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Relative Validity of a Food Frequency Questionnaire among Multi-ethnic Working Population in Malaysia

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Food frequency questionnaire (FFQ) is suitable to assess the dietary intakes of populations in large scale and longitudinal nutritional studies. Specific FFQ should be developed and validated for specific populations. We aimed to develop and validate an FFQ among a multi-ethnic working population in the Klang Valley, Malaysia. The participants were required to record their dietary intake for seven days (DR), then to fill the FFQ twice over two weeks (FFQ1 and FFQ2). The agreement between FFQ-1 and DR was evaluated using Bland-Altman plots and cross-classification of quartiles analysis. Calibration coefficients were estimated from FFQ-1 and DR. Spearman correlation coefficients and Intra-class Correlation Coefficient (ICC) between two FFQs were computed. Bland-Altman plots demonstrated good agreement between methods. Classification into the same and adjacent quartiles ranged from 49.2% (riboflavin) to 55.8% (cholesterol), while grossly misclassified participants varied from 3.6% (retinol) to 9.1% (energy). Spearman correlation coefficients between the two FFQs fell within the range of 0.43 to 0.62. The ICCs ranged from 0.56 (carbohydrate) to 0.66 (fat) for macronutrients, and from 0.59 (potassium and thiamine) to 0.74 (vitamin C) for micronutrients. The FFQ is valid and reliable in estimating dietary intakes among our multi-ethnic, working population.

Keywords: validation; reproducibility; FFQ; multi-ethnic; Malaysia

I. INTRODUCTION

Unhealthy diet has been associated with obesity and CVDs (Schulz *et al.*, 2008, Schulze *et al.*, 2005) and resulted in nutritional recommendations for these diseases (Kim *et al.*, 2012, Montonen *et al.*, 2005, Schulze *et al.*, 2003). However, the great challenge in the study of diet-disease association is the measurement of usual dietary intake. Generally, an individual's usual intake can be assessed using different dietary instruments which involve a comprehensive evaluation of the quantity and quality of food and beverages intake (Rutishauser, 2005). The common dietary assessment instruments include the Food Frequency Questionnaire (FFQ), dietary record (DR), and 24-hour dietary recall. Each of these instruments has its own strengths and limitations. Selection of the dietary assessment instrument depends on the study objectives,

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participant characteristics, respondent burden and available resources.

Amongst these instruments, an FFQ is most commonly used to assess diet in large-scale epidemiological studies (Alhazmi *et al.*, 2014, McEvoy *et al.*, 2014), due to its ability to estimate usual intake over an extended period, its ease of administration and the low cost. The use of this instrument does not require highly trained interviewers and it is able to capture usual intake over a long period with a single administration. Measurement errors in FFQs can be estimated by comparing the FFQ with another more precise method.

Therefore, to properly interpret the results of epidemiological studies that use FFQs, the reproducibility or how consistently FFQs can be repeated on the same individual, is a useful first estimate of questionnaire performance (Willett, 2012). It is also necessary to know its validity reflecting the relationship between reported intakes from the FFQ and better approximations of the unknown underlying true usual intakes.

One of the most commonly used methods used in assessing the validity of FFQ is dietary record. Food intake on a dietary record is to be recorded by the participant at the time the foods are eaten, which minimize the reliance on memory. The participants are required to record complete and accurate food items consumed. Household measuring tools such as cups, bowls and spoons are commonly used to estimate the quantity of food consumed. Changes in eating habits while keeping the dietary records may be one of the limitations of this method (Baranowski, 2013). The number of days of recording food intake will also affect the accuracy of this method.

The population of Malaysia is made up of multi-ethnic groups namely Malays, Chinese and Indians as the major ethnic groups. To date, there are no validated FFQs to assess Malaysian adults' diet. FFQs from the West or other countries are not suitable as our cultural background and traditions are different. The Malays, Chinese and Indian ethnic groups have their own cultures with different dietary intakes; however, it is common to observe individuals from one ethnic group consuming dishes typical of another ethnic group. Therefore, it is timely to develop and validate an FFQ suitable to assess the dietary intakes of these major ethnic populations which can be used for large scale and longitudinal nutritional studies in the future.

