

Development and validation of food frequency questionnaire for estimating food and nutrient intakes of people in rural Laos

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### Abstract

Food frequency questionnaire (FFQ) has been developed for estimating food and nutrient intakes at both individual and group levels. The foods listed for FFQ have been chosen based on the data of semi-weighed dietary record (DR) collected in autumn, 2004 from children in Lahanam area, and other qualitative information on the dietary habits of Lao population. The validation study with FFQ and 3-day DR was performed using 113 adult women in Lahanam in summer, 2005. Mean intakes of some food groups were severely overreported in FFQ than in DR although the food list of FFQ almost covered major foods necessary for the assessment of the target population. In order to minimize over/underreporting tendency by food group, the portion sizes in the calculation algorithm of FFQ were corrected using the over/underreport ratios of food groups. After this correction, nutrient intakes estimated from FFQ were compared with those assessed with DR at individual and village levels. Mean nutrient intakes of the whole population estimated from FFQ were close to those assessed with DR. However, the correlation coefficients of nutrient intakes between the two methods were null or low ( $r$  ranged from -0.14 [% energy of fat] to 0.21 [niacin]). In contrast, the correlation analysis showed a reasonable reproducibility between the two FFQs assessed one-month apart ( $r$  ranged from 0.07 [retinol] to 0.60 [carbohydrate]). Further consideration with careful checking of the collected data may be necessary to develop a reliable and usable FFQ for people in rural Laos.

### Introduction

Dietary habit is one of the most important environments related to health status. In this case, habitual intake is necessary to know rather than short-term, for example one-day, intake. In nutritional epidemiologic studies, diet record and 24-hour recall methods are often used to collect dietary information. But these methods are not suitable for collecting data of habitual intake. Food frequency questionnaire (FFQ) is used to collect data of habitual dietary intakes in several nutritional epidemiologic studies over the world. However, the data obtained from FFQ heavily depend both on the quality, i.e., validity, of the questionnaire and on the characteristics of the subjects. It means that FFQ should be developed based on the actual data of dietary habits of the target population, and that the developed FFQ should critically be validated before the use.

Because the reliability of FFQ depends on the memory and understating ability of the subjects, it has usually been developed and used in developed countries. Some research groups have recently started to apply FFQ for studies in developing societies (1-4) although the validation studies are still limited.

This research project needs information of habitual dietary intakes and behaviors including nutrient intake

levels. Therefore, we tried to develop FFQ for Lao people living in rural Laos, and validated it using semi-weighted using 3-day dietary record (DR) as “gold standard”. Because the calculation algorithm for food and nutrient intakes of the developed FFQ is still under consideration, we describe the temporary results in this report.

### Methods

Basic schedule and scheme of development and validation of FFQ: We followed the basic schedule and scheme for the development and validation of FFQ as described below and shown in Figure 1. Firstly, we analyzed foods consumed among children in Lahanam using the data obtained from 1-day semi-weighted DR in November, 2004, and other qualitative information on the dietary habits of Lao population. We selected major foods commonly consumed, grouped the foods, and made the structure of FFQ. Thirdly, in August, 2005, we randomly selected 113 women aged 19-40 years in Lahanam area, and performed FFQ survey (twice with one-month apart, August and September) and 3-day semi-weighted DR survey for these subjects (DR was done just after the first FFQ survey). The calculation algorithm with portion size database of the foods listed in the FFQ was developed referring the data obtained from the DR in 2005. Finally, we validated FFQ using the nutrient intakes estimated from the first FFQ and the data of DR. We checked the reproducibility of FFQ comparing the nutrient intakes estimated from the first and second FFQs.

