Original Article

Validity and reproducibility of a semi-quantitative food frequency questionnaire for use among pregnant women in rural China

Yue Cheng MD[1], Hong Yan MD[1], Michael John Dibley MB BS MPH[2], Yuan Shen MD[1], Qiang Li MD[3] and Lingxia Zeng MD[1]

[1]*Department of Public Health, Xi'an Jiaotong University School of Medicine, Xi'an, Shaanxi, P.R. China*
[2]*The School of Public Health, and The George Institute for International Health, University of Sydney, NSW, Australia*
[3]*The George Institute for International Health, University of Sydney, Sydney, NSW Australia*

A longitudinal study was conducted to validate a 68-item semi-quantitative food-frequency questionnaire (FFQ) for assessing nutrient intake among pregnant women in rural China. The interview administrated FFQs were conducted at the start of the third trimester (FFQ1) and repeated three months later prior to delivery (FFQ2), and compared with six repeated 24-hour recalls collected between the FFQs. From June to September 2004, 125 women at 23 to 26 weeks of gestation were recruited into the study in two rural counties in Shaanxi province, China. Pearson correlation coefficients for crude nutrients assessed by FFQ1 and FFQ2 had a mean of 0.46, and ranged from 0.31 for thiamin to 0.61 for fat. Pearson correlation coefficients estimated by FFQ2 and 24-hour recalls had a mean of 0.62 for all nutrients, and ranged from 0.53 for cholesterol and carotene to 0.70 for α-vitamin E and potassium. De-attenuated coefficients had a mean of 0.69 for all nutrients, and ranged from 0.58 for cholesterol to 0.77 for α- vitamin E. Bland-Altman plots revealed significant relationships between the difference and the average of the two methods with larger differences at higher average intakes. On average, 74% of participants were classified into the same or adjacent nutrient intake quintiles, while 1% were grossly misclassified to opposite quintiles. In conclusion, this FFQ has adequate reproducibility and validity for most nutrients but would benefit from the addition of wheat porridge to ensure it is suitable for assessing dietary intake in pregnant women in rural China.

Key Words: food frequency questionnaire, calibration, pregnancy, diet surveys, China

INTRODUCTION

There is evidence to suggest that maternal diet during pregnancy should be sufficient and varied to provide enough energy and nutrients to meet the mother's usual requirements, as well as the needs for fetal growth and development, along with alterations in maternal tissues and metabolism.[1, 2] Appropriate methods are needed to assess diet in pregnancy and to evaluate the role of the diet on pregnancy outcomes. The food frequency questionnaire (FFQ) is currently the method most often used for assessing food intake for population-based studies.[3] It is practical and provides estimates that are more representative of usual intake than a single 24-hour dietary recall.[4]

A potential problem of using FFQs to evaluate dietary intake during pregnancy are the fluctuations in appetite and nausea commonly experienced by pregnant women especially in the first trimester, which may influence reported dietary intake. Another potential issue is the reference period for reporting dietary intake in pregnancy. This will vary depending on the study purpose and might refer to diet in the pre-conceptual period and early pregnancy when examining dietary factors associated with congenital abnormalities, but refer to the third trimester if assessing the impact of diet on fetal growth.

In China, the most populace developing country in the world, the prevalence of low birth weight (LBW) is highest in socio-economically disadvantaged populations mainly living in rural western China. In disadvantaged populations there is much interest in assessing the contribution of diet, and especially micronutrient intakes, to inadequate fetal growth and low birth weight.[5] In this setting dietary intake methods which are relatively cheap and easy to administer to large populations of women with low levels of literacy are needed for studying the role of the diet in pregnancy outcomes, including low birth weight.

Corresponding Author: Professor Hong Yan, Department of Public Health, Xi'an Jiaotong University School of Medicine, Xi'an 710061, P.R. China.
Tel: +86(29) 8265 5001; Fax: +86(29) 8265 5387
Email: xjtu_yh.paper@yahoo.com.cn; yanhonge@mail.xjtu.edu.cn
Manuscript received 4 June 2007. Initial review completed 1 August 2007. Revision accepted 10 October 2007.

A FFQ should be developed and validated specifically for each population in which it will be used in order to adjust the questionnaire according to local foods and food culture, as well as to ensure it is easily understood by the proposed study population. While several different FFQs have been developed and validated for urban populations in China, [6-14] there is only one report of a FFQ developed for an urban-rural combined population in China [9] and none targeted at pregnant Chinese women.

This study aimed to develop and validate a semi-quantitative food-frequency questionnaire to measure the intake of nutrients among pregnant women in their third trimester in rural Shaanxi, western China. This instrument was needed to assess the dietary intake of women in a large field trial of multi-micronutrient supplements (MMS) in pregnancy and birth weight, conducted in this population.

MATERIALS AND METHODS

Study population and setting

The participants in this validation study were recruited from amongst the subjects enrolled in the trial of MMS in pregnancy and their impact on birth weight. These trial participants were registered in their first or second trimester (≤ 28 gestation week) and allocated to receive one of three daily prenatal supplements. The main project and validation study were conducted in two poor rural counties, Changwu and Bin, located in Shaanxi Province in western China.

All pregnant women enrolled in the MMS trial with the date of their last menstrual period (LMP) date between December 2003 and Mar 2004 were invited to take part in the validation study, which was conducted from June to December 2004. Inclusion criteria for the validation study were women who were at gestational periods of between 23 to 26 weeks at enrollment and intended to reside in the county for the following three months until delivery. Signed informed consent was obtained from the participants after the validation study was fully explained to them. The protocol was reviewed and approved by the Human Research Ethics Committee of the Xi'an Jiaotong University School of Medicine.

A total of 240 women from the MMS trial were identified as potential study participants based on their LMP date, however 76 of these women could not be located before they reached 26 weeks of gestation. Therefore, a total of 164 women were interviewed and invited to participate based on their gestation age and 94% (153) agreed to participant. The reasons given for refusing to take part included the desire to avoid attention from the family planning department (n=6) and five women gave no reason. Among the 153 women who agreed to participate, 125 women completed all six 24-hour recalls and the two FFQs. The reasons for not completing the six 24-hour recalls were miscarriage (n=2), moving to another area (n=12) and delivery earlier than expected (n=4) and withdrawal from the study (n= 10).

Study design

Figure 1 illustrates the design of both the reproducibility and comparative validity studies. The participants completed the test FFQ twice, separated by a three-month interval during the third trimester of pregnancy. The first FFQ (FFQ1) and the first 24-hour recall were completed at enrollment which was around 23-26 gestation weeks. The second FFQ (FFQ2) and the sixth 24-hour recalls were completed approximately 13 weeks later but shortly before the expected delivery date. The remaining four 24-hour recalls were collected on randomly selected days at the woman's home between the days on which the FFQs were administered. Both the FFQs and 24-hour recalls were collected through interview by trained project staff. Socio-demographic data were collected at the time the subjects first enrolled in the MMS trial.

The reproducibility of the FFQ over the third trimester of pregnancy was assessed by comparing nutrients intakes from FFQ1 and FFQ2. The comparative validity was evaluated by comparing the nutrient intakes from the average of the six 24-hour recalls with those from the first, the second and the average of the two FFQs.