II. MATERIALS AND METHOD

A. Development of FFQ

The FFQ was developed using data from the first Malaysian Adult Nutrition Survey (MANS) (Mirnalini *et al.*, 2008). MANS was a nationally representative food consumption survey conducted in 2003 from both Peninsular Malaysia and East Malaysia. A total of 7349 adults aged 18 to 59 years old participated in the survey. The dietary information was collected by nutritionists using a single interviewer administered 24-hour dietary recall. However, we only used data from the Peninsular Malaysia (which made up of 84% of the data) as the proposed FFQ was meant for the major ethnic groups of Peninsular Malaysia, ie. Malay, Chinese and Indians.

The food list was constructed using the data-based approach by Block *et al.* (1986). Food items were ranked according to their contribution for energy, macro- and micro-nutrients such as protein, fat, carbohydrate, vitamin A, thiamine, riboflavin, niacin, vitamin C, sodium, potassium, calcium, phosphorus and iron. Food items that contributed to at least 90% of energy and nutrients were included in the food list. These food items were then grouped into food groups. The frequency of food consumption was measured as number of times per day, week, month, year or never. Portion sizes were estimated using common household measurements such as cup (250ml), small bowl (200ml), tablespoon (15ml), etc.

Experts' opinion (from dietitians and researchers) on instructions, layout of the FFQ, methods of recording, portion sizes estimation and list of food items were obtained to ensure all frequently consumed foods were included and to help improve its content validity. Some minor changes including an expanded list of foods and revised portion size estimation were made. The final FFQ was pretested among ten adults not involved in the validation study to ensure the FFQ was easy to understand and administered.

B. Validation of FFQ

1. Study sample

The study was conducted from February 2014 until October 2015, in the primary and secondary schools from the Klang Valley, Malaysia. All teachers and clerical staff from ethnic groups of Malays, Chinese or Indians, and aged 20 to 60 years old were invited to participate. Chinese and Indian participants were oversampled to correct for the proportions of teachers from these two ethnic groups. Pregnant women were excluded.

2. Ethical consideration

Ethics clearance was obtained from the Medical Research and Ethics Committee of the Ministry of Health, Malaysia (NMRR-13-755-16953) as well as the Ethics Committee of the Faculty of Medicine, University of Malaya (Ref No: MEC 950.1). Informed consent was obtained from all participants before data collection. All data were anonymised.

3. Food Frequency Questionnaire (FFQ)

The FFQ consisted of 136 food items with a combination of raw, cooked and mixed dishes. The food items were grouped into 17 food groups based on their nutrient content. Information on beef, poultry, and fish was categorized by typically used cooking methods such as deep-fried, cooked with coconut milk, cooked without coconut milk, grilled/roasted, or steamed. The serving sizes were based on the usual household measurements according to the food atlas from Shahar *et al.* (2009). There was a total of five major columns in the FFQ; the first column indicated the codes of the food items while the second column contained the names of the food items. The third column presented the frequency intake of these food items, which was further divided into five columns for the frequency response options by day, week, month, year and never. The fourth column described the standard serving size and the last column was used to capture the number of serving size consumed. The participants were required to write for each food item the number of times per day, week, month or year as well as the number of serving size in a specified unit that they typically consumed over the past year. For food items that were never consumed or consumed less than once a year, the participants were required to mark “never” without indicating serving size. Besides, colour photographs of serving size for selected food items were attached with the FFQ to improve the estimation of serving size. The FFQ was written in both Malay (national language) and English. The FFQ took approximately 30-45 minutes to complete.

4. Study protocol

The participants were first required to record their dietary intake in a predesigned form for seven days (7-day diet record). They were required to record all foods and beverages consumed from the time they woke up until the night they went to sleep. They were given some examples of household measurements and estimation of portion size for common foods using food photos. After they completed the 7-day diet records, the researcher went through their diet records and discrepancies were checked with the participants. The participants were then asked to fill the FFQ after two weeks (FFQ1). Instructions were also given on how to fill the FFQ. As Malaysia has no seasonal difference over the year, only one 7-day diet record (DR) was collected to be compared with FFQ1 (validation). For the reproducibility testing, these participants were required to fill the FFQ again two weeks (FFQ2) after FFQ1. The two-week interval was selected to minimize changes over time if the interval was too long and recall of previous answers if interval too short. In addition, there is no seasonal variability in food habits among Malaysians. Although there may be some seasonal food items consumed during festive periods, these patterns do not reflect a typical diet. Therefore, two-week interval between the two FFQs and one 7-day diet record (DR) were used in our study.

