Short Communication

Validation of a simplified food frequency questionnaire as used in the Nutrition and Health Survey in Taiwan (NAHSIT) for the elderly

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A 28-item simplified food frequency questionnaire (SFFQ) combined with 9 open questions about staples was designed for the Elderly Nutrient and Health Survey in Taiwan (NAHSIT) to collect information on participants' usual food intake of the previous month. We have examined the validity of this SFFQ via comparison with data on multiple 24-hour dietary recall (n=81) and biomarkers (n=1473). All questionnaires were completed by face-to-face interview and fasting blood samples were taken. Thirty seven males and 44 females were randomly selected from NAHSIT participants. Of these, 31 and 50 subjects completed 2 or 3 24-hour dietary recalls within one month, respectively. Mean daily intake frequencies for each food group were calculated from the SFFQ and 24-hr recalls, respectively. Spearman rank correlation coefficients between frequencies of food group obtained from the FFQ and from dietary recalls ranged from 0.132 to 0.678 for men; 0.052 to 0.759 for women. Correlation coefficients between frequency and food weight were similar. When validated by nutrient status, the most correlated was dairy intake frequency judged by 24-hour vitamin B-2 and calcium intakes and by erythrocyte glutathione reductase (EGRAC) for B-2 functionality, where the correlation coefficients were, respectively, 0.533, 0.518 and -0.205 for men; 0.494, 0.475 and -0.174 for women; fish and fruit frequency followed in overall validity. The SFFQ measured the food patterns of NAHSIT elders with validity high for dairy and good for fish and fruit intakes in both genders.

Key Words: simple food frequency questionnaire, 24-hour dietary recall, food group, biomarker, NAHSIT Elderly

INTRODUCTION

In population surveys, there is a need to be minimally intrusive to avoid subject fatigue and to reduce costs and demands on human resources. Ease for respondents and the acceptance of a greater work-load on the part of the enquirer can help achieve greater and more enduring participation rates.[1] Burke first documented the dietary history cross-check method.[2] In its variously elaborated and abridged forms, it has been used from public health to clinical studies and practice.[3] In due course, efforts were made to systemize the collection of dietary data with food frequency questionnaires (FFQs). They have become the most used dietary assessment tool for nutritional epidemiologic studies.[4]

The simplified food frequency questionnaire (SFFQ) is a particular form of FFQ in which portion sizes are not specified. Hatloy et al has used an SFFQ with food items consumed in the household the previous day to form a food variety score.[5] Wakai and colleagues developed a simple FFQ with 97 foods and dishes for Japanese [6] and found it to have reasonable reproducibility and validity for nutrients and food groups.[6,7]

An SFFQ and 24-hour dietary recall methods were used to evaluate dietary status in the Nutrition and Health Survey in Taiwan (NAHSIT) for the elderly. We assessed the validity of this SFFQ using the average frequencies of food group and food weight intakes derived from multiple 24-hour dietary recalls as the reference point as well as nutrient intakes and biomarkers.

MATERIALS AND METHODS

Study population

Participants were from the Elderly NAHSIT which was conducted during 1999-2000. The design for this survey can be found elsewhere.[8] The dietary information was collected using an SFFQ and 24-hour dietary recall. All

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information was collected by face-to-face interview by trained interviewers. A sub-sample of 81, randomly selected from the NAHSIT, who completed multiple 24-hour dietary recalls within one month after baseline interview, was recruited for this validity study. We also studied 1473 survey subjects to examine the associations between SFFQ and nutrient intake as well as biomarkers. The study received ethics approval by the Institutional Review Board of Academia Sinica.

Simplified food frequency questionnaire (SFFQ)
Based on an FFQ used for Taiwanese,[9] a 37 food item (18 food groups, 1 sugar/honey/syrup, 1 desert, 3 drinks, 5 processed foods, 9 staples) SFFQ was designed for the NAHSIT Elderly. Participants were requested to indicate how many times each food was consumed per month/ week/day in the past month. We categorized those food items into the following 9 groups: total grain, whole grain, milk, meat, fish, egg, soy, vegetable and fruit.

