methodological framework for this procedure. In the event of a successful validation of the instrument, a further objective was to determine the intakes of specific nutrients in the diet of this population and to identify any dietary risk factors for chronic disease.

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Table 1 Stepwise multiple regression results for selected nutrients, showing the foods included in the FFQ

Energy		Protein		Lipids		Carbohydrate		Ca		Fe	
Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2
Bread	0·373	Meat	0·436	Sunflower oil	0·348	Bread	0·541	Cheese	0·632	Fish	0·799
Cheese	0·508	Cheese	0·786	Olive oil	0·571	Pasta	0·885	Milk	0·849	Bread	0·878
Sunflower oil	0·627	Rice	0·845	Corn oil	0·704	Fruit	0·917	Yoghurt	0·906	Legumes	0·915
Pasta	0·727	Milk	0·884	Cheese	0·841	Potatoes	0·940	Bread	0·947	Eggs	0·945
Olive oil	0·818	Cold meats	0·920	Meat	0·906	Vegetables	0·959	Vegetables	0·968	Meat	0·964
Corn oil	0·863	Fish	0·951	Bread	0·919	Milk	0·968				
Meat	0·894	Yoghurt	0·960	Milk	0·933						
Cold meats	0·919	Eggs	0·968	Fish	0·938						
Milk	0·942			Eggs	0·942						
Salad	0·960										

Se		Zn		P		Mg		Thiamin		Riboflavin	
Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2
Fish	0·938	Fish	0·916	Cheese	0·306	Bread	0·538	Rice	0·418	Milk	0·827
Meat	0·961	Legumes	0·943	Legumes	0·522	Legumes	0·748	Bread	0·694	Meat	0·926
Legumes	0·983	Bread	0·954	Bread	0·698	Vegetables	0·848	Meat	0·775	Vegetables	0·946
Yoghurt	0·864	Fruit	0·803	Cheese	0·892	Fruit	0·86	Legumes	0·959		
Pasta	0·896	Potatoes	0·914	Vegetables	0·911	Cheese	0·968				
Meat	0·921	Milk	0·942	Legumes	0·939	Bread	0·979				
Milk	0·956	Rice	0·964	Precooked	0·969						

Niacin		Folic acid		Vitamin C		Vitamin A		Vitamin E		Vitamin D	
Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2	Foods	R^2
Bread	0·655	Vegetables	0·705	Vegetables	0·630	Vegetables	0·458	Sunflower oil	0·966	Fish	0·816
Meat	0·835	Salad	0·840	Juice	0·808	Fruit	0·793	Legumes	0·98	Eggs	0·874
Cold meats	0·88	Potatoes	0·902	Fruit	0·897	Salad	0·886	Milk	0·894		
Rice	0·919	Juice	0·922	Potatoes	0·967	Precooked	0·951	Cheese	0·902		
Potatoes	0·956	Yoghurt	0·906								

$P < 0·001$ for the R^2 value of each nutrient.

Experimental methods

Population

The population of interest comprised families living in Hebron and nearby villages in Palestine, recruiting 169 volunteer participants from among female homemakers. After obtaining informed consent for participation in the study, a single researcher gathered data from each participant, using an interviewer-administered questionnaire, on the following variables: sex, age, weight, height, number of family members, number of children, employment, schooling, nutrition-related lifestyle habits (both qualitative and quantitative variables) and dietary behaviour (consumption of breakfast, number of meals per day, special diet, diabetes, calorie restriction, etc.). The FFQ and 3 d diet recall were administered at the same interview (see below).

Development of specific FFQ

Previously, a different group of fifty women from the same region had participated in a preliminary study to determine the food items to include in the FFQ for Palestine. These women were administered 24 h recall questionnaires on three consecutive days (including one non-working day). The data gathered on their daily diet were used to construct an initial FFQ, using a previously established methodology[20]. FFQ results in the same population were subjected to a stepwise multiple regression analysis for each nutrient, with the total nutrient intake as dependent variable[11], in order to select the food items for inclusion in the final FFQ. Nutrients that explained ≥80 % of the between-person variability were included in the final FFQ. Based on these results, the final semi-quantitative FFQ for the Palestinian population, shown in Table 1, included the following food groups: cereals and grain products; starchy roots and tubers; dry grain legumes and legume products; nuts and seeds; vegetables; fruit; sugars, syrups and sweets; meat and poultry; eggs; fish and shellfish; milk and milk products; oils and fats; and beverages. The thirteen food groups contain a total of ninety-eight types of food and the FFQ permits estimation of the consumption of twenty-two nutrients, including energy.