5. Other variables collected

Socio-demographic data on age, gender, ethnicity and highest education levels achieved, were collected using a self-administered questionnaire. Weight and height were self-reported. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (meter).

C. Statistical methods

The participants' energy and nutrients intake in both DR and FFQs were calculated using the Nutritionist Pro software (Axxya Systems, 2006) with nutrients' values based on the Malaysia Food Composition Database (Tee *et al.*, 1997). For food items and/or nutrients (i.e.: cholesterol, saturated fat, PUFA, MUFA,) that were not available, the Energy and Nutrient Composition Database from Singapore (Health Promotion Board Singapore, 2003) was used. Nutrient composition of the most closely comparable category was adopted if any of the food items was not available in both databases. Participants who reported missing frequencies greater than 20% (Michels and Willett, 2009) (n=18) , missing page(s) (n=4) or implausible energy intakes ie: <800 or >4,000 kcal/day for men and <500 or >3,500 kcal/day for women were excluded (Willett, 2012) (n=143). For the FFQ, food items with missing frequency were imputed as zero (Michels and Willett, 2009, Fraser *et al.*, 2009), while missing serving size were imputed with the median (Koster-Rasmussen *et al.*, 2014). The frequency intake specified as weekly, monthly and yearly was converted to daily. The daily intake of a nutrient for each food item was calculated using the product-sum method (Willett, 2012). Most of the nutrient intake data were not normally distributed; therefore, all nutrient data were log-transformed.

For validity assessment, nutrients intake derived from FFQ-1 were compared with DR. Nutrients intake derived from FFQ-1 and DR were presented as medians (interquartile range). Spearman correlation coefficients were used to assess the correlations for crude- and energy-adjusted nutrients using the residual method (Willett, 1998). Bland-Altman analysis was performed on the log-transformed nutrients to assess the agreement between two methods. Visual representation of agreement between two methods was presented for energy and all nutrients. Cross-classification of quartiles analysis and kappa coefficients were also used to assess the capacity of FFQ-1 and DR to allocate individuals according to the levels of nutrient intakes, demonstrating the agreement between both methods. The proportions of participants classified into same, adjacent, and grossly misclassification (more than two quartiles apart) were calculated.

For the reproducibility analyses, spearman correlation coefficients for crude- and energy-adjusted nutrients as well as Intra-class Correlation Coefficient (ICC) were used to assess the correlations between FFQ1 and FFQ2. All statistical analyses were conducted using Stata version 13.0 (STataCorp, 2013).

III. RESULT

The validation study had 285 participants, one of which was excluded as the food record was less than seven days (n=1); and 70 participants were excluded due to implausible energy intakes reported in FFQ1, resulting in 214 participants included in the analyses (Figure 1). As per study protocol, all participants from the validation study were invited to participate in the reproducibility study. However, the response rate of these participants for FFQ2 was poor (n=109, response rate=51%), and consequently new participants for the study were recruited. In total, there were 333 participants in the reproducibility study (with 109 participated in the validation study and n= 224 recruited just for the reproducibility study), but 95 had to be excluded due to implausible energy intake, resulting in 238 participants in the reproducibility study.

Table 1. Socio-demographic characteristics of participants

Characteristics[a]	Validation (n=214)	Reliability (n=238)	p
Age (mean±SD)	*39.9±9.6	**40.8±9.7	0.33
Sex			
Men	19 (8.9)	17 (7.1)	0.50
Women	195 (91.1)	221 (92.9)	
Ethnicity			
Malay	85 (39.7)	86 (36.1)	0.01
Chinese	68 (31.8)	106 (44.5)	
Indian	61 (28.5)	46 (19.3)	
Education level			
Secondary	80 (37.4)	80 (33.6)	0.59
Degree	124 (57.9)	149 (62.6)	
Master/PhD	10 (4.7)	9 (3.8)	
BMI (mean±SD)	#25.6±5.5	##24.5±4.4	0.08

SD: Standard deviation; a data presented as means ± SD for continuous variables and number (column %) for categorical variables; *13 missing; **18 missing; #133missing; ##83missing

The socio-demographic characteristics of participants who took part in the validation and reproducibility components of the FFQ were comparable (p>0.05) except ethnic groups (Table 1). Their mean age was about 40 years, predominantly females with tertiary education, about one third were clerical staff, but with a slightly lower proportion of Indian participants in the reproducibility study.

