Original Article

Development of a semi-quantitative food frequency questionnaire to determine variation in nutrient intakes between urban and rural areas of Chongqing, China

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Nationwide surveys of food and nutrient intake in China have revealed geographical variation between urban and rural areas. This study developed a semi-quantitative food frequency questionnaire (SQFFQ) for cancer risk assessment suitable for both urban and rural populations by conducting a survey of food intake in Chongqing, China. We recruited 100 urban and 104 rural healthy residents aged from 35 to 55 years in Chongqing, and collected dietary data with 3-day weighed records to assist in the development of the SQFFQ. The intake of 35 nutrients was calculated according to Standard Food Composition Tables for China and Japan. For each nutrient estimated by percentage contribution analysis (CA) and multiple regression analysis (MRA), foods with up to a 90% contribution or a 0.90 cumulative R^2 were selected as items for SQFFQs. The food items of the combined SQFFQ were selected from all items listed in either urban or rural SQFFQs. Mean intake of energy, protein and carbohydrate did not differ between the urban and rural residents. The latter consumed more fat than their urban counterparts. We selected 119 food items for the combined SQFFQ, comprising 22 specific items for the urban SQFFQ, 6 for the rural, and 78 common and 13 additional items. The combined SQFFQ covered 33 nutrients with up to a 90% contribution in each area. We were able to develop a data-based SQFFQ that can estimate nutrient intake of both urban and rural populations, with suitable coverage rates. Further reliability and reproducibility tests are now needed to assess its applicability.

Keywords: urban population, rural population, semi-quantitative food frequency questionnaire, Chongqing, China

Introduction

Dietary habits in China are changing with economic development. Recently, intakes of energy, fat and protein by the Chinese population is greater than previously.[1-4] The leading causes of mortality in China have also shifted from infectious to chronic diseases such as cancers and cardiovascular diseases. This trend is observed in both the western Chinese migrants and domestic population.[1,3,5-7] A nationwide nutrition survey in China reported geographical variation in intake not only between regions, but also between urban and rural areas within the same region.[8] Thus there is a requirement for area-specific evaluation to assess the relations between dietary factors and chronic diseases, with due reference to variation between urban and rural populations.

Assessment of food and nutrient intake is generally performed by one of several methods, such as diet history, 24-hour recall, weighed records and food frequency questionnaires, each of which has both advantages and disadvantages.[9,10] For epidemiological studies, the food frequency questionnaire is a valid tool to assess nutrient intake and appears to be of some utility in ranking individuals according to their usual intake.[11,12]

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Previous studies have reported this method to be comparable with other approaches, such as investigator-administered diet history or 24-h recall, as a predictor of nutrients estimated from weighed food records, although complete estimation of food and nutrient intake by these methods remains difficult.[13-14] Although several studies reported the development of a food frequency questionnaire for overseas Chinese populations,[6,15] only a few reports have been published regarding the development of data-based food frequency questionnaires to estimate nutrient intake in China.[16-18]

Chongqing, located in southwest China, one of the municipalities under the direct control of Chinese Central Government, has a population of near 30 million. The spectrum of causes of death and dietary habits in Chongqing and its adjacent provinces have changed appreciably over the last several decades, with an increased incidence of cancer cases.[19-21] This study aimed to develop a semi-quantitative food frequency questionnaire (SQFFQ) for cancer risk assessment by conducting a survey of food and nutrient intakes in urban and rural (40km from the city) areas of Chongqing, China. The instrument was designed to obtain comprehensive dietary habits by being sensitive to differing foods habits in both urban and rural populations.

Subjects and methods

Subjects

By multiple-stage stratified random sampling, we selected 7 blocks in urban areas of Chongqing (Shuangbei, Zhongxinwan, Guangrongpo, Dahegou, Tuanjieba, Qian-jinpo and Qiaomenshan) and 9 villages and towns in rural areas (Jingkou, Xianfengjie Niujiaofen, Majiapu, Heishizui, Wazupo, Daho, Fuxin, Huidibao). We selected rural areas within 40 km of urban areas, because our pilot survey of cancer patients in the target hospitals revealed the majority lived within this geographical distance (personal communications). At first, we selected the house according to our rule that the last number of the address in the surveyed street and village was "3". Then, we selected only one person who was 35 to 55 years old in the house, and asked him/her to participate in our study after oral explanation. When more than one person was nominated, we selected the oldest among them. We excluded residents who were suffering from diet-related diseases such as fatty liver or diabetes, or severe acute ailments, because their dietary habits might be influenced by their conditions. We determined that the number of study subjects required was 200 with 3-day dietary records according to previous studies in Japan and China that had sufficiently developed semi-quantitative food frequency questionnaire (SQFFQs). A previous Japanese study recruited 351 subjects with one-day records[22] and obtained data that covered 31 nutrients from the SQFFQ with up to 80% coverage. Our previous study in Jiangsu Province of China on 198 urban subjects and 214 rural subjects, both using the same method for the development of urban and rural SQFFQs, showed 29 and 28 nutrients of the uban and rural SQFFQs with up to 80% coverage, respectively.[18] This study was conducted in accordance with the internationally agreed ethical principles for conducting medical research.