Semi-quantitative food frequency questionnaire (FFQ)

The study population resides in rural counties in western China where socio-economic circumstances and dietary habits are very different from the populations involved in the development and validation of other FFQs in

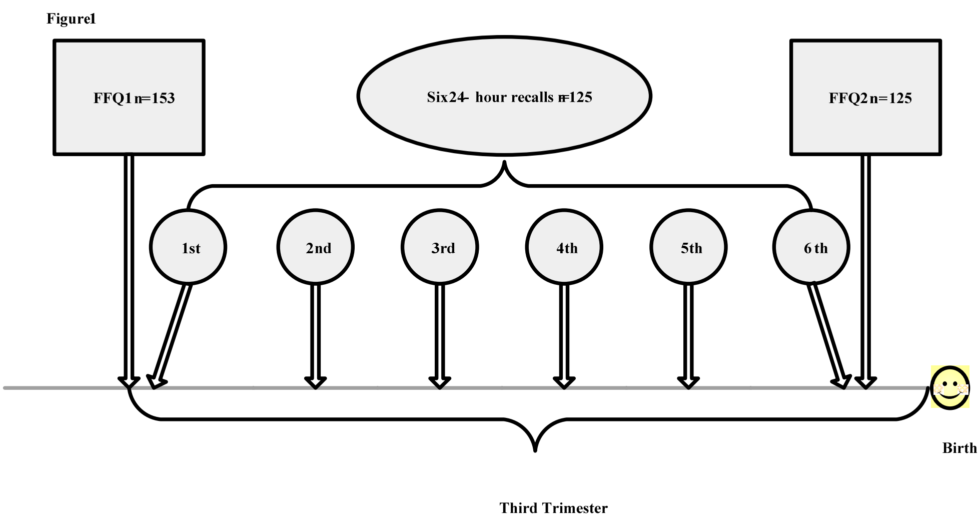

Figure 1. The design of the semi-quantitative food frequency questionnaire (FFQ) reproducibility and validation study among 125 pregnant women in rural Shaanxi China, Jun to Dec 2004

China.[6,8-13] As a consequence, a new food list was developed for the FFQ based on foods reported in two 24-hour recalls collected from 50 subjects in study counties in fall and spring, to identify the foods available in different seasons. A total of 78 foods were identified for the FFQ food list by this approach. Comments about the foods in this tentative list were invited from local maternal and child health (MCH) staff, MMS trial participants and their mothers-in-law. The final list contained 68 foods.

The participants were asked about their usual frequency of consumption of the listed foods, and an additional question about their usual portion size, over the three months prior to the interview, which corresponded approximately to the third trimester of pregnancy. The frequency question was open ended because closed frequency options were found to confuse the respondents. The participants could report the frequency of consumption as the number of "times per day"; "times per week"; "times per month"; "times per three months"; or as "never consumed", for example a range of frequency such as 2-3 times per week was accepted. The interviewer recorded the reported frequency of consumption of the foods in the corresponding space on the questionnaire.

The portion size of each food listed on the questionnaire was specified as large, medium or small sized, and photos were used to help subjects to estimate their usual portion sizes. The portion size categories were based on an analysis of the pilot 24-hour recall data collected to identify foods for the food list. The food portions in each picture were compared to a spoon and a plate, which were common in the study area and familiar to the study subjects. The camera settings were fixed when preparing the pictures for the potion size album to provide consistency of the images when subjects compared portions sizes of different foods.

24-hour recall

It was not feasible to use food records with the rural women in this study because of their limited literacy skills, thus the relevant method used was the repeated 24-hour recall, for a sufficient number of days, to estimate the average long term intake.[15]

It was estimated that six repeated 24-hour recalls would be adequate to assess long term intake of most nutrients in this population of pregnant women.[4] All interviewers were trained to conduct the 24-hour recall interviews in a standardized way by practicing interviewing with each other under the direction of an experienced nutritionist. The interviews recorded the intake of main foods, dishes, fruits and snacks for the whole day prior to interview. Neutral probes were used to gather information about familiar names and descriptions of foods and dishes together with their portion sizes and recipes, when required. The respondents were assisted in their estimation of portion sizes with a book of pictures of commonly consumed foods and they indicated their usual portion sizes as multiples or fractions of those illustrated in the book. For food items not included in the picture booklet, the subjects were asked to describe the portion sizes using pictures of plates and bowls common in the study area. The weight of the food equivalent to these estimated portion sizes was measured after the interview.

Nutrient calculation

For the FFQ, daily nutrient intakes were calculated as the total number of grams of each food consumed multiplied by the amount of nutrient in each gram of that food, multiplied by the frequency of consumption. Frequencies which were a range of values were taken as the average of the upper and lower frequencies divided by the time interval such as per day, per week, or per month. For the 24-hour recalls, recipes for the dishes recorded in the recalled diets were calculated and the amounts eaten of each dish were split into its ingredients. The total nutrient intake was calculated from the sum of the amount of foods consumed multiplied by the nutrient content. The nutrient content for the foods in both the FFQ and the 24-hour recalls was derived from the electronic version of the 2002 China Food Composition Tables.[16]

Statistical analysis

Stata/SE 9.2 for windows[17] was used for all statistical analyses. The median and 25th and 75th percentiles of nutrient intakes were computed separately for the FFQs and six 24-hour recalls. Wilcoxon's signed rank test was used to test the differences between the two methods (FFQ *vs*. average of six 24-hour recalls) and between different surveys (FFQ1 *vs*. FFQ2).[3]

All nutrient intakes were log-transformed to improve normality before further analysis. Energy-adjustment was used to remove variation due to energy, using the regression model method.[18]

Pearson correlations were used to evaluate the reproducibility between the two FFQs and comparative validity between the second FFQ and the average of the six repeated 24-hour recalls. To take into account the within-person variations due to day-to-day fluctuations in dietary intake, Pearson correlation coefficients were de-attenuated using the ratio of within-to between-person variance measured from the average of the six repeated 24-hour recalls.[4]

The Bland-Altman method was used to assess reproducibility and validity in conjunction with correlation. This method assesses the agreement between the two methods across the range of intakes.[19] By plotting the difference between the methods against the average of nutrients from the two methods, the dispersion and the extent the two methods agree can be visualized.[19] Dependency between the difference and the average of the two methods was tested by fitting a linear regression line (H_0: $\beta=0$, $\alpha=0.05$). Log-transformed nutrient data were used in the Bland-Altman plots when there was a dependency between the differences in the methods with the average intake from both methods.[20] The antilog of the mean difference between the log-transformed data of two FFQs indicated the mean intakes of FFQ2 compared with that of FFQ1, and likewise for the comparison of FFQ2 and 24-hour recalls.