FFQ overestimated all values of macro- and micro-nutrients compared to DR (Table 2). Correlations between nutrients estimated by the FFQs and DR are shown in Table 3. The Spearman's correlation coefficients for crude data varied from 0.02 (fibre) to 0.33 (cholesterol). Adjusting for total energy intake improved the correlations in the macro-nutrients (carbohydrate, protein and fat), sodium, beta-carotene and vitamin C, but decreased the values for nutrients such as cholesterol and retinol.

Table 2. Daily nutrients intake assessed by FFQ-1 and DR

Nutrient	FFQ-1	DR	Spearman's Correlation coefficient[a]	Energy adjusted Spearman[a,b] Correlation coefficient
	Median (IQR)	Median (IQR)		
Energy, kcal	2045.6 (1559.2-2689.7)	1390.6 (1156.5-1679.9)*	0.1	-
Protein, g	86.4 (61.3-121.9)	54.3 (42.7-67.3)*	0.18[s]	0.26 §
Fat, g	73.5 (49.2-100.1)	51.0 (41.7-65.2)*	0.13	0.23 §
Carbohydrate, g	250.7 (197.5-321.8)	176.0 (147.6-212.8)*	0.1	0.32 §
Saturated fat, g	24.7 (16.4-34)	6.6 (3.7-9.2)*	0.08	0.01
Cholesterol, mg	252.3 (155.7-364.2)	79.7 (45.7-132.7)*	0.33 §	0.28 §
Sodium, mg	3752.1 (2835.8-5197.6)	2056.0 (1639.1-2618.2)*	0.21 §	0.31 §
Beta-carotene, μg	2906.6 (1724.3-4299.1)	881.4 (480.2-1328)*	0.18[s]	0.19[s]
Calcium, mg	884.9 (552.9-1435.1)	372.6 (286.7-466.4)*	0.14[s]	-0.01
Iron, mg	24.1 (16.2-32.8)	13.1 (10.1-17.6)*	0.18[s]	0.05
MUFA, g	22.1 (14.7-30.1)	5.7 (3.6-8.2)*	0.09	0.11
Phosphorus, mg	1268.0 (883.8-1896.2)	723.4 (569-951)*	0.16[s]	0.12
PUFA, g	15.6 (12-21.7)	4.9 (3.3-6.9)*	0.13	0.01
Potassium, mg	2047.4 (1514.2-3054.4)	1008.3 (811.3-1316.5)*	0.13	0.12
Retinol, μg	1040.5 (654.6-1447)	494.7 (332.3-706.7)*	0.29 §	0.21 §
Riboflavin, mg	1.8 (1.2-2.7)	0.8 (0.6-1.1)*	0.13	0.06
Thiamin, mg	1.2 (0.8-1.7)	0.5 (0.4-0.7)*	0.13	0.06
Vitamin C, mg	127.8 (75.8-200.2)	33.5 (16.1-66.6)*	0.14[s]	0.20 §
Zinc, mg	8.5 (5.8-11.3)	2.0 (1.3-3.2)*	0.19[s]	0.11

*Significantly different from FFQ: paired t-test on log-transformed values, p<0.001; a Data was log-transformed; b Adjusted for energy using residual method; [s]p<0.05; §p<0.001

Bland-Altman plots demonstrated good levels of agreement between FFQ1 and DR for energy and macronutrients adjusted for total energy intake (Figure 1), while the levels of agreement for micronutrients were moderate (supplementary file). Classification of participants into the same and adjacent quartiles ranged from 49.2% (riboflavin) to 55.8% (cholesterol), while grossly misclassified participants varied from 3.6% (retinol) to 9.1% (energy) (Table 3).