Three-day weighed food records

We used the three-day weighed food record (WFR) method to assist us in the development of the SQFFQ. Our previous Chinese study using this method for the development of SQFFQs revealed no apparent difference in nutrient intake between the 3-day and 7-day WFRs.[18] To standardize the survey method, nineteen investigators received a special 12-hour training course with simulated weighed food records. Furthermore, the weighing test for 20 commonly consumed foods, such as rice, fruits, meat, several vegetables and liquid, was performed within a variation of 5g/ml for every 250g/ml. In April of 2001, the survey was carried out, commencing on Sunday. The investigators weighed and recorded all food items consumed measuring them as raw materials before cooking. In some cases where foods could not be weighed before cooking, the weights of raw materials were estimated by both investigators and study subjects (with their agreement), using a recall method and food samples. Intake of alcoholic beverages was estimated by measuring volumes of water in the same containers. We measured the total amount of oils and condiments that were consumed over three days, and estimated actual intake amount by the subject according to the information from their family members, sharing the same diet. Investigators checked all data recorded within 24 hours, and some of them were again re-checked by a supervisor.

Target nutrients

We calculated the intake of 35 nutrients after adding the weights of foods consumed over three days and multiplying them by their nutrient contents, using the Standard Food Composition Table (version 1)[23] compiled by the Nutrition and Food Hygiene Institute, Preventive Medicine Science of Academy of China. The Japanese Standard Table of Food Composition (version 4)[24] and the Follow-up of Japanese Standard Table of Food Composition (version 4)[25] were also employed for those nutrients whose compositions were not listed in the Chinese Standard Table. For some foods whose nutrient contents were not listed in Standard Tables, we applied nutrient data for surrogate foods with similar constituents. The 35 nutrients of interest were total energy, protein, fat (animal, plant, marine), carbohydrate, cholesterol, crude fibre, 9 vitamins (carotene, retinol, vitamins A, B_1, B_2, C, D, E and nicotinic acid) and 10 minerals (potassium, sodium, calcium, magnesium, phosphorus, iron, zinc, copper, manganese and selenium), saturated fatty acid (SFA), mono-unsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), oleic acid, linoleic acid, linolenic acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), n3-PUFA and n6-PUFA.

Data analyses and selection of foods

At first, we independently developed two SQFFQs suitable for both urban and rural populations, using the actual data from the 3 day weighed food records survey. All food items in these two SQFFQs were then combined in one common SQFFQ, expected to cover both populations. The selection of food items for developing the SQFFQs was performed using the same procedures as adopted by Tokudome and his colleagues.[22] In brief, a modified cumulative % contribution analysis (CA) was employed. Each food item was listed according to its contribution to particular nutrients. We then selected food items with up to 90 cumulative % contribution. Furthermore, we performed forward multiple regression analysis (MRA), and selected food items with up to a 0.90 cumulative multiple regression coefficient, by nutrient. Thus, we determined food items for the urban and rural SQFFQs which were selected by either CA or MRA. Some food items with only a very small % contribution were excluded, because they may contribute marginally to total nutrient intake. Foods contributing only three or fewer nutrients, with relatively small % contributions, were also excluded. Finally, the food items of the combined SQFFQ were selected from all items listed in either the urban or rural SQFFQs.

The statistical package, SPSS for Windows 10.0.1 (SPSS Inc., Chicago), was employed for analysis of the data. Differences in mean nutrient intake between areas were tested by the two-tailed Student t test.

Intake frequency and portion size

Following the methods of Tokudome,[22] we classified intake frequency into eight categories: 1-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week, once a day, twice a day, thrice a day and four or more times a day. The mean portion size of each food was determined by mean food intake per one meal in the 3-day WFR. Portion size in SQFFQs was divided into six categories: none, 0.5, 1.0, 1.5, 2.0 and 3.0 or more. We also developed a food model booklet with standard portion sizes and actual sizes in pictures for representative food items.

Results

Subjects

We recruited 50 males and 50 females in the urban areas and 51 males and 54 females in the rural areas. The response rate was 100%, because our investigators, local doctors or health administrators, had a close and confidential relationship with the general population. As the working time of rural residents was not stable, this resulted in recruitment of 5 more rural subjects than the urban counterparts. One woman in the rural area had to be excluded from the study because of the development of severe heart disease. Finally, 100 urban and 104 rural residents were eligible. The mean ages and standard deviations were 43.5 ± 6.0 and 46.1 ± 6.3, respectively, for urban males and females, and 44.8 ± 6.4 and 46.2 ± 6.3 for rural males and females. The small age differences were not statistically significant between rural and urban subjects.