The degree of misclassification across categories between the FFQ and the repeated 24-hour recalls was examined by dividing nutrient intake values into quintiles. The proportion of subjects classified into the same and adjacent and extreme quintiles was calculated. Gross misclassification into the extreme quintile comprises both misclassifications from the first to the fifth quintile, and vice versa; from the fifth to the first quintile. Quadratic weighted kappa values were calculated to compare quintiles of intake for nutrients derived from FFQ2 and the six 24-hour recalls.[21]

RESULTS

The validation study sample consisted of 125 subjects who completed the six repeated 24-hour recalls and the two FFQs. (Table 1) Their median age was 25.4 years and their mean BMI was 20.9 kg/m^2 (95% CI 20.5 to 21.2. kg/m^2). Most women (90%) had no paid employment outside their home and lived from their family's agricultural activities. More than half (56%) of the women had completed nine years of compulsory education. Among the study participants, 48% of them were having their first pregnancy.

Reproducibility

Table 2 shows the median intake of nutrients as assessed by the two FFQs. Most nutrients were generally higher when assessed by FFQ2 than FFQ1; except for: protein, cholesterol, vitamin A, retinol, niacin, calcium and selenium. The Pearson correlation coefficients for un-adjusted nutrients derived from FFQ1 and FFQ2 (Table 2) ranged from 0.31 (thiamin) to 0.61 (fat). The average of the coefficients for all un-adjusted nutrients was 0.46. After adjustment for energy intake, Pearson correlation coefficients for most nutrients decreased ranging from 0.08 (zinc) to 0.50 (manganese) with the exception of carbohydrate, selenium and manganese, but the average of the coefficients for all energy-adjusted nutrients was only 0.29 (data not shown).

The Bland-Altman plot for protein intake (Figure 2) shows no dependency between the difference of the two surveys (FFQ1 vs FFQ2) and the average protein intake from both methods. The mean difference for protein was –1.54g (95% CI –4.42g, 1.33g) indicating the protein estimated from FFQ2 was slightly lower than that from FFQ1. The limits of agreement (LOA) were –33.4g to 30.3g for un-adjusted protein. Bland-Altman plots for the other nutrients revealed similar patterns.

Table 1. Characteristics of 125 pregnant women in the FFQ validation study in rural Shaanxi China, Jun to Dec 2004

Characteristics	Mean, Median or Percent
Age (years)†	25.4 (21, 29)
Weight enrolled (kg)‡§	51.1 (48, 55)
Height (cm)‡§	158 (157, 159)
BMI ‡§	20.9 (20.5, 21.2)
Education (%)	
Incomplete primary (<6th grade)	5.6
Primary (6th grade)	29.6
Secondary (9th grade)	56
High school graduate or above (≥ 12th grade)	8.8
Occupation (%)	
Agriculture	90.4
Government staff/doctor	6.4
Private business	3.2
Gravidity (%)	
First	48.4
Second	32.6
≥ third	19.0

† Median and (25th, 75th percentiles). ‡ Mean and (95% Confidence Interval). §Weight and height measurements taken during a multi-micronutrients supplementation trial in pregnancy.

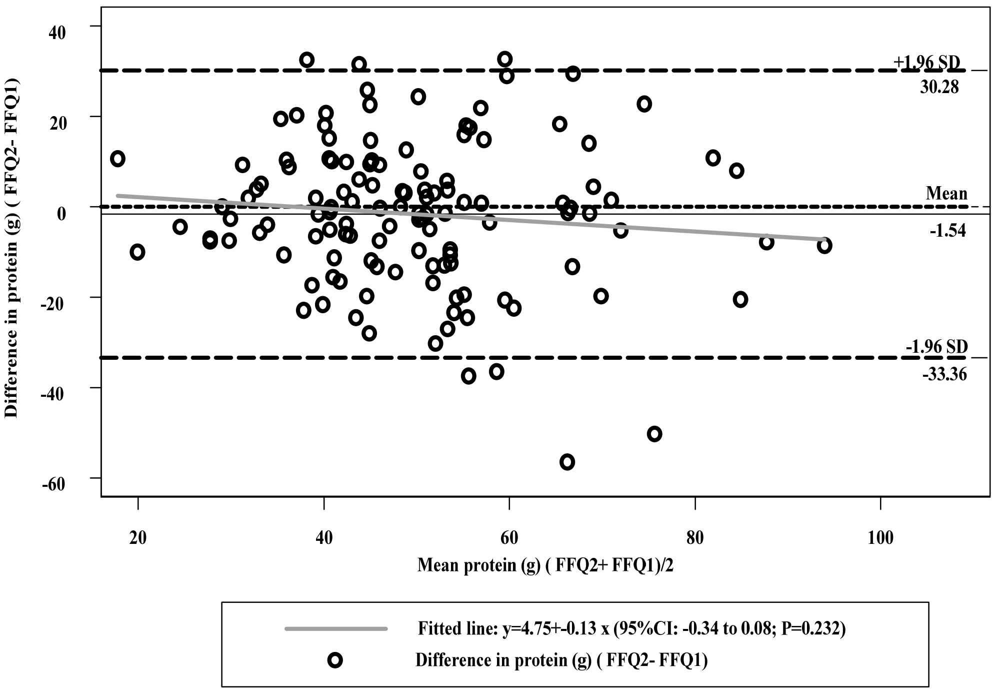

Figure 2. The difference in protein intake measured with the semi-quantitative food frequency questionnaires (FFQ1 and FFQ2), plotted against the mean protein intake measured with the two FFQs (n=125)

Table 2. Reproducibility study: Comparison of median, 25th,75th percentiles of daily consumption of food frequency questionnaires (FFQ1 and FFQ2) and Pearson correlation coefficients between the food frequency questionnaires(FFQ1 and FFQ2) completed by 125 pregnant women in rural Shaanxi, China, Jun to Dec 2004