Table 3. Cross classification of nutrients in quartiles assessed by FFQ-1 and DR

Nutrients (per day)	Same quartile (%)	Adjacent (%)	Extreme (%)	Same or adjacent (%)	Kappa coefficient
Energy, kcal	21.4	30.8	9.1	*52.2*	*0.07*
Protein, g	22.5	31.2	8.7	*53.7*	*0.10*
Fat, g	24.3	26.4	8.3	*50.7*	*0.09*
Carbohydrate, g	20.3	31.5	8.3	*51.8*	*0.06*
Saturated fat, g	18.1	32.6	8.0	*50.7*	*0.03*
Cholesterol, mg	23.2	32.6	5.1	*55.8*	*0.16*
Sodium, mg	22.8	29.7	7.2	*52.5*	*0.10*
Beta-carotene, µg	25.4	29.0	6.5	*54.4*	*0.16*
Calcium, mg	21.4	29.0	8.0	*50.4*	*0.06*
Iron, mg	23.9	29.0	6.5	*52.9*	*0.13*
MUFA, g	22.1	27.2	8.3	*49.3*	*0.05*
Phosphorus, mg	21.4	30.1	6.9	*51.1*	*0.08*
PUFA, g	24.3	25.4	7.2	*49.7*	*0.09*
Potassium, mg	20.3	33.3	6.5	*53.6*	*0.10*
Retinol, µg	26.4	27.5	3.6	*53.9*	*0.19*
Riboflavin, mg	19.9	29.3	8.3	*49.2*	*0.03*
Thiamine, mg	24.3	26.1	8.0	*50.4*	*0.09*
Vitamin C, mg	23.2	29.7	8.7	*52.9*	*0.10*
Zinc, mg	21.0	30.1	6.2	*51.1*	*0.08*

Table 4. Daily nutrients intake, Intra-class Correlation Coefficients (ICC), Spearman's Correlation coefficients for energy and nutrients intake assessed by FFQ-1 and FFQ-2

Nutrients (per day)	FFQ-1 Median (IQR)	FFQ-2 Median (IQR)	ICC[a]	Spearman's Correlation coefficient
Energy, kcal	1981.3 (1511.7, 2482.6)	1842.0 (1418.5, 2385.0)	0.60*	0.43*
Protein, g	86.0 (61.5, 115.5)	79.0 (57.5, 107.3)	0.65*	0.48*
Fat, g	71.8 (53.1, 92.9)	67.5 (46.9, 93.4)	0.66*	0.49*
Carbohydrate, g	242.1 (185.2, 294.4)	218.1 (163.7, 291.6)	0.56*	0.44*
Saturated fat, g	24.2 (18.8, 32.5)	23.6 (16.5, 31.9)	0.66*	0.47*
Cholesterol, mg	264.3 (163.0, 347.7)	240.7 (158.4, 347.9)	0.73*	0.56*
Sodium, mg	3954.0 (2975.0, 5278.7)	3866.8 (2685.9, 4949.6)	0.68*	0.52*
Beta-carotene, µg	2587.0 (1668.3, 4044.5)	2510.5 (1479.0, 4175.5)	0.61*	0.50*
Calcium, mg	847.4 (553.7, 1384.6)	808.4 (550.8, 1341.9)	0.60*	0.48*
Iron, mg	23.8 (16.6, 31.8)	21.8 (16.3, 30.1)	0.63*	0.47*
MUFA, g	21.3 (16.1, 28.6)	20.6 (16.5, 29.3)	0.65*	0.47*
Phosphorus, mg	1265.1 (847.9, 1772.6)	1187.6 (804.0, 1703.9)	0.65*	0.47*
PUFA, g	14.9 (11.9, 204)	14.3 (10.3, 22.4)	0.63*	0.49*
Potassium, mg	2003.7 (1508.9, 2813.2)	2010.4 (1415.3, 2840.7)	0.59*	0.43*
Retinol, µg	976.0 (693.5, 1394.1)	928.8 (591.9, 1336.8)	0.71*	0.54*
Riboflavin, mg	1.7 (1.2, 2.5)	1.7 (1.1, 2.4)	0.62*	0.49*
Thiamin, mg	1.1 (0.8, 1.6)	1.1 (0.8, 1.5)	0.59*	0.44*
Vitamin C, mg	109.7 (67.4, 197.7)	117.9 (68.8, 193.7)	0.74*	0.62*
Zinc, mg	8.4 (5.8, 10.6)	7.6 (5.6, 10.6)	0.65*	0.49*