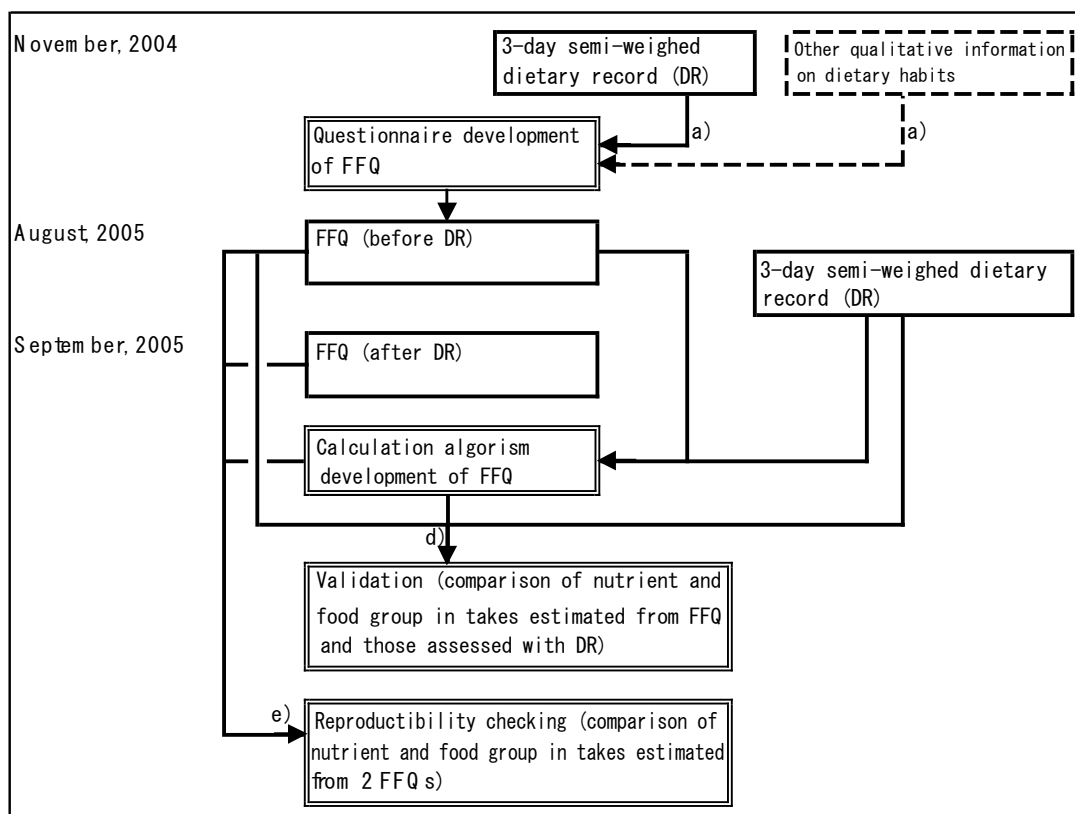


Figure 1 Study scheme and schedule of development and validation of food frequency questionnaire for people in rural Laos

□ indicates field survey □ indicates office work. □ indicates work with other information

- a) Food list development using DR data.
- b) Portion size determination of each food.
- c) Determination of correction factor due to over/under reporting foods.
- d) Validation.
- e) Reproducibility checking..

Development of FFQ: The foods commonly consumed in Lahanam area were selected based on the data obtained from 3-day semi-weighed DR in November, 2004 for children, and other qualitative information on the dietary habits of Lao population. Then the foods were grouped into food groups considering the food concepts, the cooking methods, and dietary behaviors of the target population. The test-version of FFQ has been made for the validation and reproducibility study in the survey, 2005. The FFQ is shown in Figure 2. Considering both the ability of memory and necessity to know “habitual” intake, we decided to ask frequency of food intake of “the pervious one month”.

Development of nutrient calculation algorithm of FFQ: In order to estimate food and nutrient intake levels (gram per person per day), portion size was needed for each food asked in FFQ. Seasoning use (gram per person per cooking) for major cooking per time was also needed. These values were obtained from the data collected in the DR in summer, 2005. Using these data, we developed a food and nutrient intake calculation algorithm, and then calculated the food and nutrient intakes per person using the data of first FFQ survey.

The ASEAN food composition table, 2005 (5), was used as basic food composition tables in the FFQ. For some foods of whose compositions were missing, the data were obtained from alternative sources such as the Thai food composition tables (6) and the Japanese food composition tables, 5th revised edition (7). The standard recipes to determine the portion size of seasoning in major cooking methods were obtained from the direct observation of some cooking during the field survey in summer, 2005.

Correction of portion size of foods: In many cases, severe over- or under-reporting is seen in a questionnaire survey. The systematic reporting errors in FFQ sometimes happen among specific food groups. Therefore, we examined over- or under-reporting of food intake by food group. The portion sizes were corrected using this over- or under-reporting tendency of each food group, i.e., the ratio of mean intake by FFQ to that by DR (see the result section for more in detail). The corrected portion size was used for the subsequent validation and reproducibility checking process.

Validation and reproducibility checking: The nutrient intake levels at a village level (among 5 villages) and at an individual level estimated from the first FFQ were compared with those assessed with DR. The nutrient intake levels at an individual level estimated from the first and second FFQs were compared each other. Spearman correlation coefficient was used for judging the validity and reproducibility at an individual level.  $P < 0.05$  was considered statistically significant.

Two subjects with extremely low energy intake (less than 800kcal/day) in DR were excluded, and then 111 subjects were included in the final analysis (mean age  $\pm$  standard deviation = 25.7  $\pm$  4.4 years).

## Results

Table 1 shows the food list (for 85 foods) used in FFQ. The portion sizes, both original and corrected, are shown in the table. Table 2 shows the portion sizes of three major seasonings in six major cooking methods for meat, fish, and vegetables.