24-hour dietary recalls
A total of 31 and 50 subjects, randomly selected from the study population, completed 2 days or 3 days of 24-hour dietary recalls, respectively. We grouped the recall food items into the same 9 groups as for the SFFQ and obtained mean frequencies of consumption per day for each group. The mean weight and nutrient intakes were calculated. The computational details for nutrient intake can be found with NAHSIT 1999-2000 and NAHSIT 1993-1996 report.[8,10]

Measurements of biomarkers
Subjects fasted for 8 hours before venipuncture. Erythro-cyte transketolase reductase (ETKAC) and erythrocyte glutathione reductase (EGRAC) were used to evaluate the nutritional status of vitamins B-1 and B-2, respectively.[11] Plasma folate was measured by a combined system of competitive immunoassay and chemiluminesence using monoclonal antibodies, paramagnetic particles, and a chemiluminesence substrate.[12]

Statistical analysis
Frequency and weight of food intake were presented as daily intakes. Spearman's rank correlation coefficient was used to evaluate the correlation of food frequency acquired by SFFQ with 24-hour dietary recall data (frequency, food weight, and nutrients) as well as with biomarkers by gender. All nutrient intakes were adjusted for total energy intake using the regression residual method.[13] All analyses were performed using SAS statistical software (version 9.0, SAS Institute Inc, Cary, NC).

RESULTS
Table 1 show the baseline characteristic of subjects. There were 3 groups, namely, those who undertook an SFFQ and a 24-hr dietary recall (n=1937), those who also had biomarkers (n=1473), and those who also had repeated 24-hr dietary recalls (n=81), respectively. Although the 3 groups were generally comparable, those who had repeated 24-hr recalls were more likely female, younger, Fukienese, less educated, and lower in BMIs than the other 2 groups.

Table 2 shows the gender specific mean daily intake frequency for each food group by SFFQ and repeated 24-hour dietary recalls. In general, the mean daily frequency of total grain, meat, fish, soy products, or vegetable intake

Table 1. Baseline characteristic of study subjects

	Subjects with SFFQ and 24-hr recall (n=1937)	Subjects with SFFQ, and biomarkers (n=1473)	Subjects with repeated 24-hr recalls (n=81)
Gender-male	50.1	51.1	45.7
Age (yrs)			
65-69	33.0	33.5	36.3
70-74	34.6	35.0	26.3
75-79	20.5	20.1	27.5
≥80	12.0	11.4	10.0
Ethnicity			
Fukienese	61.8	59.2	65.4
Hakka	10.5	10.5	8.64
Mainlander	17.2	18.5	14.8
Aboriginal	10.4	11.8	11.1
Education			
Illiterate	35.3	33.2	34.6
Primary school	44.4	45.8	51.9
≥ High school	20.3	21.0	13.6
Physical activity			
More than most	18.8	20.4	16.0
Same as most	46.6	46.8	61.3
Less than most	34.6	32.7	22.7
Ever smoker	34.6	36.0	32.1
Alcohol drinker	26.3	27.4	27.2
BMI (kg/m²)			
<18.5	7.02	7.02	9.86
18.5-23.9	45.6	45.6	45.1
24.0-26.9	29.4	29.4	28.2
≥27.0	17.9	17.9	16.9

All data presented by %

Table 2. Frequency of daily intake by simplified food frequency questionnaire (SFFQ) and repeated 24-hour dietary recalls