Nutrients	FFQ1		FFQ2		*p*-value‡	FFQ2/FFQ1×100 (Median)	Pearson correlation coefficient§
	Median	(P_{25}, P_{75})†	Median	(P_{25}, P_{75})†			
Energy (kcal)	1.77*10³	(1.42*10³-2.07*10³)	1.88*10³	(1.62*10³-2.20*10³)	0.012	106	0.45
Protein (g)	49.0	(40.1-59.5)	47.5	(39.2-56.1)	0.374	97	0.49
Fat (g)	38.3	(26.8-55.1)	40.1	(28.1-47.5)	0.329	105	0.61
Carbohydrate (g)	314	(248-378)	346	(288-424)	<0.001	110	0.37
Dietary fiber (g)	11.8	(8.7-16.2)	16.2	(12.6-20.5)	<0.001	138	0.42
Cholesterol (mg)	114	(26-309)	90	(21-170)	0.001	78	0.49
Vitamin A¶ (μgRE)	422	(296-606)	401	(241-560)	0.134	95	0.45
Carotene (μg)	1.85*10³	(1.27*10³-2.87*10³)	1.94*10³	(1.26*10³-2.80*10³)	0.632	105	0.36
Retinol (μg)	67.8	(16.0-145)	43.3	(8.5-106)	0.004	64	0.55
Total Vitamin E (mg)	26.8	(18.3-35.2)	32.4	(22.7-39.8)	<0.001	121	0.55
α- Vitamin E (mg)	8.6	(5.9-11.6)	12.7	(8.7-16.1)	<0.001	148	0.45
Vitamin C (mg)	80.9	(48.3-117)	107	(76.1-141)	<0.001	133	0.44
Niacin (mg)	7.20	(5.33-10.0)	7.00	(5.80-9.97)	0.752	97	0.48
Thiamin (mg)	0.80	(0.61-1.01)	0.97	(0.81-1-14)	<0.001	121	0.31
Riboflavin (mg)	0.68	(0.50-0.86)	0.68	(0.56-0.87)	0.158	100	0.46
Calcium (mg)	342	(228-441)	302	(238-415)	0.096	88	0.59
Phosphorus (mg)	908	(773-1.11*10³)	905	(781-1.09*10³)	0.784	100	0.52
Potassium (mg)	1.78*10³	(1.37*10³-2.36*10³)	1.97*10³	(1.56*10³-2.43*10³)	0.007	110	0.47
Magnesium (mg)	266	(203-330)	269	(220-314)	0.526	101	0.48
Iron (mg)	19.0	(14.9-23.1)	19.8	(16.7-22.8)	0.033	104	0.43
Zinc (mg)	7.42	(5.70-8.88)	7.71	(6.56-9.07)	0.012	104	0.44
Selenium (μg)	51.0	(40.4-63.5)	50.3	(41.1-63.3)	0.985	99	0.40
Copper (mg)	1.30	(1.03-1.67)	1.70	(1.28-2.36)	<0.001	131	0.38
Manganese (mg)	4.64	(3.64-5.70)	4.71	(3.93-5.72)	0.306	102	0.43
Folate (μg)	189	(139-250)	193	(153-241)	0.496	102	0.47

† 25th, 75th percentiles. ‡ Differences were tested using Wilcoxon's signed rank test. § Nutrient values were log transformed and un-adjusted. ¶ Calculated as retinol equivalents (RE): 1 RE Vitamin A = 1 μg retinol+ 1/6 μg carotene.

Validity

Table 3 compares the median intake of nutrients from FFQ2 with the average of the six 24-hour recalls, and it reveals that the nutrient intakes tended to be overestimated by FFQ2, ranging from 102% (niacin) to 154% (cholesterol). Also shown in Table 3 are the Pearson correlation coefficients for un-adjusted nutrients that range from 0.53 for cholesterol and carotene to 0.70 for α-vitamin E and potassium. The average of the correlation coefficients after de-attenuation was 0.69, and, the individual nutrients ranged from 0.58 for cholesterol to 0.77 for α-vitamin E. This average was higher than average of the crude coefficients of 0.63. Similar to the reproducibility study, adjustment for energy led to a decrease in correlation coefficients for most nutrients except cholesterol and retinol which remained stable. The most conspicuous changes after energy adjustment occurred in iron (from 0.65 to 0.25), protein (from 0.61 to 0.22) and zinc (from 0.67 to 0.27). As expected, comparisons of FFQ1 and the average of the six 24-hour recalls revealed correlation coefficients that were slightly lower than those reported for FFQ2, and for the average of the FFQs, close to those reported for FFQ2 (data not shown).

A summary of the results of the Bland-Altman analyses for all nutrients is found in Table 4. To illustrate these findings, the analysis of protein is considered in detail. The Bland-Altman plot of crude protein intake (Figure 3) reveals a significant relationship between the difference, and the average of the two methods (slope 0.58, 95% CI 0.41, 0.75), with larger differences at higher average intakes. At low average protein intakes, the FFQ underestimates intake but at higher levels of intake, the FFQ overestimates nutrients compared to the 24-hour recalls. As seen in Table 4, for most nutrients except cholesterol and retinol, a significant linear relationship was found between the difference and the average of the two methods. Although there was a modest improvement following log-transformation of nutrient values, a significant linear relationship was still present for those nutrients. For example with protein, the slope decreased from 0.58 with 95

Table 3. Validation study: Comparison of median, 25th,75th percentiles of daily consumption between the second food frequency questionnaire (FFQ2) and the average of six 24-hour recalls (24HRs) and Pearson correlation coefficients between FFQ2 and the average of 24-hour recalls completed by 125 pregnant women in rural Shaanxi, China, Jun to Dec 2004

Nutrients	Average of six 24HRs		FFQ2		*p*-value‡	FFQ2/24-hours recall *100 (Median)	Pearson correlation coefficient§		
	Median	(P_{25}, P_{75})†	Median	(P_{25}, P_{75})†			Un-adjusted	Energy adjusted	De-attenuated & un-adjusted
Energy (kcal)	1.68*10^3	(1.45*10^3-1.89*10^3)	1.88*10^3	(1.62*10^3-2.20*10^3)	<0.001	112	0.68	.	0.73
Protein (g)	43.9	(38.4-50.1)	47.5	(39.2-56.1)	0.001	108	0.61	0.22	0.67
Fat (g)	32.1	(26.1- 39.5)	40.1	(28.1-47.5)	<0.001	125	0.55	0.49	0.59
Carbohydrate (g)	313	(274-360)	346	(288-424)	<0.001	111	0.68	0.49	0.74
Dietary fiber (g)	14.7	(12.9-19.5)	16.2	(12.6-20.5)	0.074	110	0.63	0.34	0.69
Cholesterol (mg)	58.2	(12.9-128.7)	89.6	(21.1-170.2)	0.025	154	0.53	0.53	0.58
Vitamin A¶ (μgRE)	342	(223-438)	401	(241-560)	<0.001	117	0.58	0.48	0.64
Carotene (μg)	1.69*10^3	(1.19*10^3-2.26*10^3)	1.94*10^3	(1.26*10^3-2.80*10^3)	<0.001	115	0.53	0.37	0.61
Retinol (μg)	34.1	(8.93-69.9)	43.3	(8.47-106)	0.004	127	0.59	0.60	0.65
Total Vitamin E (mg)	27.4	(22.4-33.3)	32.4	(22.7-39.8)	<0.001	118	0.61	0.49	0.66
α- Vitamin E (mg)	8.8	(7.1-11.3)	12.7	(8.7-16.1)	<0.001	145	0.70	0.54	0.77
Vitamin C (mg)	94.1	(73.0-131)	107.3	(76.1-141)	0.101	114	0.61	0.43	0.68
Niacin (mg)	6.87	(5.56-8.78)	6.99	(5.80-9.97)	0.006	102	0.66	0.57	0.72
Thiamin (mg)	0.82	(0.71-0.96)	0.97	(0.81-1-14)	<0.001	118	0.67	0.48	0.74
Riboflavin (mg)	0.64	(0.51-0.81)	0.68	(0.56-0.87)	0.002	106	0.63	0.50	0.68
Calcium (mg)	271	(222-341)	302	(238-415)	0.001	111	0.66	0.60	0.71
Phosphorus (mg)	805	(694-926)	905	(781-1.09*10^3)	<0.001	112	0.65	0.52	0.70
Potassium (mg)	1.80*10^3	(1.45*10^3-2.10*10^3)	1.97*10^3	(1.56*10^3-2.43*10^3)	<0.001	110	0.70	0.47	0.75
Magnesium (mg)	240	(211-282)	269	(220-314)	<0.001	112	0.69	0.41	0.75
Iron (mg)	17.2	(15.2-19.9)	19.8	(16.7-22.8)	<0.001	115	0.65	0.25	0.71
Zinc (mg)	7.03	(6.17-7.89)	7.71	(6.56-9.07)	<0.001	110	0.67	0.27	0.72
Selenium (μg)	45.4	(39.9-51.3)	50.3	(41.1-63.3)	<0.001	111	0.59	0.49	0.65
Copper (mg)	1.65	(1.31-2.25)	1.70	(1.28-2.36)	0.835	103	0.54	0.28	0.61
Manganese (mg)	4.38	(3.77-5.11)	4.71	(3.93-5.72)	<0.001	108	0.63	0.52	0.69
Folate (μg)	156	(136-192)	193	(153-241)	0.958	124	0.66	0.55	0.71