In both the initial and final FFQ, data were gathered on the consumption or not of an item and the number of times it was consumed per day, week or month during the previous year. The amounts of food consumed were expressed in grams or millilitres or in other common measures, such as a slice, tablespoon or cup, or as standard

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serving size, modified from European references according to the experience and knowledge of the Palestinian author. Foods were converted to nutrients by using a computer program that included Spanish food tables and FAO food composition tables for the Middle East[21,22]. The daily intake of each nutrient was calculated by multiplying the amount reported in the questionnaire by the corresponding value in the food composition tables[11].

Procedure

The 3 d diet recall questionnaire and the final FFQ were administered at home face-to-face by a trained dietitian (M.H.) to the women recruited for the main study. The recall questionnaire covered the previous three days, ensuring that one non-working day was included. According to the application norms, participants were given no advance warning of the day on which it would be presented.

Statistical analysis

The mean and standard deviation for intake of each nutrient were computed for both the FFQ and 3 d diet recall. Stepwise regression models were used to assess the contribution of each food item to the total intake and to determine the between-person variability, with individual food items as independent variables and total nutrient intake as dependent variable. The concordance between the FFQ and 3 d diet recall results (mean of three 24 h diet recalls) was analysed by means of the Wilcoxon signed-rank test, de-attenuated intra-class correlation analysis and the Bland–Altman method[23], in which the limits of agreement were calculated as the mean difference ± 1·96 (values close to or greater than 95 % = very good compliance). $P < 0·05$ was considered significant in all tests. The statistical software package SPSS version 15 was used for the statistical analyses.

Results

Out of the initial sample of 169 women, twenty (12 %) were excluded for failure to complete the questionnaire or unwillingness to continue in the study, leaving a final study sample of 149 women representing 149 families. The majority of the participants were overweight, were aged between 31 and 50 years, and had only primary schooling. The characteristics of these women are given in Table 2. Slightly more than half of them worked at home as housewives, while 43 % worked both inside and outside the home. Family size ranged from three to fourteen members and the number of children from one to twelve. The median number of meals per day was three (range two to five).

The nutrient intakes estimated from the 3 d diet recall results are given in Table 3, which reports the within-subject CV (among the three 24 h recalls) and the between-subject CV[11]. Table 4 and Fig. 1 exhibit the results of Bland–Altman plots for the agreement between the FFQ and the 3 d diet recall, which evidenced a high level of concordance.

Table 5 shows the mean intakes calculated from the FFQ results and compares them with international recommendations[24]. The mean SFA intake was above the recommended daily intake, while deficiencies (<2/3 of the recommended daily intake) were observed in the intakes of vitamin D, folic acid, Ca, Fe and K.

Discussion

In the present study, a specifically developed FFQ was validated in a group of mothers from Palestine, using the

Table 2 Characteristics of the study population: 169 women from Hebron, Palestine

	%	*n*	χ^2	*P*
BMI (kg/m^2)				
≤25·00	30·2	45		
25·01–31·06	47·0	70	13·705	0·001
≥31·07	22·8	34		
Age (years)				
≤30	25·5	38		
31–50	63·8	95	66·940	0·001
≥51	10·7	16		
Schooling				
None	6·7		51·96	0·001
Primary	53·7			
Secondary	39·6			
Place of work				
In home	57·0		3·35	0·067
In home and out of home	43·0			
	Minimum	Maximum	Median/mode	Range
Family size	3	14	6/8	11
No. of children	1	12	4/6	11
No. of meals/d	2	5	3/3	3

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mean 3 d diet recall results as reference value. In order to capture the intake of nutrients whose consumption varies widely in and among individuals, the mean of multiple-day recalls is often utilized as reference scale for FFQ validation rather than single recall data[3,25–27].