Table 3 shows that the mean food group intakes of DR and the first FFQ, and their ratios. The ratios were used as correction factors of portion sizes to calculate food and nutrient intake levels from FFQ in the subsequent analysis. Some food groups with very low intakes in DR such as nuts and seeds, potatoes, confectioneries, pulses, and milks were severely overreported: more than five times.

Table 4 shows mean energy (kcal/day) and selected nutrient intakes (crude intake per day and energy density values) assessed with DR and those estimated from the first FFQ. In DR, energy intake was significantly higher in the subjects of Kockphork than in them of any other 4 areas ( $p < 0.05$ ). In DR, protein and fat intakes

ID	<input type="text"/>	year	2005	month	<input type="text"/>	day	<input type="text"/>
Name	<input type="text"/>	Survey	1	2			

Answer your frequency of eating during the last one month of each listed food. "Rough thinking" is O.K.  
Please answer to all the questions. Do not skip.  
You can omit very small foods.

Including "Never" ↘

Fish	per day		per week			per month	
Fish without bones (incl crab, shell, prawn)	2-	1	4-6	2-3	1	2	<2
fresh and raw	2-	1	4-6	2-3	1	2	<2
fresh and heated	2-	1	4-6	2-3	1	2	<2
preserved (incl dried, salted, smoked, canned)	2-	1	4-6	2-3	1	2	<2
Fish with bones (incl crab, prawn)	2-	1	4-6	2-3	1	2	<2
fresh and raw	2-	1	4-6	2-3	1	2	<2
fresh and heated	2-	1	4-6	2-3	1	2	<2
preserved (incl dried, salted, smoked, canned)	2-	1	4-6	2-3	1	2	<2
Minced fish ball	2-	1	4-6	2-3	1	2	<2
frog	2-	1	4-6	2-3	1	2	<2
without bones	2-	1	4-6	2-3	1	2	<2
with bones	2-	1	4-6	2-3	1	2	<2

Fresh meats	per day		per week			per month	
Cow, buffalo, pork, goat	2-	1	4-6	2-3	1	2	<2
raw	2-	1	4-6	2-3	1	2	<2
medium heated	2-	1	4-6	2-3	1	2	<2
well heated	2-	1	4-6	2-3	1	2	<2
Chicken, duck, goose, wild bird	2-	1	4-6	2-3	1	2	<2
Rat, rabbit, wild animal	2-	1	4-6	2-3	1	2	<2
Other animal foods	per day		per week			per month	
Dried meat	2-	1	4-6	2-3	1	2	<2
Sausage (Sai kok)	2-	1	4-6	2-3	1	2	<2
Blood, liver	2-	1	4-6	2-3	1	2	<2
raw	2-	1	4-6	2-3	1	2	<2
heated	2-	1	4-6	2-3	1	2	<2
Insect (Chinai mengda, takaten)	2-	1	4-6	2-3	1	2	<2
Egg	2-	1	4-6	2-3	1	2	<2

Vegetables	per day		per week			per month	
Green leafy vegetables (mong g bry, spinach, mint, pumpkin leaf, yodmak-u, tammin, katin, others)	2-	1	4-6	2-3	1	2	<2
Young papaya	2-	1	4-6	2-3	1	2	<2
Tomato	2-	1	4-6	2-3	1	2	<2
Cucumber	2-	1	4-6	2-3	1	2	<2
Green beans (Mac tua)	2-	1	4-6	2-3	1	2	<2
Eggplant	2-	1	4-6	2-3	1	2	<2

Figure 2 The developed food frequency questionnaire for Lao people (test-version)