	Males (n=37)				Female (n=44)			
	24-hour dietary recall		SFFQ		24-hour dietary recall		FFQ	
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Total grain	3.30±0.88	1.33-5.50	3.08±0.56	2-4.29	3.10±0.80	1.33-4.67	2.90±0.61	0.86-4.00
Whole grain	0.20±0.32	0-1.00	0.12±0.29	0-1.14	0.32±0.46	0-1.50	0.08±0.42	0-2.71
Dairy	0.41±0.47	0-1.50	0.78±1.18	0-7.00	0.47±0.50	0-1.67	0.78±1.20	0-7.00
Meat	1.40±0.93	0-3.33	1.37±1.54	0-8.43	1.14±0.98	0-3.33	1.02±0.91	0-4.17
Fish	1.68±1.33	0-5.00	1.13±0.98	0-4.05	1.36±1.13	0-4.50	1.08±0.85	0-3.03
Fish	1.32±1.17	0-4.50	0.89±0.81	0-3.00	1.13±0.91	0-3.50	0.92±0.75	0-3.00
Shrimp	0.24±0.35	0-1.33	0.13±0.34	0-2.00	0.20±0.44	0-2.00	0.09±0.20	0-1.00
Oyster	0.12±0.38	0-2.00	0.11±0.19	0-1.00	0.03±0.16	0-1.00	0.07±0.16	0-1.00
Egg	0.42±0.42	0-1.50	0.65±1.12	0.07-7.00	0.29±0.42	0-1.50	0.40±0.74	0-4.00
Soy	0.60±0.71	0-2.50	0.44±0.46	0-2.07	0.50±0.66	0-3.00	0.72±2.15	0-14.0
Soymilk	0.15±0.37	0-1.50	0.25±0.36	0-2.00	0.20±0.41	0-2.00	0.38±1.09	0-7.00
Soy product	0.45±0.57	0-2.00	0.18±0.22	0-1.00	0.30±0.57	0-3.00	0.33±1.13	0-7.00
Vegetable	5.14±3.79	0.50-19.7	2.91±1.56	0.29-7.03	4.11±2.34	1.50-14.3	2.36±1.65	0.39-10.0
Vegetable	5.02±3.71	0.50-19.7	2.69±1.48	0.29-7.00	4.01±2.37	1.00-14.3	2.16±1.33	0.36-7.00
Mushroom	0.12±0.26	0-1.00	0.21±0.46	0-2.00	0.11±0.23	0-1.00	0.19±0.53	0-3.00
Fruit	1.13±1.14	0-6.00	1.45±1.41	0-7.00	1.07±1.13	0-5.00	1.17±1.23	0.07-7.14
Fruit	1.11±1.10	0-5.67	1.28±1.31	0-7.00	1.05±1.13	0-5.00	1.09±1.18	0-7.00
Fruit juice	0.02±0.08	0-0.33	0.17±0.61	0-3.50	0.02±0.07	0-0.33	0.08±0.22	0-1.00

Table 3. Gender-specific Spearman's rank correlation coefficients between frequency of food intake accessed by simplified food frequency questionnaire and repeated 24-hour dietary recalls

	Total grain	Whole grain	Dairy	Meat	Fish	Egg	Soy	Vegetable	Fruit
Males (n=37)									
Total grain	0.225								
Whole grain		0.132							
Dairy			0.678***						
Meat				0.440*					
Fish					0.552**				
Egg						0.449*			
Soy							0.363*		
Vegetable								0.176	
Fruit									0.456*
Female (n=44)									
Total grain	0.198								
Whole grain		-0.052							
Dairy			0.759***						
Meat				0.466*					
Fish					0.511**				
Egg						0.129			
Soy							0.219		
Vegetable								0.334*	
Fruit									0.546**

*$p<0.05$; **$p<0.001$; ***$p<0.0001$

assessed by SFFQ was lower compared with that assessed by 24-hour recalls. Men had higher frequencies of intake per day than did women, no matter whether they were assessed by FFQ or 24-hour recalls.

Overall, the Spearman's rank correlation coefficients between daily intake frequencies of various food groups derived from SFFQ and those from repeated 24-hour dietary recall ranged from 0.132 to 0.678 and -0.0.52 to 0.759 for males and females, respectively. Dairy (0.678 in men; 0.759 in women), meat (0.440; 0.466), fish (0.552; 0.511), fruit (0.456; 0.546) had statistically significant (p<0.05) correlation coefficients, ranging moderate to high between these two methods in men and women, respectively. Additionally, there were also significant corre-

lation coefficients for eggs (0.449) and soy (0.363) in men. (Table 3)

The correlation coefficients between SFFQ frequencies and weight of food intakes calculated from 24-hour recall are shown in Table 4. In both men and women, significant correlation coefficients were observed for dairy (0.620; 0.812), fish (0.395; 0.371) and fruit (0.472; 0.532) intake, so were correlation coefficients for meat (0.462) and for vegetable (0.590) in women.

A total of 1473 subject were examined for correlation coefficients between SFFQ-frequency and 24-hour nutrient intake and between SFFQ-frequency and biomarker level by gender (Table 5). Fruit and vegetable frequencies were correlated significantly with 24-hour dietary fiber

Table 4. Gender-specific Spearman's rank correlation coefficients between frequency and weight of food intake accessed by simplified food frequency questionnaire and repeated 24-hour dietary recalls

	Total grain	Whole grain	Dairy	Meat	Fish	Egg	Soy	Vegetable	Fruit
Males (n=37)									
Total grain	-0.291								
Whole grain		0.123							
Dairy			0.620***						
Meat				0.285					
Fish					0.395*				
Egg						0.415*			
Soy							0.376*		
Vegetable								0.315	
Fruit									0.472*
Females (n=44)									
Total grain	0.138								
Whole grain		-0.014							
Dairy			0.812***						
Meat				0.462*					
Fish					0.371*				
Egg						0.143			
Soy							0.236		
Vegetable								0.590***	
Fruit									0.532**