[a]log-transformed nutrients; *p<0.001

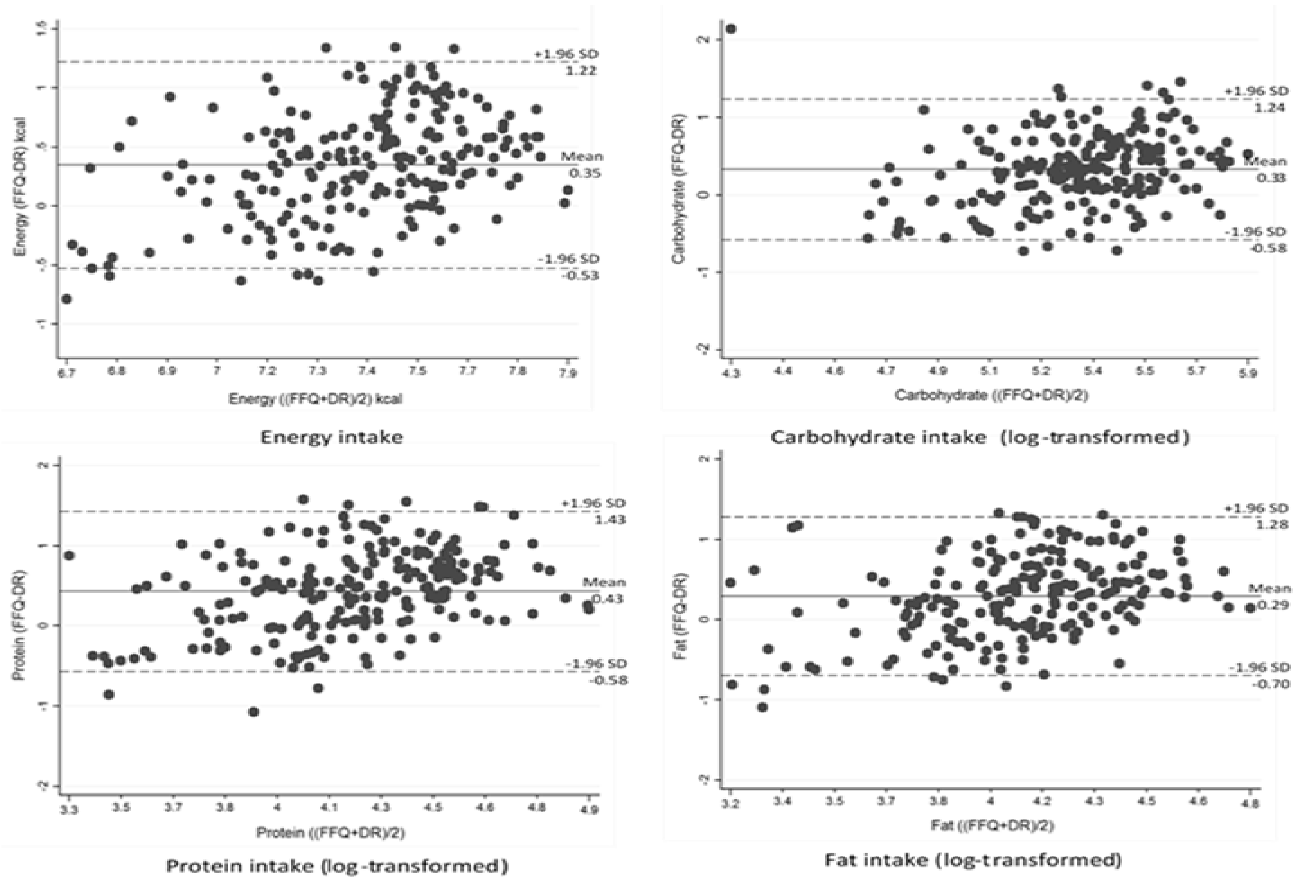

Figure 1. Bland-Altman plots for energy and macronutrients

Spearman correlation coefficients between the two FFQs (reproducibility) are presented in Table 4. The correlations fell within the range of 0.43 to 0.62. The Intra-correlation coefficients (ICCs) between FFQ1 and FFQ2 were found to be relatively high, ranging from 0.56 (carbohydrate) to 0.66 (fat) for macronutrients, and from 0.59 (potassium and thiamine) to 0.74 (vitamin C) for micronutrients.