Intake of energy and selected nutrients by area and gender

Mean intake of total energy, protein, carbohydrate and other nutrients did not differ between the urban and rural subjects, except for fat, several fatty acids, vitamin B_1 and sodium (Table 1). The rural residents consumed more fat, including plant fat, SFA, MUFA and oleic acid, than the urban residents, with statistical significance. Animal and plant fats were similarly consumed within both areas, while intake of marine fat was extremely low. Mean intakes of total energy and macronutrients tended to be higher in males than in females.

The proportional ratios for total energy in urban and rural males were 13.7% vs. 12.8% for protein, 32.9% vs. 37.8% for fat, and 49.3% vs. 46.2% for carbohydrate. In urban and rural females they were 14.5% vs. 13.1% for protein, 34.7% vs. 37.6% for fat, and 50.8% vs. 49.5% for carbohydrate, respectively (data not shown in the Table).

Selection and listing of food items

The total number of food items listed in the survey was 171 in the urban area and 166 in the rural area. Of these, the numbers of food items with up to 90% CA ranged from 3 and 2 for Vitamin D to 53 and 48 for Vitamin B_2 in the urban and rural areas, respectively (Table 2). The numbers for each nutrient in the urban population were larger than those for their rural counterparts, except for the cases of carotene, retinol, vitamin C, linolenic acid and n3-PUFAs, and more than half of the items were common to both. The numbers of food items selected by up to 0.9 R^2 MRA were smaller than with CA for every nutrient, but the variation between urban and rural areas was again limited.

We selected 129 and 100 food items for the urban and rural SQFFQs according to the selection criteria of CA or MRA methods, respectively. Foods that contained the same or similar nutrients with different cooking processes, appearance, or subgroups were combined into 100 urban and 84 rural food items by research nutritionists, such as rice (polished rice and hybridized rice), high quality flour (roasted bread, battercake and flour) and edible roots (sweet potatoes and taros). Furthermore, we intentionally added another 13 foods to the SQFFQ (see Appendix), because they are important food items for dietary factors of cancer[26] (e.g pig colon, loach, green tea and others), or seasonally taken at a high frequency in early spring (e.g bamboo roots, garlic seedlings) and in late summer and autumn (e.g hollow caudex vegetables, balsam pears, towel gourds). Finally, we selected 119 food items for the combined SQFFQ, comprising 22 specific items from the urban SQFFQ, 6 from the rural, and 78 common and 13 additional items. We listed these items according to the categorization scheme of the Chinese Standard Tables of Food Composition as follows: rice, flour products and noodles (11), dry legume and beans products (8), fresh beans (5), edible roots (5), melons (7), cauliflower (1), green-yellow vegetables (20), fruits (4), nuts (4), meat (domestic animal) and organ meat (12), bird meat (including chicken etc.) (5), marine lives (8), eggs (4), milk and milk products (1), preserved vegetables (4), mushrooms (6), oil (4), beverages (4) and condiments (6) (see Appendix).

List of food items by energy and macronutrient

Rice was the food item contributing the most to total energy in both urban and rural areas, followed by rape oil (Table 3). Of the top 10 food items, 7 were common to both areas. Rice also contributed most to protein intake in

Table 1. Intake of 35 target nutrients by area and gender according to 3-day WFRs