† 25th, 75th percentiles. ‡ Differences were tested using Wilcoxon's signed rank test. § Nutrient values were log transformed. ¶ Calculated as retinol equivalents (RE): 1 RE Vitamin A = 1 μg retinol+ 1/6 μg carotene.

Table 4. Mean differences between FFQ2 and the average of six 24-hour recalls, the limits of agreement and the slope with 95% confidence intervals for a linear regression of the difference against the means of the two methods completed by 125 pregnant women in rural Shaanxi, China, Jun to Dec 2004

	Mean difference	Lower LOA†	Upper LOA†	Slope‡	(95% CI§)
Energy (kcal)	266	-669	$1.2*10^3$	0.68	(0.54, 0.83)
Protein (g)	4.4	-19.6	28.5	0.58	(0.41, 0.75)
Fat (g)	7.3	-20.7	35.4	0.53	(0.35, 0.70)
Carbohydrate (g)	47.5	-151	245	0.74	(0.60, 0.88)
Dietary fiber (g)	2	-14.2	18.3	0.71	(0.53, 0.88)
Cholesterol (mg)	25.7	-183	234	0.19	(-0.02, 0.39)
Vitamin A¶ (μgRE)	74.5	-329	478	0.34	(0.15, 0.53)
Carotene (μg)	338	$-1.78*10^3$	$2.46*10^3$	0.36	(0.16, 0.56)
Retinol (μg)	18.6	-138	175	0.13	(-0.07, 0.33)
Total Vitamin E (mg)	5.5	-19.4	30.4	0.62	(0.45, 0.79)
α- Vitamin E (mg)	4. 7	-8.0	17.3	1.00	(0.88, 1.12)
Vitamin C (mg)	12.4	-105	129	0.56	(0.36, 0.75)
Niacin (mg)	0.79	-4.2	5.8	0.42	(0.26, 0.58)
Thiamin (mg)	0.2	-0.42	0.83	0.74	(0.60, 0.88)
Riboflavin (mg)	0.88	-0.38	0.54	0.49	(0.33, 0.66)
Calcium (mg)	41.9	-184	268	0.37	(0.21, 0.54)
Phosphorus (mg)	137	-321	595	0.58	(0.42, 0.74)
Potassium (mg)	315	$-1.06*10^3$	$1.69*10^3$	0.64	(0.48, 0.79)
Magnesium (mg)	30.2	-109	170	0.56	(0.41, 0.71)
Iron (mg)	3.2	-7.7	14.2	0.69	(0.53, 0.84)
Zinc (mg)	0.96	-3.4	5.3	0.61	(0.46, 0.77)
Selenium (μg)	7.1	-19.9	34.1	0.66	(0.49, 0.82)
Copper (mg)	0.14	-2.11	2.39	0.61	(0.41, 0.81)
Manganese (mg)	0.47	-1.97	2.90	0.62	(0.45, 0.78)
Folate (μg)	40.9	-90. 3	172	0.56	(0.41, 0.72)

† LOA - limit of agreement. ‡ Slope of linear regression line where Difference in Methods = Intercept + Coefficient× (Average of Methods). § CI – confidence interval. ¶ Calculated as retinol equivalents (RE): 1 RE Vitamin A = 1 μg retinol+ 1/6 μg carotene.

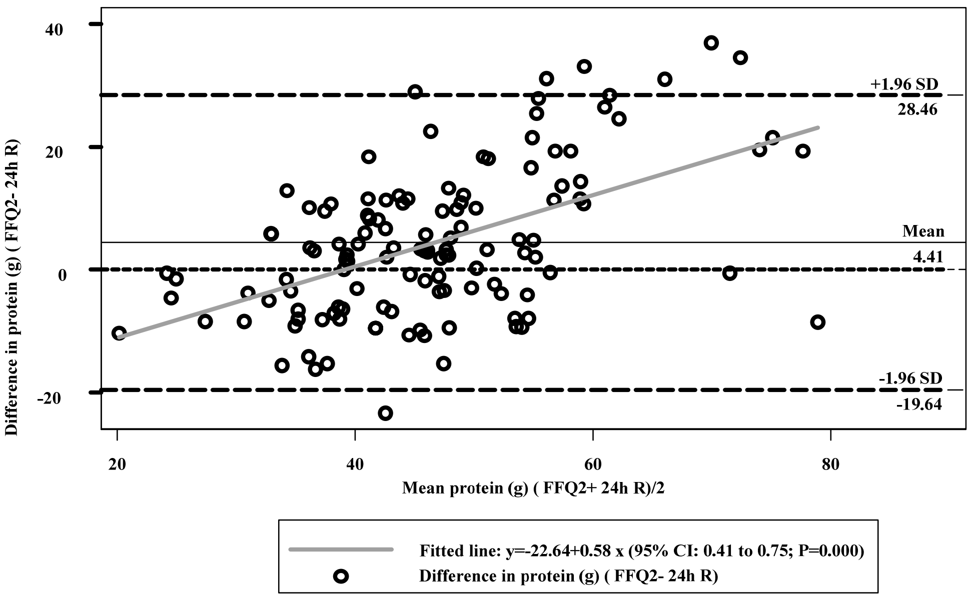

Figure 3. The difference in protein intake measured with the second semi-quantitative food frequency questionnaires (FFQ2) and the average of six 24-hour recalls (24h R), plotted against the mean protein intake measured with the two methods (n=125)

% CI (0.41, 0.75) to 0.50 with 95 % CI (0.33, 0.66). This relationship between the difference and the average of the two methods precluded meaningful assessment of the limits of agreement which were too large for low intakes and too small for higher intakes.

These findings suggest that the food list of the FFQ may have been missing foods consumed by women with lower nutrient intakes. An examination of the 24-hour recalls identified frequent consumption of wheat porridge by some women but this food was not included on the FFQ. An analysis of the 24-hour recalls found the contribution of this food to total energy intake progressively increased from 4% to 14% as total energy intake decreased. Very few women (n=6), who had total energy intakes of over 2000 kcal per day, reported eating this food in their 24-hour recalls.