Table 3 Within-person (CV_w) and between-person (CV_b) coefficients of variation in nutrient intakes estimated from the 3 d diet recall (mean of three 24 h diet recalls) among 149 women from Hebron, Palestine

Energy or nutrient	Mean	Median	CV_w (%)	CV_b (%)
Energy (MJ/d)	6·62	6·18	20·18	38·64
Protein (g/d)	58·70	55·15	29·94	46·73
Lipids (g/d)	52·03	48·83	29·01	46·01
Carbohydrate (g/d)	232·72	204·70	25·83	44·68
Fibre (g/d)	20·29	17·20	37·37	74·24
Ca (mg/d)	506·64	465·50	35·47	47·85
Fe (mg/d)	11·30	9·98	28·37	47·45
Mg (mg/d)	256·25	218·13	33·85	66·71
P (mg/d)	926·12	858·16	29·77	53·59
Zn (mg/d)	6·27	5·63	37·54	72·19
Se (μg/d)	70·35	56·95	38·83	79·32
K (mg/d)	2334·03	2199·96	32·29	48·74
Na (mg/d)	1758·80	1515·79	52·77	91·51
Iodine (μg/d)	29·38	26·73	39·16	51·74
Thiamin (mg/d)	1·15	1·00	31·53	72·15
Riboflavin (mg/d)	2·61	2·52	46·30	67·10
Niacin (mg/d)	30·62	29·36	37·73	85·86
Vitamin B_6 (mg/d)	1·79	1·67	38·56	65·37
Folate (μg/d)	258·01	226·01	39·03	53·32
Vitamin C (mg/d)	72·57	112·04	68·53	79·50
Vitamin A (μg/d)	400·80	388·68	63·43	58·11
Vitamin D (μg/d)	0·54	0·05	125·88	281·54
Vitamin E (mg/d)	7·48	6·61	30·83	54·26

The FFQ proposed for this population contained a total of ninety-eight food types in thirteen food groups. These foods correspond to items consumed in the Mediterranean region in general[20,28,29] and in Palestine in particular[21]. This FFQ was validated by using the Wilcoxon test to compare its results with those of the 3 d diet recall, finding no significant differences between them in eleven out of the twenty-two nutrients evaluated (energy, protein, total lipids, carbohydrates, fibre, Ca, P, Se, K, Na and vitamin B_6), but observing significant differences in the remaining micronutrients. Application of the Bland–Altman test[23] to compare between the results of the 3 d diet recall and the FFQ showed that only the estimations of Mg, Zn, Fe, vitamins A, E, C and D, thiamin, riboflavin, niacin and folic acid failed to meet the criteria for concordance, which may be attributable to the lower representation of these micronutrients in the diet of this population. Outliers in this analysis ranged from 0 to 5 %. According to these results, the proposed FFQ for the Palestinian population can be considered validated. Table 4 shows the nutrients that are validated in the FFQ (>50 %).

The methodology of our study deserves further comment. Correlation coefficients (r) have been used by some authors to evaluate the concordance between instruments. However, this method can yield the association between two variables but not the degree of agreement;

Table 4 FFQ validation: comparison of energy and nutrient intakes estimated by the FFQ and 3 d diet recall (mean of three 24 h diet recalls, 24hR), correlation between the two methods and results of Bland–Altman test of agreement among 149 women from Hebron, Palestine

	FFQ		24hR				Bland–Altman test	
Energy or nutrient	Median	IQR	Median	IQR	De-attenuated intra-class correlation	*P* value (Wilcoxon test, FFQ v. 24hR)	Mean difference (FFQ – 24hR)	95 % CI
Energy (MJ/d)	6·57	1·46	6·18	4·00	0·601	0·317	7·8	−152·9, 168·5
Protein (g/d)	42·05	19·62	55·15	25·81	0·559	0·062	−16·5	−23·2, −9·7
Lipids (g/d)	67·51	23·14	48·83	36·24	0·755	0·061	20·6	13·6, 27·6
Carbohydrate (g/d)	337·10	102·33	204·57	146·02	0·763	0·263	71·6	48·5, 94·6
Fibre (g/d)	21·04	5·62	17·20	12·92	0·650	0·399	−0·9	−4·4, 2·6
Ca (mg/d)	540·05	327·86	465·50	308·22	0·516	0·273	44·1	−30·9, 119·0
Fe (mg/d)	17·55	9·55	9·98	7·00	0·523	0·010	7·1	5·4, 8·7
Mg (mg/d)	237·99	64·15	218·13	173·23	0·400	0·030	−37·7	−75·7, 0·4
P (mg/d)	1281·93	387·88	858·16	574·73	0·532	0·095	376·0	250·1, 501·9
Zn (mg/d)	19·54	16·18	5·63	4·81	0·471	0·001	15·3	13·3, 17·3
Se (μg/d)	44·34	46·10	56·95	47·34	0·615	0·065	−21·1	−36·7, −5·5
K (mg/d)	1758·90	486·1	2199·96	1607·78	0·462	0·061	−682·5	−935·4, −429·7
Na (mg/d)	2188·75	695·14	1515·79	1029·98	0·250	0·362	276·7	−121·2, 74·7
Thiamin (mg/d)	1·39	0·42	1·00	0·70	0·415	0·016	−0·3	0·1, 0·5
Riboflavin (mg/d)	1·58	0·92	2·52	3·16	0·035	0·001	−0·9	−1·3, −0·5
Niacin (mg/d)	20·06	4·27	29·36	25·10	0·372	0·001	−3·4	−6·8, 0·02
Vitamin B_6 (mg/d)	1·92	1·32	1·67	1·28	0·337	0·265	0·1	−0·1, 0·4
Folate (μg/d)	221·73	53·02	226·01	53·93	0·358	0·022	−131·2	−162·7, −99·6
Vitamin C (mg/d)	66·43	28·53	112·04	120·45	0·209	0·001	−48·2	−68·4, −28·1
Vitamin A (μg/d)	635·96	367·93	386·68	326·52	0·486	0·001	225·8	147·9, 303·6
Vitamin D (μg/d)	1·25	1·08	0·05	0·91	0·003	0·001	1·0	0·6, 1·3
Vitamin E (mg/d)	10·81	7·22	6·61	5·46	0·815	0·001	4·7	3·1, 6·2