Nutrients	Male Urban (*N*=50)	Male Rural (*N*=53)	Female Urban (*N*=50)	Female Rural (*N*=51)	Total Urban (*N*=100)	Total Rural (*N*=104)	*P* value[a]
Age	43.5±6.0	44.8±6.4	46.1±6.2	46.2±6.3	44.8±6.3	45.5±6.3	0.455
Energy (kcal)	2552.6±715.7	2702.3±844.5	2048.9±510.5	2181.0±512.5	2300.8±668.3	2446.7±745.8	0.143
Protein (g)	87.3±26.2	86.4±26.1	74.3±24.3	71.2±21.9	80.8±26.0	78.9±25.2	0.600
Fat (g)	93.3±55.2	113.6±72.5	79.0±38.6	91.1±44.1	86.2±47.9	102.6±61.1	0.035
Animal (g)	46.9±30.5	52.3±60.0	43.0±22.9	43.0±28.4	45.0±26.9	47.7±47.2	0.610
Plant (g)	45.4±45.2	60.2±44.3	35.4±29.8	7.3±30.2	40.4±38.4	53.9±38.4	0.013
Marine	0.93±2.12	1.07±1.85	0.59±1.07	0.89±1.58	0.76±1.68	0.98±1.71	0.353
Carbohydrate (g)	314.8±103.9	312.0±85.9	260.1±80.2	270.1±57.6	287.5±96.3	291.5±76.0	0.740
Crude fibre (g)	10.57±5.55	11.04±7.92	9.21±5.98	8.20±3.99	9.89±5.78	9.65±6.44	0.778
Carotene (mg)	5.65±5.48	5.10±4.40	4.70±3.90	4.14±3.45	5.18±4.76	4.63±4.00	0.371
Vitamin A (ug)	333.3±718.1	399.3±7547.7	364.5±994.3	213.4±245.9	348.9±863.0	308.2±570.7	0.690
Retinol (mg)	1.28±1.12	1.25±1.08	1.15±1.29	0.90±0.62	1.21±1.20	1.08±0.90	0.374
Vitamin B1 (mg)	1.81±1.46	2.13±2.09	1.20±0.75	2.08±2.20	1.51±1.19	2.11±2.14	0.014
Vitamin B2 (mg)	1.02±0.47	1.04±0.50	0.94±0.51	0.83±0.31	0.98±0.49	0.93±0.43	0.503
Nicotinic acid (mg)	17.1±5.4	16.8±5.3	14.4±5.4	12.9±4.7	15.8±5.5	14.9±5.4	0.252
Vitamin C (mg)	82.6±53.2	87.4±57.1	79.5±38.0	68.5±36.1	81.1±46.1	78.1±48.6	0.658
Vitamin D (mg)	34.8±30.7	35.3±28.6	30.2±17.5	32.9±25.4	31.5±25.1	28.2±27.7	0.380
Vitamin E (mg)	31.3±16.5	35.7±34.6	28.2±15.3	30.7±18.6	29.8±15.9	33.3±27.7	0.274
Potassium (g)	2.12±0.63	2.18±0.54	1.85±0.63	1.71±0.47	1.99±0.64	1.95±0.56	0.654
Sodium (g)	3.30±1.57	4.64±2.58	3.09±1.43	3.63±1.53	3.20±1.50	4.15±2.18	< 0.001
Calcium (mg)	457.4±212.8	476.8±182.4	405.1±155.1	411.2±150.5	431.2±187.1	444.6±169.9	0.592
Magnesium (mg)	317.4±92.4	315.8±79.8	294.2±108.8	262.3±75.1	305.8±101.1	289.6±81.7	0.207
Iron (mg)	24.7±8.3	28.7±23.9	22.0±9.9	21.1±7.1	23.3±9.2	25.0±18.1	0.417

Table 1. continued .....Intake of 35 target nutrients by area and gender according to 3-day WFRs

Nutrients	Male		Female		Total		P value[a]
	Urban (N=50)	Rural (N=53)	Urban (N=50)	Rural (N=51)	Urban (N=100)	Rural (N=104)	
Manganese (mg)	7.46±2.64	7.73±2.86	7.25±4.96	6.89±2.78	7.35±3.95	7.31±2.84	0.944
Zinc (mg)	12.8±3.8	13.3±3.6	12.4±6.9	10.54±2.9	12.6±5.6	11.9±3.5	0.293
Copper (mg)	2.55±1.24	2.46±0.90	2.37±1.16	1.98±0.62	2.46±1.20	2.22±0.81	0.103
Phosphorus (mg)	1179.4±294.9	1194.4±285.0	1007.8±248.6	1002.0±237.8	1093.6±284.7	1100.0±278.9	0.871
Selenium (ug)	52.1±25.0	48.3±22.5	45.3±19.9	44.9±19.1	48.7±22.8	46.6±20.9	0.509
Cholesterol (g)	375.0±248.0	438.3±364.1	378.6±205.8	417.0±289.0	376.8±226.7	427.9±328.0	0.199
SFA (g)	25.8±19.4	32.4±19.2	20.9±12.5	25.5±13.6	23.4±16.4	29.0±17.0	0.017
MUFA (g)	42.2±26.7	54.2±39.7	35.6±19.0	43.7±22.4	38.9±23.3	49.1±32.7	0.012
PUFA (g)	20.8±12.5	23.5±16.9	18.7±8.2	18.6±9.4	19.8±10.6	21.1±13.9	0.452
Oleic Acid (g)	29.6±22.3	38.8±24.9	24.7±15.3	29.8±15.3	27.1±19.2	34.4±21.2	0.011
Linoleic Acid (g)	17.0±10.5	19.2±12.6	15.4±6.8	15.0±7.3	16.22±8.8	17.1±10.5	0.515
Linolenic acid (g)	3.6±2.4	4.1±4.7	3.2±1.8	3.5±2.3	3.4±2.1	3.8±3.7	0.353
EPA (g)	0.01±0.03	0.01±0.02	0.01±0.01	0.01±0.02	0.01±0.02	0.01±0.02	0.252
DHA (g)	0.02±0.06	0.01±0.03	0.003±0.01	0.01±0.02	0.01±0.04	0.01±0.03	0.967
N3-PUFA (g)	3.7±2.4	4.2±4.7	3.3±1.8	3.5±2.3	3.5±2.1	3.9±3.7	0.356

SFA = saturated fatty acid, MUFA = mono-unsaturated fatty acid, PUFA = poly-unsaturated fatty acid, EPA = eicosapentaenoic acid, DHA = docosahexaenoic acid.

a) The difference of nutrient intake between urban and rural areas in combined the male and female subjects was examined by Student's t test.