Table 5. Cross-classification of intake of nutrients between the second food frequency questionnaires(FFQ2) and the average of six 24-hour recalls completed by 125 pregnant women in rural Shaanxi China, Jun to Dec 2004

Nutrients†	Same quintile (%)	Same or adjacent quintile (%)	Extreme misclassification‡ (%)
Energy	35	72	0
Protein	30	73	1
Fat	32	72	1
Carbohydrate	37	79	0
Dietary fiber	34	73	1
Cholesterol	32	68	1
Total Vitamin A§	32	76	2
Carotene	38	74	2
Retinol	39	78	2
Total Vitamin E	37	74	2
α- Vitamin E	36	78	2
Vitamin C	37	69	1
Niacin	38	70	0
Thiamin	38	74	0
Riboflavin	37	72	0
Calcium	40	82	1
Phosphorus	28	73	0
Potassium	36	73	0
Magnesium	35	77	0
Iron	31	74	1
Zinc	34	74	0
Selenium	29	72	2
Copper	34	73	2
Manganese	36	71	1
Folate	34	74	0

† Nutrient values were log transformed. ‡ The percentage for which one dietary method classifies intake into the bottom quintile; the other method classifies intake into the top quintile. § Calculated as retinol equivalents (RE): 1 RE Vitamin A = 1 μg retinol+ 1/6 μg carotene

Table 6. Major sources of energy in the diet based on the average of six 24-hour recalls and the second food frequency completed (FFQ2) by 125 pregnant women in rural Shaanxi China, Jun to Dec 2004

Food group (g)	Contribution of food group to total energy intake (%)				
	Average of six 24-hour recalls		FFQ2		
	Median	(P_{25},P_{75})†	Median	(P_{25},P_{75})†	*p*-value‡
Bread	32.7	(25.7, 38.5)	31.4	(25.7, 36.3)	0.370
Noodle	25.3	(19.2, 31.2)	25.0	(19.7, 32.8)	0.121
Fruits	13.1	(9.6, 17.5)	13.8	(8.7, 17.9)	0.643
Oils	9.7	(8.4, 10.7)	10.8	(7.5, 13.7)	0.001
Rice & Corn	6.0	(3.2, 8.9)	4.2	(1.9, 6.2)	<0.001
Prepared foods	3.8	(1.7, 6.5)	0.6	(0.0, 1.5)	<0.001
Milk	3.6	(2.0, 5.4)	0.0	(0.0, 3.2)	0.176
Vegetables	2.7	(2.1, 3.3)	2.6	(1.6, 3.7)	0.089
Nuts and seeds	2.0	(1.0, 3.2)	0.2	(0.0, 0.9)	<0.001
Meat	1.6	(1.1, 3.6)	0.1	(0.0, 0.3)	<0.001
Eggs	1.4	(0.9, 1.7)	0.9	(0.2, 1.8)	0.413
Potato	1.2	(0.6, 2.1)	1.1	(0.6, 2.1)	0.831
Bean products	0.9	(0.6, 1.4)	0.3	(0.1, 1.0)	0.024
Sugar	0.5	(0.4, 0.8)	0.0	(0.0, 0.6)	0.603
Other foods	0.1	(0.0, 0.3)	0.0	(0.0, 0.0)	<0.001

† 25th, 75th percentiles. ‡ Differences were tested using Wilcoxon's signed rank test

Misclassification

Table 5 shows the cross classification intake of nutrients between FFQ2 and the 24-hour recalls. The percentage in the same quintiles ranged from 28% for phosphorus to 40% for calcium. The proportion of individuals correctly classified within one quintile was highest for calcium (82%) and lowest for cholesterol (68%). On average across all nutrients, 74% of participants were classified into the same or adjacent quintiles of nutrient intake, while 1% was grossly misclassified to extreme opposite quintiles.

Contribution of food groups to total energy intake

Table 6 compares the contribution of food groups to the total energy intake between the average of six 24-hour recalls and FFQ2. The same four food groups, bread, noodles, fruits and fat accounted for approximately 80% of total food energy intake in both the 24-hour recalls and the FFQ2. Rice & corn, prepared foods, nuts and seeds, meat, and bean products accounted for a significantly lower percentage of total food energy intake in FFQ2 compared to the 24-hour recalls. But all other food groups tended to account for a slightly higher percentage of total food energy intakes in FFQ2 compared to the 24-hour recalls.

DISCUSSION

We evaluated the reproducibility and comparative validity of a 68-item FFQ, in a sample of pregnant women from rural Shaanxi, western China, by comparing the nutrient intake with six repeated 24-hour recalls collected during the third trimester. The correlation coefficients for most of the nutrients, for both reproducibility and validity, were within the range 0.40 to 0.80 and similar to other reports in the literature [4] including studies in pregnant women. [22, 23] These results indicate that this newly developed food frequency questionnaire performs sufficiently accurately to rank these women by the level of intake of most nutrients during the third trimester of pregnancy. It has the potential for application in epidemiological studies with regard to the role of diet in pregnancy outcomes in rural China and has been used to assess diet in a recent trial of multi-micronutrient supplements in pregnancy and their effect on birth weight. (Unpublished work)

The strengths of this validation study include the appropriate design of the study with an adequate number of repeated 24-hour recalls to estimate long term dietary intake and a representative population-based sample from the study population in which the instrument was to be used. The education and anthropometric status of the study subjects were similar to that observed in surveys using samples representative of rural China.[24, 25] The food list for the FFQ was constructed taking into account the seasonal variation in food intake in this rural population. Data were collected by appropriately trained field staff and monitored by experienced nutritionists. The FFQ was interview administered and suitable visual aids were used to facilitate respondent recall of usual portion sizes of the foods on the list. The validation study was conducted from summer to autumn which covered the period of greatest seasonal food variation especially for fruits and vegetables. Assessments of dietary intake during early and late pregnancy are both potentially of importance for studies of the relationship between dietary intake and birth outcomes. A recall period of three months was selected for this study because the instrument was designed to measure dietary intake during the third trimester of pregnancy. The duration of the recall periods used in other FFQs ranges from 7 days to three years [4], however the selection of this recall period should be related to the specific purpose of the questionnaire. Dietary intake during the third trimester was chosen in this study because one of the major causes of LBW in developing countries is inadequate dietary intake of the mother during the third trimester of pregnancy that results in restricted fetal growth. [26] The measurement of dietary intake during the third trimester is easier than in earlier trimesters because women are less mobile and more accessible and their appetite and food intake is less influenced by fluctuations in nausea and appetite.