IQR, interquartile range.

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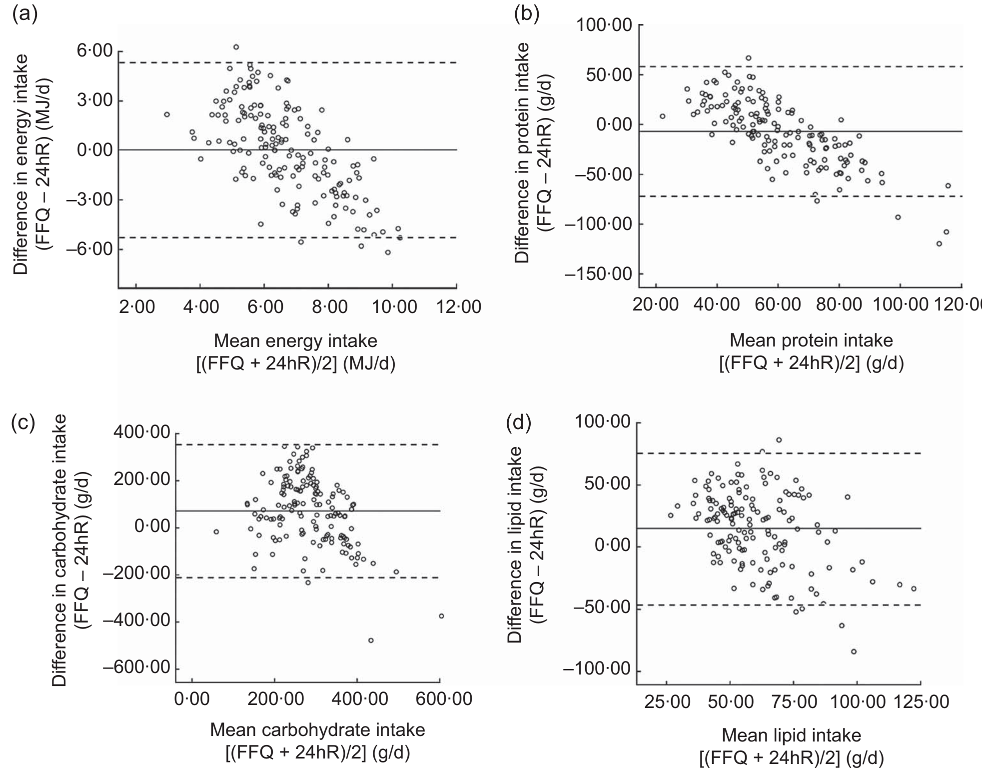

Fig. 1 Bland–Altman plot for FFQ validation: agreement between the semi-quantitative FFQ and the 3 d diet recall (mean of three 24 h diet recalls, 24hR) in estimating (a) energy intake, (b) protein intake, (c) carbohydrate intake and (d) lipid intake among 149 women from Hebron, Palestine. ——— indicates the mean difference; – – – – – indicate the upper and lower limits of agreement

Table 5 Minimum, maximum and mean intakes, and percentages of recommended intake, from FFQ responses among 149 women from Hebron, Palestine