IV. DISCUSSION

Compared with other dietary assessment methods, FFQ is the most practical and cost-effective means for assessing diet in large-scale nutritional epidemiology studies (Willett and Stampfer, 1986). However, food availability, demographic, socioeconomic, cultural aspects influence the food intake of each population. Therefore, FFQs should be developed and validated specifically for the populations they are intended to be used, in order to produce valid and reliable data. To the best of our knowledge, there are no validated and peer reviewed FFQs available to assess general diets of Malaysian adult population. However, there are local validated FFQs to assess general diets of specific target groups such as children (Fatihah *et al.*, 2015), adolescents (Nurul-Fadhilah *et al.*, 2012) and pregnant women (Loy *et al.*, 2011). There are also some validated FFQs designed to assess certain food groups such as iodine (Md. Taib and Md. Isa, 2013), calcium (Chee *et al.*, 2002), vitamin D (Zaleha *et al.*, 2015), sugar (Shanita *et al.*, 2012), cholesterol and types of fats (Eng and Moy, 2011), omega-3-polyunsaturated fatty acids (Lee *et al.*, 2013), genistein (Fernandez *et al.*, 2013). Therefore, our FFQ could fill the gap in assessing diets of the three major ethnic groups of Malaysian adults.

The FFQ overestimated energy and all nutrients compared to DR, similarly as reported by others (Nurul-Fadhilah *et al.*, 2012, Loy *et al.*, 2011, Eng and Moy, 2011, Kowalkowska *et al.*, 2013). A possible explanation is that people tend to overestimate their actual intake when they are asked to recall the frequency of a large number of foods consumed in an FFQ. In addition, inadequate estimation of the food portion size and social desirability bias may also contribute to overestimation. On the other hand, DR may also be subjected to underestimation by the participants.

Correlation coefficients of macronutrients improved with energy adjustment, when its variability was related to energy intake (Willett and Stampfer, 1986). Correlation coefficients of some nutrients improved (sodium, beta-carotene and vitamin C) or decreased (cholesterol and retinol) indicating that the FFQ may over- or under-estimate intake of these nutrients; however, errors in over- or under-estimation by FFQ are expected. The energy-adjusted correlation coefficients for FFQ and DR were lower than the range (0.38-0.53) reported for FFQs with unweighted dietary records (Cade *et al.*, 2004). However, the Bland-Altman plots demonstrated an acceptable level of agreement between FFQ and DR for energy, macro- and micro-nutrients adjusted for energy intake (Giavarina, 2015). Classification of our participants into the same and adjacent quartiles was moderate, while grossly misclassified participants were less than 10%. These demonstrated FFQ and DR had a good between method agreement.

With regards to the FFQ's reproducibility, the correlation coefficients (0.43-0.62) and ICCs (0.56 - 0.74) were within the acceptable range of 0.5 to 0.7, as reported in a review (Cade *et al.*, 2004). Our findings are comparable to other FFQs developed for adolescents (Nurul-Fadhilah *et al.*, 2012) and pregnant women (Loy *et al.*, 2011) in Malaysia. A short interval between the administration of FFQ1 and FFQ2 may artificially inflate the observed correlations, while a longer time interval may lower the observed correlations. However, a two-week interval is a generally accepted interval in our setting.

The incomplete or out-dated national nutrient database used in this study may contribute to measurement errors to the FFQ. Additional recruited participants for the reproducibility study may have biased the results. However, sensitivity analysis including only participants involved in both reproducibility and validation studies showed the same results with the current analysis. Our participants may not represent the general population as they were better educated and highly motivated, as evidenced by the completion of 7-day diet records and two FFQs. The 7-day diet records used may be subjected to over- or underestimation. However, a better reference instrument such as the recovery biomarkers that provide unbiased measurement with errors independent of those from FFQ was not used as they were expensive and invasive. In addition, they are available for a limited number of nutrients only (i.e. energy, protein, K and Na).

On the other hand, this FFQ has included all commonly consumed food items by the three major ethnic groups of the country, thus enabling the dietary intakes of these ethnic groups to be assessed using the same FFQ. In addition, dietary acculturation of these ethnic groups warrants one FFQ to be used.

In summary, our study provides evidence for the degree of validity and reliability of an FFQ to be used in the multi-ethnic working adult population in Malaysia. The developed FFQ may be used in monitoring dietary intakes and food consumption patterns amongst our population and at guiding the development of effective, evidence-based public health strategies for the prevention of obesity and cardiovascular diseases. Further research should explore the feasibility of this FFQ for assessing usual dietary intake among all adult populations of the country.

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