Four potential limitations of the study should be considered when interpreting the findings. The first was the use of repeated 24-hour recalls as the reference method. Ideally in a validation study of an FFQ, the measurement errors in the referent dietary intake method should be independent of those in the food frequency questionnaire and thus this method should not require food recall. In practice the choice of referent method is usually either food records (weighed or by diary) or 24-hour recalls. Although 24-hour recalls can lead to difficulties with memory and conceptualization of portion sizes, they are less demanding for the participants and may be more appropriate when co-operation or literacy of the study subjects is limited. We were compelled to use this method because of the low literacy skills of the rural women in the study, but our results may have overestimated the performance of the FFQ because of correlation of dietary recall errors in both methods. The second relates to conducting the study over six months rather than across a full year. The FFQ may have performed differently in other seasons. Summer and autumn are periods of decreasing food availability in this rural population that harvests its main crops in autumn. The third was the lack of an appropriate method to identify underreporting of dietary intake. The commonly used Goldberg cutoff method [27] to identify underreporting is based on minimum energy intakes for sex, age and body weight groups in adults, but no comparable data exists for pregnant women. Furthermore there is limited information available about the level of physical activity in rural women in China to guide the selection of a suitable physical activity factor required by this method. The low levels of total energy intake reported by some of the women in this study should not be interpreted as due solely to underreporting of dietary intake but likely reflect the limited nutrient intake of these poor rural women. In our study, 125 out of 164 women finished all 24 hours recall and two FFQs. Analyses revealed no differences for mother's education and household wealth between the women who finished and those who did not finish the validation study.

In the reproducibility study, the Pearson correlations between the two FFQs for most nutrients ranged from 0.4 to 0.7 with a mean of 0.45 for all nutrients. These findings were similar to correlation coefficients reported in other reproducibility studies of FFQs that generally reported correlation coefficients ranging from 0.5 to 0.7 [3, 12, 13, 28] and similar to those reported in other studies of FFQs designed for use in pregnancy. [22, 23, 29] We found the thiamin had the lowest correlation coefficients and we also observed a marked reduction in retinol intake in FFQ2 which was only 57% of that in FFQ1. In our study, the median intakes derived from FFQ2 were higher than those from the FFQ1 for most nutrients. These results differed from the findings reported in a validation study of an FFQ for Finnish pregnant women, where intake of all nutrients increased with the second FFQ. [23] In our reproducibility study, the FFQs compared were referring to different periods during pregnancy and were collected in different seasons in a population mainly dependent on their own food production. This may in part explain the poorer performance of our FFQ for selected nutrients, and the difference in findings from the Finnish study. Overall we found the reproducibility of the FFQ for pregnant rural Chinese women adequate to allow an assessment of its validity.

Pearson correlation coefficients after de-attenuation for within-person variation ranged from 0.5 to 0.8. In the other validation studies, the average correlation coefficients generally ranged from 0.4 to 0.8 [4] and -0.02 to 0.55 for energy-adjusted nutrients among validation studies of pregnant women. [23] The assessment of dietary intake of pregnant women is complicated because of nausea and appetite fluctuations that vary during pregnancy. Poor correlation between instruments may be partly explained by variations in these symptoms, which may also influence the responses of the pregnant women and the assessment of long term dietary intake during pregnancy. [30] The absolute intakes we observed using the FFQs were higher than the 24-hour recall estimates for most nutrients. A similar tendency to overestimate dietary intake by FFQs compared with 24-hour recall or food records has been reported in earlier validation studies including those in pregnant women. [22, 23, 31-33] Despite this overestimation of absolute intakes, on average, 74% of the nutrients fell into the same or adjacent quintiles, which was comparable to the results reported in other studies [23, 34] indicating the nutrient intake measured by the FFQ was adequate to rank the pregnant women by level of nutrient intake.

The Bland-Altman analysis for validity revealed that despite adequate correlation coefficients for most nutrients, there was a consistent pattern for most nutrients of increasing differences between the methods with increasing nutrient intake. These plots also revealed that at lower nutrient intakes, the FFQ underestimated intake but overestimated it at higher intakes. The subsequent identification of a food frequently consumed by women with lower total energy intakes, namely wheat porridge, strongly indicates that this food needs to be added to the final version of the FFQ for use in the MMS trial.

For both the reproducibility and validation studies among pregnant women in rural Shaanxi, we observed that energy adjustment did not improve the Pearson correlation coefficients. In the validity study, after adjustment for total energy intake, the correlation coefficients of most nutrients decreased especially for protein (from 0.61 to 0.22), zinc (from 0.67 to 0.27) and iron (from 0.65 to 0.25). A similar decrease in the correlation coefficients has also been observed in other FFQ validation studies. [9, 35-37] An FFQ validation study conducted in Guatemala[32] showed the main contribution to total energy estimated by 24-hour recalls and FFQ was tortillas and bread, while meat and eggs contributed less than 10% of total energy. This pattern was very similar to our results (Table 6) in which bread and noodles accounted for more than half of the total energy intake where as protein rich food such as meat, eggs and milk also contributed less than 10% energy intake. Thus in populations with similar dietary patterns where energy intake is closely linked to the amount of staple food consumed, energy adjustment may over adjust nutrients intake and mainly reflect fluctuations in measurement errors by the methods.

The development and validation of this FFQ was the first attempt to create a practical dietary intake instrument targeted at pregnant women in rural China. The future application of this instrument will aid in the study of dietary factors associated with pregnancy outcomes in rural populations in western China

ACKNOWLEDGMENT

This project was supported in part by UNICEF, the National Natural Science Foundation of China (Grant # 30271131), Beijing, China and Grant of Shaanxi Social development (2003k09-G13-2), China. The authors would like to thank Mr. Tran Thanh Do, National Institute of Nutrition, Hanoi, Viet Nam who provided the program for the Bland Altman analysis.

AUTHOR DISCLOSURES

Yue Cheng, Hong Yan, Michael John Dibley, Yuan Shen, Qiang Li and Lingxia Zeng, no conflicts of interest.

REFERENCES

1. Ziegler E, Filer L, editors. Present knowledge in nutrition. Washington, DC: ILSI Press; 1996.
2. King JC. Physiology of pregnancy and nutrient metabolism. Am J Clin Nutr. 2000;71(5 Suppl):1218S-25S.
3. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires - a review. Public Health Nutr. 2002;5(4):567-87.
4. Willett W. Nutritional Epidemiology. Second Edition ed. Oxford: Oxford University Press; 1998.
5. Ramakrishnan U. Micronutrients and pregnancy outcome: a review of the literature. Nutr Res. 1999;19(1):103-59.
6. Xu L, Dibley J, D'Este C. Reliability and validity of a food-frequency questionnaire for Chinese postmenopausal women. Public Health Nutr. 2004;7(1):91-8.
7. Zhao W, Hasegawa K, Chen J. The use of food-frequency questionnaires for various purposes in China. Public Health Nutr. 2002;5(6A):829-33.
8. Song FY, Toshiro T, Li K, Yu P, Lin XK, Yang HL et al. Development of a semi-quantitative food frequency questionnaire for middle-aged inhabitants in the Chaoshan area, China. World J Gastroenterol. 2005;11(26): 4078-84.
9. Zhou ZY, Takezaki T, Mo BQ, Sun HM, Wang WC, Sun LP et al. Development of a semi-quantitative food frequency questionnaire to determine variation in nutrient intakes between urban and rural areas of Chongqing, China. Asia Pac J Clin Nutr. 2004;13(3):273-83.
10. Zhang M, Binns CW, Lee AH. A quantitative food frequency questionnaire for women in southeast China: development and reproducibility. Asia Pac J Public Health. 2005; 17(1):29-35.
11. Ke L, Toshiro T, Fengyan S, Ping Y, Xiaoling D, Kazuo T. Relative validity of a semi-quantitative food frequency questionnaire versus 3 day weighed diet records in middle-aged inhabitants in Chaoshan area, China. Asian Pac J Cancer Prev. 2005;6(3):376-81.
12. Li K, Takezaki T, Lv LW, Yu P, Song FY, Tajima K. Reproducibility of a semi-quantitative food frequency questionnaire in Chaoshan area, China. Asian Pac J Cancer Prev. 2005;6(4):521-6.
13. Shu XO, Yang G, Jin F, Liu D, Kushi L, Wen W, Gao YT, Zheng W. Validity and reproducibility of the food frequency questionnaire used in the Shanghai Women's Health Study. Eur J Clin Nutr. 2004;58(1):17-23.
14. Jian L, Binns CW, Lee AH. Validity of a food-frequency questionnaire for elderly men in southeast China. Public Health Nutr. 2006;9(7):928-33.
15. Nelson M, Black AE, Morris JA, Cole TJ. Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. Am J Clin Nutr. 1989; 50(1):155-67.
16. Yang Y, Wang G, Pang X. China Food Composition. Peiking University Medical center Press; 2002. (in Chinese)