*$p<0.05$; **$p<0.001$; ***$p<0.0001$

Table 5. Gender-specific Spearman's rank correlation coefficients between frequency of food intake by simplified food frequency questionnaire with biomarkers and nutrient intakes by 24-hour dietary recall by gender (n=1473)

	Male (n=752)				Female (n=721)			
	Meat	Dairy	Fruit	Vegetable	Meat	Dairy	Fruit	Vegetable
Nutrient intake†								
Protein	-0.010				0.081*			
Vitamin B-1	0.081*				0.100*			
Vitamin B-2		0.533***				0.494***		
Vitamin C			0.289***				0.310***	
Dietary fiber			0.243***	0.112*			0.244***	0.167***
Mg				0.116*				0.110*
Ca		0.518***				0.475***		
Biomarker								
ETKAC	0.103*				0.051			
EGRAC		-0.205***				-0.174***		
Folate			0.085*	0.103*			0.110*	0.095*

† energy adjusted nutrients from one-day 24-hour dietary recall.
*$p<0.05$; **$p<0.001$; ***$p<0.0001$

intakes and blood folate levels. The frequencies of fruit and vegetable intake were also significantly correlated with vitamin C and calcium intakes, respectively. The frequency of dairy intake per day was significantly correlated with levels of vitamin B-2 intake (0.533; 0.494), calcium intake (0.518; 0.475), and EGRAC (-0.205; -0.174) in men and women, respectively.

DISCUSSION
Uses of simplified food frequency questionnaire (SFFQ)
Valid food assessment tools are essential to understand food or nutrient-health relationships. Which food intake methodology is used depends on the questions to be probed, the settings and participants, and the outcomes required.[1] At best methods will be simple and quick, comprehensive and of high resolution, accurate and precise, and amenable to efficient and reliable data management. An SFFQ without specific portion size aims to re-

duce the burden on respondents. Portion size estimation for each single food has not necessarily improved the validity of FFQ.[14] In this regard, Pietinen et al and Wakai et al have developed SFFQs for Finnish and Japanese people, respectively.[6,15] Both SFFQs are able to estimate energy-adjusted nutrient intake with reasonable validity.[7,15]

Evaluation by food group
The bases of validation of food intake methods are several.[4] They include repeatability (with assumptions about dietary stability), inter-method comparisons (e.g., history and recall; records be they written, digitized or photographic; weighed food (with the limitation of intrusiveness and altered food behavior)); use of biomarkers, more recently and particularly, metabolic characteristics or events.[16] No matter which method has been chosen, most studies of the reproducibility and validity of FFQs have been on the basis of nutrient intakes.[4,6] To apply or for-

mulate dietary recommendations, however, the reproducibility and validity for food groups are more relevant. The present study suggests that the SFFQ, as short as 37 items, can provide good estimates of dietary intake frequency as measured by repeated 24-hour dietary recalls. Overall, grain had the lower and dairy the higher correlation coefficients. The lesser correlations between the measures of grain intake, may reflect the generality of the question in a Taiwanese dietary context, where rice, noodles (rice, wheat, and mung bean), and breads are consumed in versatile ways, so as to include many items. Contrarily, dairy is not a habitual food for more than 40% in Taiwanese.[17] It comes from a limited range of products, mainly liquid fresh or reconstituted milk and dairy products like yoghurt and, to a small extent, cheese.

Evaluation by nutrient intakes and biomarkers

We found that dairy, but not other food group, intake frequency by SFFQ was correlated well with its biomarker, EGRAC, and vitamin B-2 and calcium intakes from a one-day 24-hour recall. Lower correlation coefficients between food group intake frequency with nutrient intake from a single 24-hour dietary recall and with biomarkers may have been so for several reasons. Firstly, each food group includes many food items and nutrients and a single day's food intake could not represent an individual's usual intake. Secondly, biomarkers for water soluble vitamins may be affected by short term nutrient intake, with resultant lower correlations. There is a hierarchy of validity evident with the SFFQ used in this study design. It is high, however, for dairy and good for fish and fruit intakes in both genders.