	Minimum	Maximum	Mean	SD
Energy (MJ/d)	2·70	9·60	6·48	1·19
Carbohydrate (g/d)	50·49	462·06	319·50	83·63
Fibre (g/d)	8·05	31·02	21·20	5·01
Water from foods (ml/d)	276·61	731·84	512·39	101·46
Percentages of recommended intake*				
Lipids	72·89	242·50	141·79	36·50
MUFA	45·28	192·80	116·57	31·14
PUFA	37·75	270·75	176·58	64·75
SFA	96·60	277·00	169·20	34·80
Protein	64·11	207·05	138·58	27·82
Cholesterol	47·34	110·29	80·43	13·94
Ca	20·39	63·99	40·02	8·57
Fe	27·62	89·03	59·82	12·65
Mg	30·77	96·69	68·55	14·29
P	67·57	213·92	147·58	27·39
Zn	44·36	158·01	106·21	21·14
Se	40·58	258·74	176·70	48·86
K	22·96	63·81	43·85	7·38
Na	28·30	164·80	116·30	27·83
Iodine	13·93	47·51	30·42	5·85
Thiamin	38·37	120·33	84·45	17·46
Riboflavin	43·22	110·54	78·28	12·86
Niacin	69·23	273·22	179·55	37·84
Vitamin B_6	44·30	127·95	83·22	16·78
Folate	31·40	90·46	57·73	12·81
Vitamin C	12·75	127·66	71·69	24·89
Vitamin A	24·34	197·30	104·40	35·51
Vitamin D	2·03	25·94	11·49	6·49
Vitamin E	10·99	122·04	74·06	32·85

*Percentage of daily intake recommended by the Dietary Guidelines for Americans 2005[24].

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therefore, data with high correlation coefficients may show little concordance. It is therefore recommended to apply other tests, including the Wilcoxon test or Student's *t* test[30], although it must be borne in mind that a lack of concordance may simply result from an inadequate sample size with these tests. Bland and Altman[23] proposed establishing the concordance between quantitative instruments by calculating limits of agreement according to the mean (d) and standard deviation of the difference between the measured values. For a normal distribution, the majority of differences should fall between the mean and about 2 SD of the difference variable ($d \pm 1 \cdot 96$). Generally, this type of distribution is not followed by the measurements themselves, but it is followed by the values of differences. Graphs constructed with the Bland–Altman method permit the investigation of relationships between measurement errors and true values, evaluating the magnitude of disagreement between measurements and identifying outliers.

FFQ and multiple-day recall studies can be considered calibration and correlation rather than validation procedures, given that these methods may share some errors, as noted in the introduction. The use of biomarkers as a reference method is not feasible because there are no markers for many micronutrients and they do not generally offer a good fit with other estimation methods. In the present study, our aim was not to fit questionnaire results to a given nutrient but rather to calibrate a questionnaire for a group of nutrients, i.e. the diet of a specific population. Serra-Majem *et al.*[31] proposed various criteria for the correct calibration of a nutritional assessment method, including a sample size of 100–200 participants with different characteristics (e.g. age, BMI) from a single region and the use of statistical tests for the validation. These criteria were met in the present study of 169 women from Hebron in Palestine who varied in age and BMI, among other variables. In addition, we applied the Wilcoxon test for comparison of means and de-attenuated intra-class correlation analysis, which is critical to reduce the dependence on inter-individual variations, and we also used the Bland–Altman test to estimate the concordance between quantitative tests. Our study further complied with the above recommendations by gathering data in a face-to-face interview with a trained specialist. Moreover, the 3 d diet recalls covered one non-working day and two working days and were conducted during the same month (August) in two successive years. In their review of 124 validation studies, Serra-Majem *et al.*[31] assigned quality scores ranging from 0·5 to 6. Based on the same scale, we have estimated a score of about 5 for the present study, considered a very good result. One study limitation was that no data were available to compare the characteristics of participants and non-participants. Moreover, future studies should attempt to recruit a larger number of women.

Application of the proposed FFQ revealed an elevated mean protein intake in this Palestinian population, as reported in the majority of published studies on human groups[19,20,31], whereas the consumption of Ca, Fe, K, folic acid and vitamin D was deficient (<2/3 of the recommended daily intake), which may be attributable to a reduced intake of dairy products and red meat.

The availability of diet assessment instruments designed for specific populations and cultures is of immense value to researchers and policy makers. The present study describes a simple and effective method to develop and validate an FFQ for a given population of interest.

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