17. Stata/SE 9.2 Stata Corporation, College Station, TX, USA; 2006.
18. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol. 1986;124(1): 17-27.
19. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999;8(2):135-60.
20. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1(8476):307-10.
21. Streiner D. Health measurement scales: a practical guide to their development and use: Oxford University Press Oxford 1995.
22. Wei EK, Gardner J, Field AE, Rosner BA, Colditz GA, Suitor CW. Validity of a food frequency questionnaire in assessing nutrient intakes of low-income pregnant women. Matern Child Health J. 1999;3(4):241-6.
23. Erkkola M, Karppinen M, Javanainen J, Rasanen L, Knip M, Virtanen SM. Validity and reproducibility of a food frequency questionnaire for pregnant Finnish women. Am J Epidemiol. 2001;154(5):466-76.
24. China BPCoSP. Tabulation on the 2000 Population census of Shaanxi Province China. Beijing: China Statistics Press; 2002. (in Chinese)
25. Yang XG, LI YP, Ma GS, Hu XQ, Wang JZ, Cui CH, Wang ZH, Yu WT, Yang ZX, Zhai FY. Study on weight and height of the Chinese people and the differences between 1992 and 2002. Zhonghua Liu Xing Bing Xue Za Zhi 2005;26(7):489-93. (in Chinese)
26. Ladipo OA. Nutrition in pregnancy: mineral and vitamin supplements. Am J Clin Nutr. 2000;72(1 Suppl):280S-90S.
27. Goldberg. GR, Black. AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, AM. P. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. Eur J Clin Nutr. 1991;45(12):569-81.
28. Xu L, Dibley J, D'Este C. Reliability and validity of a food-frequency questionnaire for Chinese postmenopausal women. Public Health Nutr. 2004;7(1):91-8.
29. Mouratidou T, Ford F, Fraser RB. Validation of a food-frequency questionnaire for use in pregnancy. Public Health Nutr. 2006;9(4):515-22.
30. Wirfält E. Cognitive aspects of dietary assessment. Scand J Nutr. 1998;42:56-9.
31. Robinson S, Godfrey K, Osmond C, Cox V, Barker D. Evaluation of a food frequency questionnaire used to assess nutrient intakes in pregnant women. Eur J Clin Nutr. 1996; 50(5):302-8.
32. Forsythe HE, Gage B. Use of a multicultural food-frequency questionnaire with pregnant and lactating women. Am J Clin Nutr. 1994;59(1 Suppl):203S-6S.
33. Suitor CJ, Gardner J, Willett WC. A comparison of food frequency and diet recall methods in studies of nutrient intake of low-income pregnant women. J Am Diet Assoc. 1989;89(12):1786-94.
34. Rodriguez MM, Mendez H, Torun B, Schroeder D, Stein AD. Validation of a semi-quantitative food-frequency questionnaire for use among adults in Guatemala. Public Health Nutr. 2002;5(5): 691-9.
35. Pandey D, Bhatia V, Boddula R, Singh HK, Bhatia E. Validation and reproducibility of a food frequency questionnaire to assess energy and fat intake in affluent north Indians. Natl Med J India. 2005;18(5):230-5.
36. Fornes NS, Stringhini ML, Elias BM. Reproducibility and validity of a food-frequency questionnaire for use among low-income Brazilian workers. Public Health Nutr. 2003; 6(8):821-7.
37. Lee MS, Pan WH, Liu KL, Yu MS. Reproducibility and validity of a Chinese food frequency questionnaire used in Taiwan. Asia Pac J Clin Nutr. 2006;15(2):161-9.

Original Article

Validity and reproducibility of a semi-quantitative food frequency questionnaire for use among pregnant women in rural China

Yue Cheng MD[1], Hong Yan MD[1], Michael John Dibley MB BS MPH[2], Yuan Shen MD[1], Qiang Li MD[3] and Lingxia Zeng MD[1]

[1]*Department of Public Health, Xi'an Jiaotong University School of Medicine, Xi'an, Shaanxi, P.R. China*
[2]*The School of Public Health, and The George Institute for International Health, University of Sydney, NSW, Australia*
[3]*The George Institute for International Health, University of Sydney, Sydney, NSW Australia*

半定量食物频率問卷用於中国贫困地区孕妇的重现性和真实性

本次前瞻性研究的目的是检验针对中国贫困地区孕妇膳食摄入调查的半定量食物频率问卷(68 项食物条目)的重现性和真实性。食物频率问卷采用访问式，分别在第三孕期初和分娩前进行，两次访问间隔 3 个月，在此期间随机完成 6 次 24 小时膳食回顾调查。食物频率问卷与 24 小时膳食回顾调查的结果进行比较以检验该食物频率问卷的重现性和真实性。2004 年 6-9 间，在中国陕西省的两个贫困县，共 125 名孕妇(入组时孕周为 23-26 周)参与并完成了本研究的所有问卷。两次食物频率问卷间营养素的相关系数范围在 0.31(硫胺素)到 0.61(脂肪)之间，均数为 0.46。第二次食物频率问卷与 24 小时膳食调查测量到的营养素之间的相关系数范围从 0.53(胆固醇)到 0.70(α-维生素 E 和钾)，均数为 0.62；通过校正个体内变异对相关系数的影响后，相关系数均数为 0.69，范围从 0.58(胆固醇)到 0.77(α-维生素 E 和钾)。Bland-Altman 图显示食物频率问卷和 24 小时膳食回顾两种方法得到的营养素摄入的差值和均数之间存在显著相关；平均摄入较高时，两种方法测得营养素摄入存在更大的差异。根据两种膳食调查方法得到的营养素摄入量将受试者分为人数相等的五组，74%的被分到了同一个或相邻的组，1%的被分到了极端对立的两组。本研究结果显示该食物频率问卷，在测量中国贫困地区孕妇营养素摄入情况时有较好的重现性和真实性，尤其在加入面糊这一食物后。

關鍵字：食物頻率問卷、分級、懷孕、飲食調查、中國。