Table 2. Number of foods contributing to 35 nutrients with up to 90 cumulative % contribution and 0.90 cumulative R^2 by area

Nutrients	Cumulative % contribution			Cumulative R^2		
	Urban	Rural	Common	Urban	Rural	Common
Energy	32	28	27	14	13	7
Protein	42	35	30	21	19	10
Fat	17	14	14	5	5	5
Carbohydrate	16	10	10	7	7	6
Crude fibre	43	37	29	10	6	3
Carotene	11	12	9	2	3	2
Vitamin A	6	7	5	1	1	1
Retinol	16	18	13	2	3	2
Vitamin B_1	25	18	17	2	1	1
Vitamin B_2	53	48	39	11	14	5
Nicotinic acid	43	35	30	18	14	11
Vitamin C	19	23	17	9	10	5
Vitamin D	3	2	2	3	3	3
Vitamin E	26	21	17	3	1	1
Potassium	52	47	37	19	25	9
Sodium	10	7	6	4	4	3
Calcium	51	45	35	12	17	8
Magnesium	47	42	35	20	20	9
Iron	52	44	38	13	3	2
Manganese	24	22	17	4	7	4
Zinc	45	38	33	18	18	10
Copper	40	39	29	7	10	4
Phosphorus	44	36	33	23	20	11
Selenium	40	31	29	16	15	7
Cholesterol	18	16	15	9	7	5
SFA	13	13	11	5	5	4
MUFA	12	12	11	4	4	4
PUFA	16	16	14	5	4	4
Oleic acid	15	13	13	5	6	5
Linoleic acid	17	16	14	6	5	5
Linolenic acid	6	7	5	2	2	2
EPA	6	4	3	4	4	3
DHA	6	4	3	2	3	1
N3-PUFA	7	8	6	2	2	2
N6-PUFA	17	16	15	5	6	5

SFA: saturated fatty acid, MUFA: mono-unsaturated fatty acid, PUFA, poly-unsaturated fatty acid, EPA: eicosapentaenoic acid, DHA: docosahexaenoic acid.

both areas, and 6 items were common in the top 10. Horse beans specifically contributed more as a protein resource in the urban area. For fat, rape oil was the major contributor in both areas, and 8 items were common in the top 10 foods. Lard was consumed more in the rural area. For carbohydrate, polished rice was a major contributor in both areas, and 9 items were common in the top 10 foods.

Percentage coverage of nutrients by the SQFFQ

We calculated the percentage coverage of each nutrient of the urban, rural and combined SQFFQs, for each intake in standard WFRs (Table 4). The number of food items with up to 90% of the coverage was 33, 32 and 33 in the urban, rural and combined SQFFQs, respectively. The coverage percentages for EPA and DHA were less than 80%.

Discussion

Foods and nutrient intake in the urban and rural areas

The present investigation revealed that intake of total energy and macronutrients, except for fat, did not significantly differ between urban and rural residents of Chongqing. This is in contrast to the findings reported by the National Nutrition Survey of China. In the nationwide survey, fat and protein intake in the urban areas were higher than in the rural areas, but carbohydrate intake was greater in the latter.[8] The variation in Sichuan Province, bordering on Chongqing, was similar to that at the national level. Obvious differences in other nutrients, except for vitamin B_1, sodium, oleic acid, SFA, and MUFA, were also not observed between the urban and rural areas in the present study. Actually, the total energy intake for combined male and female was only 7.5%

Table 3. Percentage contributions of the top 10 foods for protein, fat and carbohydrate in the urban and rural areas