Vegetables (continued)	per day		per week			per month	
Bamboo shoot	2-	1	4-6	2-3	1	2	<2
Mushroom	2-	1	4-6	2-3	1	2	<2
Bean sprouts	2-	1	4-6	2-3	1	2	<2
Pumpkin	2-	1	4-6	2-3	1	2	<2
Zucchini	2-	1	4-6	2-3	1	2	<2
Banana flower	2-	1	4-6	2-3	1	2	<2
Cabbage	2-	1	4-6	2-3	1	2	<2
Lettuce	2-	1	4-6	2-3	1	2	<2
Carrot	2-	1	4-6	2-3	1	2	<2
River weeds							
Com	2-	1	4-6	2-3	1	2	<2
Sweetpotato	2-	1	4-6	2-3	1	2	<2
(French) potato	2-	1	4-6	2-3	1	2	<2
Yam	2-	1	4-6	2-3	1	2	<2
Taro	2-	1	4-6	2-3	1	2	<2
Cassava	2-	1	4-6	2-3	1	2	<2
Fruits	per day		per week			per month	
Citrus fruits (Orange, green mango, green tamarind,	2-	1	4-6	2-3	1	2	<2
Ripped papaya	2-	1	4-6	2-3	1	2	<2
Ripped mango	2-	1	4-6	2-3	1	2	<2
Bananas fruits	2-	1	4-6	2-3	1	2	<2
Melon, Watermelon	2-	1	4-6	2-3	1	2	<2
All others	2-	1	4-6	2-3	1	2	<2
Nuts	per day		per week			per month	
Nuts, Peanuts	2-	1	4-6	2-3	1	2	<2
Sweets	per day		per week			per month	
Lao cakes	2-	1	4-6	2-3	1	2	0
Boiled	2-	1	4-6	2-3	1	2	0
Steamed	2-	1	4-6	2-3	1	2	0
Grilled	2-	1	4-6	2-3	1	2	0
Cakes	2-	1	4-6	2-3	1	2	0
Biscuit	2-	1	4-6	2-3	1	2	0
Baked banana	2-	1	4-6	2-3	1	2	0
Fried banana	2-	1	4-6	2-3	1	2	0
Desserts (Nam wam)	2-	1	4-6	2-3	1	2	0
Ice-cream	2-	1	4-6	2-3	1	2	0
Jerry	2-	1	4-6	2-3	1	2	0
Packed snacks (Kanom krieb kum)	2-	1	4-6	2-3	1	2	0
Candy	2-	1	4-6	2-3	1	2	0

How many glasses/cups per time if he/she drinks once or more per week ?

Beverages	per day		per week				
Drinking water	2-	1	4-6	2-3	1	<1	
	Well Pumped		Rain		River Piped		
	Boiled			Notboiled			
Softdrinks	2-	1	4-6	2-3	1	<1	
Tea	2-	1	4-6	2-3	1	<1	
Coffee	2-	1	4-6	2-3	1	<1	
Ovaltín	2-	1	4-6	2-3	1	<1	
Sugarcane juice	2-	1	4-6	2-3	1	<1	
Coconut juice	2-	1	4-6	2-3	1	<1	
Nam monoy/nam phaknok	2-	1	4-6	2-3	1	<1	
Fresh fruit juice	2-	1	4-6	2-3	1	<1	
Soyamilk	2-	1	4-6	2-3	1	<1	
Milk (fresh)							
Milk (powder)	2-	1	4-6	2-3	1	<1	
Condensed milk	2-	1	4-6	2-3	1	<1	
Yogurt	2-	1	4-6	2-3	1	<1	
Alcohol	per day		per week				
Beer	2-	1	4-6	2-3	1	<1	
Rice wine (Lao sab)	2-	1	4-6	2-3	1	<1	
Rice wine (Lao ha)							
Liquor (Lao Lao, Laokhao)	2-	1	4-6	2-3	1	<1	
Lao det	2-	1	4-6	2-3	1	<1	
Whisky	2-	1	4-6	2-3	1	<1	
including "Never" ↗							
Noodle/bread	per day		per week			per month	
Noodle	2-	1	4-6	2-3	1	2	<2
Rice	2-	1	4-6	2-3	1	2	<2
Wheat	2-	1	4-6	2-3	1	2	<2
Tapioca	2-	1	4-6	2-3	1	2	<2
Bread	2-	1	4-6	2-3	1	2	<2
with condensed milk	2-	1	4-6	2-3	1	2	<2
with pate	2-	1	4-6	2-3	1	2	<2
Rice	per day		per week			per month	
Non sticky rice	2-	1	4-6	2-3	1	2	<2
Sticky rice	2-	1	4-6	2-3	1	2	<2
How many balls per day							balls
Show the standard ball, ask the question.							

<b>Cooking methods</b>							
<b>Meat</b>		per day		per week			per month
Raw (Laap, koy, saephear)		2-	1	4-6	2-3	1	2 <2
Steamed		2-	1	4-6	2-3	1	2 <2
Grilled		2-	1	4-6	2-3	1	2 <2
Boiled (Soup, curry)		2-	1	4-6	2-3	1	2 <2
Stir fried		2-	1	4-6	2-3	1	2 <2
Deep fried		2-	1	4-6	2-3	1	2 <2
<b>Fish</b>		per day		per week			per month
Raw (Laap, koy)		2-	1	4-6	2-3	1	2 <2
Steamed		2-	1	4-6	2-3	1	2 <2
Grilled		2-	1	4-6	2-3	1	2 <2
Boiled (Soup, curry)		2-	1	4-6	2-3	1	2 <2
Stir fried		2-	1	4-6	2-3	1	2 <2
Deep fried		2-	1	4-6	2-3	1	2 <2
<b>Vegetables</b>		per day		per week			per month
Raw (Laap)		2-	1	4-6	2-3	1	2 <2
Steamed		2-	1	4-6	2-3	1	2 <2
Grilled		2-	1	4-6	2-3	1	2 <2
Boiled (Soup, curry)		2-	1	4-6	2-3	1	2 <2
Stir fried		2-	1	4-6	2-3	1	2 <2
Deep fried		2-	1	4-6	2-3	1	2 <2
<b>Oil/fat</b>		per day		per week			per month
Oil/fat for frying	Lard	2-	1	4-6	2-3	1	2 <2
	Vegetable oil	2-	1	4-6	2-3	1	2 <2
<b>Foods cooked with coconuts</b>		per day		per week			per month
Sweets		2-	1	4-6	2-3	1	2 <2
Dishes		2-	1	4-6	2-3	1	2 <2
Salty sauce with water crab without heating		2-	1	4-6	2-3	1	2 <2
Hotpepper (chili) use		Very much	Relatively	Medium	Relatively	Very few	
Garlic use		Very much	Relatively	Medium	Relatively	Very few	
Use these columns if important, but not-listed, foods have appeared.							
		2-	1	4-6	2-3	1	2 <2
		2-	1	4-6	2-3	1	2 <2
		2-	1	4-6	2-3	1	2 <2
		2-	1	4-6	2-3	1	2 <2