Limitations

The purpose of the present SFFQ is to evaluate dietary patterns, i.e., food groups, but not nutrients, among the Taiwanese elderly. There are, however, several limitations in the design of this SFFQ and the validity appraisal. Firstly, it is of short length (37 items) and consists of food groups rather than single food items or dishes. In addition, the reference period is only one month rather than the more usual one year which would be more representative of a person's long-term dietary intake. Given that older people tend to have relatively monotonous diets,[18] a short reference period may not be an issue. It is difficult to achieve an accurate estimate of individual nutrients by an SFFQ as short or as of limited period of enquiry as that in NAHSIT. Nevertheless, the authors have adopted the intake frequency of various food groups by this tool to derive the Overall Dietary Index-Revised (ODI-R) and found that it can predict mortality after 8 years follow-up in a cohort formed from this survey.[19]

It has been suggested that the errors of two methods under comparison should be independent to prevent overestimation of validity.[4] In this study, SFFQ and 24-hour dietary recall are each dependent on memory. Therefore, we cannot avoid the possibility that the validity may be higher than it should be. Another consideration is that the repeated 24-hour recalls were collected within one month of SFFQ completion and we have assumed that the respondents' dietary patterns have been relatively stable overtime.

There are missing food groups and nutrient values, whose relevance depends on the acceptability and the availability of marker or indicator foods and nutrients in the aged. In this study, we can assess dairy intake with vitamin B-2 and calcium. But there are no good markers for the meat group.

Finally, the problem of extrapolation within and between different sub-groups in Taiwan is worth noting. There are international and intercultural considerations in dietary validation. One question is, how universal these findings are among Chinese, as in Taiwan. One way to address this question would be to compare other Chinese food cultural instruments and validations, other than what has been used in this study, by the broader criteria for validation, including predictability of the method for morbidity and mortality, which we have mentioned.[19]

Implications and applications

There remain questions as to what could be done to increase the utility of the method and as to how practical such approaches could be. There is also some uncertainty as to how the simplified FFQ method is being used at present. We need to consider what has been published to date using it and what conclusions are being drawn. Are there any problems with what has been published in the light of the present findings about validity? For example, how valid are conclusions about grain, especially whole grain intakes in Taiwan-here is an important nutritional question which the present FFQ cannot adequately address.

What about fluid intakes in the aged (water, tea, coffee, sugary drinks) – an important question given the food-beverage-linkages we know about and also because of reduced thirst awareness in the aged, with hot climates like Taiwan, and climate change. The next generation of NAHSIT elderly should take this into account.

What applications might there be for the method in the future? There are new and emerging nutritionally-related health problems[20] like vitamin D deficiency, n–3 fatty acid status, limited fish stocks, and rising food prices.[21] These and other issues confront the future of food intake methodologies.

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臺灣老人營養健康狀況變遷調查簡易食物頻率問卷之效度研究

臺灣老人營養健康狀況變遷調查 (NAHSIT Elderly) 使用簡易食物頻率問卷 (SFFQ)，詢問參與者前一個月的日常飲食攝取狀況。該 SFFQ 有 28 題，另有 9 題主食開放問題。這份 SFFQ 的效度以多次 24 小時飲食回憶法 (n=81) 及生化指標(n=1473) 評估。問卷是以面對面的訪視完成，並採集禁食血液。從 NAHSIT 中隨機選取 37 名男性及 44 名女性。分別有 31 名及 50 名研究對象在一個月之內完成 2 天或是 3 天的 24 小時飲食回憶。分別計算 SFFQ 及 24 小時飲食回憶的 9 類食物的每日平均攝取頻率。計算 9 類食物之 FFQ 及 24 小時回憶的飲食攝取頻率間的 Spearman 等級相關係數，男性為 0.132-0.678；女性為 0.052-0.759 之間。食物重量的相關性，與頻率結果相似。而在生化指標的部分，乳類的攝取頻率以維生素 B-2，鈣質攝取量以及紅血球麩胱甘肽還原酶來評估，相關係數分別為男性 0.533、0.518 及-0.205；女性 0.494、0.475 及-0.174；魚類及水果類的效度與此結果類似。這份 SFFQ 測量臺灣老人的飲食攝取頻率，不論男女，在乳類均有高的效度，而魚類及水果類則有為良好。

關鍵字：簡易食物頻率問卷、24 小時飲食回憶、食物類別、生物標記、臺灣老人營養狀況變遷調查