Energy				Protein				Fat				Carbohydrate			
Urban		Rural		Urban		Rural		Urban		Rural		Urban		Rural	
Polished rice	30.1	Polished rice	32.1	Polished rice	17.5	Polished rice	20.4	Rape oil	20.4	Rape oil	32.3	Polished rice	55.1	Polished rice	60.1
Rape oil	10.2	Rape oil	12.2	Horse bean	8.0	Pork (muscle)	7.4	Fresh pork	15.3	Lard	13.5	HQ flour	10.3	HQ flour	16.6
Fresh pork	6.2	HQ flour	7.7	Pork (muscle)	6.5	HQ flour	7.0	Salad oil	1.5	Pork (fat)	12.2	Noodle	7.9	Peas	2.8
HQ flour	5.5	Lard	5.1	Fresh pork	5.9	Chicken egg	5.4	Pork (fat)	7.5	Fresh pork	9.7	Horse bean	5.0	Sticky rice	2.7
Noodle	4.5	Pork (fat)	4.6	Chicken egg	4.8	Fresh pork	4.5	Lard	6.2	Salad oil	4.7	Peas	2.3	Potato	1.6
Salad oil	3.9	Fresh pork	4.3	HQ flour	4.6	Peas	4.4	Pork (rib)	3.8	Pork knuckle	2.7	Soybean curd*	2.2	Soybean noodle	1.5
Horse bean	3.8	Peas	2.0	Pork (rib)	3.7	Pork knuckle	3.9	Chicken egg	2.6	Chicken egg	2.4	Horse bean	5.0	Sticky rice	2.7
Pork (fat)	2.5	Salad oil	1.8	Noodle	3.6	Preserved pork	3.4	Polishes rice	2.1	Duck	2.3	Sticky rice	2.9	Noodle	2.5
Lard	2.1	Pork (muscle)	1.7	Peas	3.5	Chub	3.4	Pork (muscle)	1.9	Pork (rib)	2.2	Peas	2.3	Potato	1.6
Ardent spirit	1.9	Chicken egg	1.7	Chicken	3.3	Soybean curd**	2.8	Sausage	1.8	Sausage	2.1	Soybean curd*	2.2	Soybean noodle	1.5

lower in the present urban area and almost equal in the rural area than those in the representative urban and rural areas of Sichuan Province (Table 5).[8] Total energy intake found in our study was also similar to values reported in another study conducted in China.[27] The mean intakes of other major nutrients in the present study's urban and rural areas respectively, were 14.6% higher and 27.4% higher for protein; 10.1% higher and 53.6% higher for fat; 27.8% lower and 51.6% lower for carbohydrate; and 46.6% lower and 26.4% lower for crude fibre, compared with the respective Sichuan figures of the 1992 nation-wide survey. Each urban and rural population in the present study consumed more protein and fat, but less carbohydrate and sodium than the urban and rural populations in the national survey. These comparisons reveal that the intake values in the rural area in the current study are closer to those of the urban area of Sichuan Province than of the rural area. The nutrient differences between urban and rural areas in the current study was relatively small, compared with urban and rural areas of the Sichuan

Table 4. Nutrient coverage (%) of the foods in the SQFFQs

Nutrients	Urban SQFFQ (100 foods)	Rural SQFFQ (84 foods)	Combined SQFFQ (106 foods)	
	Urban residents	Rural residents	Urban residents	Rural residents
Energy	97.0	96.1	97.1	96.6
Protein	95.2	92.2	95.5	93.4
Fat	97.7	95.5	97.8	95.7
Carbohydrate	97.3	98.2	97.3	98.9
Crude fibre	91.7	94.5	92.7	99.9
Carotene	96.9	97.8	98.8	98.1
Vitamin A	96.6	97.6	96.7	97.7
Retinol	96.8	97.7	98.2	98.0
Vitami n B_1	97.0	98.2	97.1	98.6
Vitamin B_2	93.7	92.9	94.6	95.8
Nicotinic acid	93.5	93.2	94.2	96.3
Vitamin C	95.4	92.0	96.6	93.3
Vitamin D	97.0	99.5	97.0	99.6
Vitamin E	96.2	97.5	96.4	97.8
Potassium	95.1	94.9	95.9	95.9
Sodium	99.2	98.8	99.2	98.9
Calcium	94.3	91.9	94.8	93.2
Magnesium	93.9	95.9	94.4	97.4
Iron	94.3	95.5	94.8	96.8
Manganese	91.9	96.2	92.1	97.7
Zinc	95.2	95.1	95.5	96.9
Copper	90.1	94.3	90.3	95.6
Phosphorous	94.9	95.6	95.3	96.7
Selenium	92.2	91.7	92.7	92.6
Cholesterol	94.6	88.0	94.9	88.5
SFA	98.3	95.7	98.4	95.8
MUFA	98.6	95.3	98.6	95.3
PUFA	98.6	97.0	98.7	97.1
Oleic acid	98.1	93.4	98.2	93.5
Linolenic acid	98.6	96.8	98.6	96.9
Linoleic acid	99.3	98.4	99.3	98.5
EPA	65.1	72.7	65.1	74.7
DHA	59.7	69.5	59.7	76.0
N3-PUFA	99.1	98.2	99.1	98.4
N6-PUFA	98.6	96.8	98.6	97.0

SFA: saturated fatty acid, MUFA: mono-unsaturated fatty acid, PUFA, poly-unsaturated fatty acid, EPA: eicosapentaenoic acid, DHA: docosahexaenoic acid.

and national surveys. The rural areas in the current study were located close to Chongqing City, whereas those in the nationwide survey were geographically distant from urban areas. Furthermore, dietary habits in Chongqing are changing, with more rapid economic progress and urbanization in rural areas than at the national level. Such factors could clearly impact to give smaller geographical variation in nutrient intakes and explain the differences between results in the present study and the nationwide survey.