*Thank you!*

Table 1 Food list used in the food frequency questionnaire				Table 1 (continued)					
Food code	Food name	Food sub-name	Portion size (g)		Food code	Food name	Food sub-name	Portion size (g)	
			Original	Corrected**				Original	Corrected
F001	Fish without bones	Fresh and raw	32	27.7	F075	Rice		100	100.0
F002		Fresh and broiled	32	27.7	F076	Rice wine (1 oz. cup)		20	20.0
F003		Preserved	32	27.7	F077	Rice wine (Lao fish)		20	20.0
F004	Fish with bones	Fresh and raw	19	16.5	F078	Liquor (Lao Lao, Laok rou)		20	20.0
F005		Fresh and broiled	19	16.5	F079	Lao dai		20	20.0
F006		Preserved	19	16.5	F080	Whisky		20	20.0
F007	Mixed fish ball		19	16.5	F081	Noodle	Rice	81	73.9
F008	Ping	Without bones	34	29.5	F082		Wheat	86	77.6
F009		With bones	34	29.5	F083		Topinok	61	55.9
F010	Cow, buffalo, pork, goat	Raw	29	25.2	F084	Dread	With condensed milk	57	52.0
F011		Medium heated	29	25.2	F085		With "paste"	57	52.0
F012		Well heated	29	25.2	F086	Non sticky rice		200	182.6
F013	Chicken, duck, goose, wild bird		29	25.2	F087	Sticky rice		200	182.6
F014	Rat, rabbit, wild animal		8	7.0	F088	Meat: Raw (1 asp, tiny saophao)		See table 2	
F015	Dried meat		25	21.6	F089	Meat: Steamed		See table 2	
F016	Sausage		29	25.2	F090	Meat: Grilled		See table 2	
F017	Blood, liver	Raw	10	8.7	F091	Meat: Dried (Soup, curry)		See table 2	
F018		1 heated	10	8.7	F092	Meat: Stir-fried		See table 2	
F019	Insect		48	41.8	F093	Meat: Deep-fried		See table 2	
F020	Egg		43	38.9	F094	Fish: Raw (1 asp, koy)		See table 2	
F021	Green leafy vegetables		19	16.5	F095	Fish: Steamed		See table 2	
F022	Young papaya		95	87.6	F096	Fish: Grilled		See table 2	
F023	Tomato		13	9.3	F097	Fish: Dried (Soup, curry)		See table 2	
F024	Cucumber		98	82.9	F098	Fish: Stir-fried		See table 2	
F025	Green beans		53	37.8	F099	Fish: Deep-fried		See table 2	
F026	Eggplant		36	26.0	F100	Veg: Raw (1 asp)		See table 2	
F027	Bamboo shoot		100	71.4	F101	Veg: Steamed		See table 2	
F028	Mushroom		73	62.1	F102	Veg: Grilled		See table 2	
F029	Bean sprouts		10	7.1	F103	Veg: Dried (Soup, curry)		See table 2	
F030	Pumpkin		38	27.1	F104	Veg: Stir-fried		See table 2	
F031	Zucchini		26	18.6	F105	Veg: Deep-fried		See table 2	
F032	Banana flower		13	9.3	F106	Oil for frying: Lard		4.9	5.9
F033	Cabbage		28	20.0	F107	Oil for frying: Vegetable oil		4.9	5.9
F034	Lettuce		28	20.0	F108	Foods cooked with coconuts: Sweets		Not used	
F035	Carrot		29	20.0	F109	Foods cooked with coconuts: Dishes		Not used	
F036	River weeds		15	10.7	F110	Salty sauce with water crab without heating		Not used	
F037	Corn		19	17.2	F111	Hot pepper (chili) use		1.7	1.2
F038	Sweet potato		73	9.6	F112	Other use		2.8	2.0
F039	(French) potato		73	9.6	* Corrected portion size was determined by multiplying the weight (in factor) (DR/TFQ) shown in Table 2 to the original portion size. The corrected portion size was used for the nutrient calculation shown in Table 3.				
F040	Yam		73	9.6					
F041	Lard		73	9.6					
F042	Cassava		73	9.6					
F043	Citrus fruits		12	4.2					
F044	Ripped papaya		65	22.7					
F045	Ripped mango		65	22.7					
F046	Bananas fruits		90	27.9					
F047	Melon, Watermelon		123	42.9					
F048	Others		66	22.7	Table 2 Portion size of 3 major seasonings in each cooking method used for meat, fish, and vegetables				
F049	Nuts, Peanuts		22	3.0					
F050	Leafy greens	Dried	74	0.6					
F051		Steamed	74	0.6	Cooking method*	Seasonings	Portion size (g)		
F052		Grilled	74	0.6			Original**		
F053	Cakes		71	0.6	Raw (Lasp, koy)	Sugar	1.0		
F054	Biscuit		30	0.3		Ajnomoto	0.5		
F055	Baked banana		60	0.7		Salt	0.5		
F056	Fried banana		80	0.7	Steamed	Sugar	1.0		
F057	Desserts (Nam wann)		57	1.3		Ajnomoto	0.5		
F058	Ice cream		50	0.4		Salt	0.5		
F059	Jelly		50	0.1	Grilled	Sugar	0.0		
F060	Packed snacks		20	0.2		Ajnomoto	0.0		
F061	Candy		5	0.0		Salt	0.6		
F062	Soft drinks		100	Not used	Boiled (Soup, curry)	Sugar	3.8		
F063	Tea		100	Not used		Ajnomoto	0.5		
F064	Coffee		100	Not used		Salt	0.5		
F065	Ovulin		19	Not used	Stir-fried	Sugar	1.2		
F066	Sugarcane juice		100	Not used		Ajnomoto	0.5		
F067	Coconut rice		100	Not used		Salt	0.5		
F068	Nam monny / nam phakmok		100	Not used	Deep-fried	Sugar	1.0		
F069	Fresh fruit juice		82	28.6		Ajnomoto	0.0		
F070	Soya milk		100	4.7		Salt	0.5		
F071	Milk (fresh)		15	2.3	* Frequency of use of these cooking method was used for calculation of these seasoning use.				
F072	Milk (powder)		5	0.8	** The correction of portion size was not used for these 3 seasonings because of a lack of reliable data in DIT.				
F073	Condensed milk		10	2.0					
F074	Yogurt		50	7.7					