More fat, especially plant fat, was consumed in the present rural area than the urban area. The same method for its measurement was employed in both areas by the same investigators in the same season, minimizing the systemic error for its estimation. This finding is in contrast to the trend observed in Sichuan Province.[8] However, higher fat intakes were observed in the rural areas compared with the urban areas in both the current study and the survey in Jiangsu Province.[18] The economic improvement in the rural area of the present study as well as previous studies was greater than that in Sichuan Province. This could have influenced the magnitude of the change in dietary habits with increased intake of protein and fat, because previous studies revealed a positive association between economic status and nutrient intakes.[28,29] Furthermore, geographical variation in fat intake was apparent for plant oil, but not animal oil. Plant oil is used for cooking, which may lead to overestimation of intake, because residual amounts in the dishes and cooking procedures are relatively large as compared with other fats and foods.

Sodium intake in males was 97.2% lower in the urban area and 53.1% lower in the rural area than those in the urban area of the Sichuan survey.[8] As we did not examine the urinary sodium concentrations to validate the estimation of its intake and no appropriate reports are available, further tests are needed to evaluate the accuracy of the present results. Other minerals revealed relatively small differences (within 20%) in intake between the present study and the urban area of the nationwide survey, except for vitamin E, consumption of this being 59.2% higher in the rural area of the present study.

Food selection

We selected food items for our SQFFQ, using CA and MRA methods. CA is suitable for evaluation of the absolute intake of foods and nutrients.[12,22] In contrast, selection by MRA is based on variance of nutrient intakes, and this method is more efficient for categorization.[30-32] Therefore, the combination of these two methods for food selection provides us with a more suitable SQFFQ for use in case-control studies, which require relative comparisons of food and nutrient intakes between individuals with adequate variation. We independently developed urban and rural SQFFQs, and combined the food items selected in both SQFFQs as a combined SQFFQ, needed to cover both urban and rural populations for our study purpose of cancer epidemiology. The developed SQFFQ appeared to adequately cover target nutrient intakes in the present populations, except for EPA and DHA. Major sources for these are fish and eggs, but consumption of these by the subjects was infrequent, with a wide range of inter- and intra-individual variation.

Methodological issues

A limitation of the present study is the relatively small sample size, limiting the statistical power to compare nutrient intakes between areas. However, Willett documented that 200 data sets with 3-day WDRs are sufficient to estimate the variation of food and nutrient intakes between individuals for the development of a food frequency questionnaire.[12] However, it must be remembered that dietary habits differ considerably between the

Table 5. Macro- and selected micronutrients intake for both male and female in current, Sichuan and national surveys

	Urban			Rural		
Nutrients	Current Study	Sichuan[a]	National[a]	Current Study	Sichuan[a]	National[a]
Energy (kcal)	2300.8±668.3	2473.2±786.9	2394.6±793.7	2446.7±745.8	2440.3±685.8	2294.0±700
Protein (g)	80.8±26.0	69.0±25.3	75.1±27.1	78.9±25.2	57.3±17.6	64.3±22.9
Fat (g)	86.2±47.9	77.5±45.4	77.7±47.7	102.6±61.1	47.6±38.4	48.3±34.3
Carbohydrate (g)	287.5±96.3	367.4±127.5	340.5±115.5	291.5±76.0	441.8±125.6	397.9±131.0
Crude fibre (g)	9.89±5.78	14.5±24.4	11.6±8.7	9.65±6.44	12.2±10.7	14.1±10.4
Vitamin A (ug)	348.9±863.0	365.8±1069.7	277.0±951.5	308.2±570.7	81.6±345.4	94.2±588.4
Vitamin C (mg)	81.1±46.1	99.1±75.9	95.6±73.4	78.1±48.6	107.0±80.5	102.6±87.3
Vitamin E (mg)	29.8±15.9	28.4±16.0	37.4±34.9	33.3±27.7	13.6±10.1	29.5±37.3
Potassium (mg)	1986.7±644.3	1952.9±1006.2	1886.3±862.9	1948.8±558.9	1761.0±827.1	1863.5±1003
Sodium (mg)	3196.4±1496.8	6302.0±5357.2	7258.8±6375.8	4146.8±2177.3	6348.8±5641.9	7042.9±6879
Calcium (mg)	431.2±187.1	461.7±362.2	475.9±323.9	444.6±169.9	271.7±146.7	378.2±318.3
Selenium (ug)	48.7±22.8	53.8±109.2	52.3±34.2	46.6±20.9	31.0±40.4	36.7±29.2

a) Reference 5.