Table 3 Mean food group intakes: results of 3-day semi weighed dietary record (DR) and food frequency questionnaire before DR in summer, 2005

		Mean daily intake			
		DR	FFQ	DR/FFQ*	FFQ/DR
Cereals	g/day	429.3	470.4	0.913	1.1
Nuts and seeds	g/day	0.4	3.2	0.138	7.3
Potatoes	g/day	1.3	10.0	0.132	7.6
Sugars	g/day	2.0	5.6	0.352	2.8
Confectioneries	g/day	1.0	113.2	0.009	116.7
Fats and oil	g/day	2.5	2.0	1.214	0.8
Pulses	g/day	0.0	0.8	0.047	21.4
Fruits	g/day	17.1	49.0	0.349	2.9
Vegetables	g/day	145.0	203.2	0.714	1.4
Seasonings	g/day	20.5	3.7	5.470	0.2
Fish	g/day	41.7	48.1	0.866	1.2
Meats	g/day	39.5	45.4	0.870	1.1
Eggs	g/day	4.3	9.7	0.440	2.3
Milks	g/day	0.4	2.7	0.154	6.5

\*The values were used as a correction factor (see text for more in detail).

Table 4 Mean energy and selected nutrient intakes by village: results of 3-day semi weighed dietary record (DR) and food frequency questionnaire before DR in summer, 2005

Dietary assessment method		3-day semi weighed dietary record						Food frequency questionnaire						
Village		V1	V2	V3	V4	V5	ANOVA	Total	V1	V2	V3	V4	V5	ANOVA
n		40	35	12	12	12		111	40	35	12	12	12	
Age	years	24.2	27.9	25.5	24.8	25.5		25.7	24.2	27.9	25.5	24.8	25.5	
Crude intake														
Energy	kcal/day	1559	1793	1711	1675	2177	<0.001	1728.7±36.7	1352	1617	1416	2208	1431	<0.05
Protein	g/day	52.2	54.8	51.4	54.7	60.3	ns	54.1±6.4	46.5	55.6	44.3	61.4	45.7	ns
Fat	g/day	13.4	13.0	16.2	11.8	14.5	ns	13.5±7.3	15.2	16.4	14.6	16.2	10.8	ns
Carbohydrate	g/day	302.7	359.6	333.8	335.5	448.0	<0.0001	343.3±91.5	256.6	311.2	276.2	453.7	287.5	<0.01
Calcium	mg/day	349.9	387.0	503.5	408.2	600.9	<0.0001	411.6±78.1	284.6	387.6	243.7	374.6	334.3	ns
Phosphorus	mg/day	485.1	555.4	595.7	540.6	747.9	<0.0001	553.7±65.5	499.5	630.1	482.5	722.5	562.3	ns
Iron	mg/day	11.4	12.7	13.1	12.0	17.6	<0.001	12.7±4.1	10.7	13.2	10.7	15.3	11.5	ns
Retinol	µg/day	307.3	270.7	361.6	331.5	500.0	ns	325.1±288.1	142.3	174.5	112.2	110.1	114.3	ns
Vitamin B <sub>1</sub>	mg/day	0.7	0.8	0.7	0.7	1.0	<0.001	0.8±0.2	0.6	0.7	0.7	1.0	0.7	<0.01
Vitamin B <sub>2</sub>	mg/day	0.4	0.4	0.4	0.4	0.7	ns	0.4±0.4	0.5	0.7	0.6	0.8	0.8	ns
Niacin	mg/day	8.4	9.5	8.9	9.5	13.5	<0.0001	9.5±3.3	8.3	10.3	8.4	12.5	10.5	<0.01
Vitamin C	mg/day	40.0	42.8	54.2	51.3	74.5	<0.01	47.4±35.5	28.9	31.3	25.5	25.2	24.4	ns
Dietary fiber	g/day	4.5	5.0	6.1	6.4	7.3	<0.0001	5.4±2.3	5.2	6.8	4.9	6.5	5.5	ns
Energy density value														
Protein	% of energy	13.2	12.3	12.1	13.1	11.1	<0.05	12.5±2.2	13.9	13.9	12.9	11.1	13.2	<0.05
Fat	% of energy	7.6	6.4	8.9	6.3	6.2	ns	7.1±3.2	10.4	9.2	9.3	6.6	7.0	<0.0001
Carbohydrate	% of energy	78.0	80.3	77.6	80.1	82.2	<0.05	79.3±4.6	75.5	76.8	77.7	82.2	79.7	<0.001
Calcium	mg/1000kcal	223.5	213.4	300.0	239.8	271.6	<0.05	235.6±77.6	218.8	251.9	184.7	169.2	256.6	ns
Phosphate	mg/1000kcal	310.8	309.7	351.1	324.2	343.2	<0.01	319.8±66.4	375.7	395.9	352.5	327.5	409.5	ns
Iron	mg/1000kcal	7.2	7.1	7.7	7.2	7.9	ns	7.3±1.2	8.0	8.2	7.8	6.9	8.3	ns
Retinol	µg/1000kcal	198.0	149.6	217.1	185.4	209.7	ns	184.7±44.3	112.0	107.1	85.7	50.6	86.0	<0.05
Vitamin B <sub>1</sub>	mg/1000kcal	0.4	0.4	0.4	0.4	0.5	ns	0.4±0.1	0.5	0.5	0.5	0.4	0.5	ns
Vitamin B <sub>2</sub>	mg/1000kcal	0.3	0.2	0.2	0.2	0.3	ns	0.3±0.2	0.4	0.5	0.5	0.3	0.6	ns
Niacin	mg/1000kcal	5.4	5.2	5.1	5.7	6.1	<0.05	5.4±1.0	6.2	6.4	6.0	5.7	7.6	ns
Vitamin C	mg/1000kcal	26.0	23.9	30.9	28.3	32.4	ns	26.8±7.6	23.1	20.6	19.8	11.4	17.9	<0.05
Dietary fiber	g/1000kcal	3.0	2.9	3.5	3.9	3.3	<0.05	3.1±1.2	4.0	4.3	3.7	2.9	4.0	ns

\*Mean ± SD.

Village: V1 = Lahanam thong, V2 = Lahanam tha, V3 = Thakham lane, V4 = Dongbang, V5 = Kockphork.

were relatively higher and carbohydrate intake was lower in the subjects of Kockphork. Some micronutrient intakes such as iron, vitamin B<sub>1</sub>, vitamin B<sub>2</sub>, niacin, and vitamin C were also relatively higher in the subjects of Kockphork. This tendency was seen in FFQ for some nutrients such as iron, vitamin B<sub>2</sub>, and niacin, but not for others.

Table 5 shows the Spearman correlation coefficients between energy and nutrient intake levels estimated from the first FFQ and those assessed with DR at an individual level. Weakly positive correlation was seen for most nutrients with significant correlations for some nutrients such as carbohydrate, vitamin B<sub>1</sub>, and vitamin B<sub>2</sub> [0.19] and niacin [0.21].

Table 6 shows the Spearman correlation coefficients between energy and nutrient intake levels estimated from the first and second FFQs at an individual level. Highly significant and positive correlation was observed for most nutrients ( $r$  ranged from 0.27 [vitamin B<sub>2</sub>] to 0.60 [carbohydrate],  $p < 0.001$ ) except for retinol.

Table 5 Correlations between energy and selected nutrient intakes assessed with 3-day semi-weighted dietary record (DR) and food frequency questionnaire before DR (n=111)

	Crude value		Energy density value	
	Unit	r#	Unit	r#
Energy	kcal/day	0.17	—	—
Protein	g/day	0.05	% of energy	-0.09
Fat	g/day	-0.07	% of energy	-0.14
Carbohydrate	g/day	0.21 *	% of energy	0.12
Calcium	mg/day	0.02	mg/1000kcal	0.03
Phosphorus	mg/day	0.08	mg/1000kcal	0.01
Iron	mg/day	0.08	mg/1000kcal	0.01
Retinol	μg/day	0.02	μg/1000kcal	0.08
Vitamin B <sub>1</sub>	mg/day	0.19 *	mg/1000kcal	0.16
Vitamin B <sub>2</sub>	mg/day	0.19 *	mg/1000kcal	0.19 *
Niacin	mg/day	0.21 *	mg/1000kcal	0.19 *
Vitamin C	mg/day	0.16	mg/1000kcal	0.18
Dietary fiber	g/day	0.07	g/1000kcal	0.09

# Spearman correlation coefficient

\*p<0.05.

Table 6 Correlations between energy and selected nutrient intakes assessed with 2 food frequency questionnaires one month apart (n=111)

	Crude value		Energy density value	
	Unit	r#	Unit	r#
Energy	kcal/day	0.58 ***	—	—
Protein	g/day	0.38 ***	% of energy	0.35 ***
Fat	g/day	0.36 ***	% of energy	0.39 ***
Carbohydrate	g/day	0.60 ***	% of energy	0.41 ***
Calcium	mg/day	0.40 ***	mg/1000kcal	0.41 ***
Phosphorus	mg/day	0.44 ***	mg/1000kcal	0.44 ***
Iron	mg/day	0.43 ***	mg/1000kcal	0.37 ***
Retinol	μg/day	0.07	μg/1000kcal	0.09
Vitamin B <sub>1</sub>	mg/day	0.55 ***	mg/1000kcal	0.33 ***
Vitamin B <sub>2</sub>	mg/day	0.27 **	mg/1000kcal	0.36 ***
Niacin	mg/day	0.44 ***	mg/1000kcal	0.41 ***
Vitamin C	mg/day	0.48 ***	mg/1000kcal	0.46 ***
Dietary fiber	g/day	0.56 ***	g/1000kcal	0.48 ***

# Spearman correlation coefficient

\*\*\*p<0.001, \*\*p<0.01.

## Discussion

As adults living in Lahanam as a target population, we have developed FFQ and the calculation algorithm of food and nutrient intakes using the data of DR collected from the target population. This type of the development, i.e., data-based approach, is recommended to develop FFQ when the target population is decided before the development and the reliable basic data are exist (8). But this type of development has rarely been used in developing societies mainly because a lack of the reliable basic data. We have fortunately collected DR data in 2004, and they were used for the development.

In many cases, severe over- and underreporting is observed for some food groups (9). This was also the case in the present study. Some food groups with very low intakes in DR such as nuts and seeds, potatoes, confectioneries, pulses, and milks were severely overreported, more than five times. The reason of this overreporting is unclear. The more analysis is needed to know the reason and to develop the correction

methods.

The mean intakes of nutrients were not so different when overall mean values were compared between FFQ and DR. However, in the village-level analysis, the results were different. Moreover, the correlations between FFQ and DR were null or low. This means low validity of FFQ. On the other hand, high reproducibility was observed in most nutrients.

Moreover, the data of DR collected in autumn were used for the development of FFQ, and the validation study was done in summer. Seasonal variation of food availability may be one of the most important problems to consider when habitual, i.e., “year-round”, intake is interesting. DR data in winter (dry season) and spring (hot season) besides in summer and autumn are necessary in order to consider differences of food availability between seasons.

In conclusion, we developed FFQ for people in rural Laos using databased approach of questionnaire development. Although the reproducibility was relatively satisfactory, the validity was not enough for the use in future researches. More detailed analysis is needed to develop more reliable calculation algorithm of food and nutrient intakes for this FFQ. The more data collection may also be required for developing FFQ with higher validity.

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