US and China. We recruited 198 urban and 214 rural subjects in the previous study of Jiangsu Province, China, and developed a corresponding SQFFQ with sufficient coverage rates of nutrient intakes.[18] The random sampling of study subjects minimizes selection bias. Nevertheless, it is difficult to determine if their dietary habits were representative of the study area because of the small sample size and the random variation. Selection of the rural areas located within 40 kilometers of the urban areas may be representative of the cancer patient population, based on the data of our pilot survey. These 'rural' areas, however, may not be truly representative of rural areas located further away. We had a high response rate for participation, because of the close relationship between the study subjects and investigators. This relationship, however, did not bias the selection of subjects, because we randomly selected the subjects before participation. Another limitation is the short period of WFRs, which may underestimate differences within individuals and between seasons. Therefore, we intentionally added 13 food items into the combined SQFFQ to cover seasonal variation. Although we standardized the weighing method to reduce measuring error, misclassification of intake amount per dish must also be considered with respect to Chinese culture. Chinese people usually share a dish with family members. However, the similar values (6.4% higher in the urban males) for total energy intake with those of the Chinese DRI (Dietary Reference Intake) suggest the impact of the misclassification on intake amount might be small.[33]

In summary, we have developed a data-based SQFFQ covering both urban and rural populations of Chongqing. Geographical variation of nutrient intakes between urban and rural areas (40km from a city) was found to be small, except for vitamin B1, sodium, fat and some fatty acids, although fat intake has the potential for over-estimation. Further reliability and reproducibility tests are now needed to assess the applicability of the SQFFQ for an epidemiological study.

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Appendix. List of food items in the SQFFQ

Rice, flour products and noodles
1. Polished rice
2. High quality flour
3. Fine dried noodle
4. Sticky rice
5. Steamed bread[a]
6. Rice noodle[a]
7. Steamed twisted roll[a]
8. Fresh corn[a]
9. Bread[a]
10. Corn powder[a]
11. Instant noodles[a]

Dry legume and beans products
12. Bean curd
13. Peas
14. Dried beancurd
15. Soybean milk
16. Vermicelli made from bean starch
17. Bean jelly[a]
18. Soybean
19. Watered bean curd

Fresh beans
20. Horsebean
21. Soybean sprout
22. Kidney bean[a]
23. Mung sprout[a]
24. Cowpea[a]

Edible roots
25. Potato
26. Lotus root
27. Sweet potato
28. Radish
29. Carrot

Melons
30. Pumpkin
31. Tomato
32. Cucumber
33. Egg plant
34. Balsam pear[c]
35. Green pepper
36. Towel gourd[c]

Green-yellow vegetables
37. Cauliflower
38. Lettuce
39. Hardy vegetable
40. Lettuce leaf
41. Cow-skin vegetable
42. Garlic sprout
43. Celery
44. Cole[b]
45. Zhe'er'geng
46. Rape flower[a]
47. Pease seedling
48. Hollow caudex vegetable[c]
49. Bamboo shoots[c]
50. Scallion[c]
51. Chinese toon
52. Spinage[b]
53. Cabbage
54. Garlic seedling[c]
55. Leek[b]
56. Caraway
57. Garlic

Fruits
58. Citrus[a]
59. Apple
60. Pear
61. Banana

Nuts
62. Peanut
63. Gingili
64. Sunflower seeds[a]
65. Walnut[c]

Meat (domestic beast) and organ meat
66. Fresh pork
67. Pork (muscle)[a]
68. Short pork rib
69. Fat
70. Preserved pork/Sausage
71. Pork (knuckle)
72. Blood curd
73. Pig liver
74. Beef
75. Pig kidney
76. Pig colon[c]
77. Cattle stomach[b]

Poultry meats
78. Duck
79. Chicken
80. Goose[a]
81. Duck gizzard[a]
82. Duck intestine[b]

Marines
83. Chub
84. Crucian
85. Grass carp[a]
86. Loach[c]
87. Sleeve-fish[a]
88. Hairtail
89. Prawn[a]
90. common eel

Eggs
91. Chicken egg
92. Duck egg
93. Preserved egg
94. Salted egg

Milk and milk products
95. Milk

Preserved vegetables
96. Salted greengrocery
97. preserved sichuan pickle
98. Pickled radish[c]
99. Preserved JiaoTou[c]

Mushrooms
100. Kelp
101. Mushroom[b]
102. White Agaric
103. Agaric
104. Filiform mushroom[c]
105. Silver mushroom

Oil
106. Rap oil
107. Salad oil
108. Stiffened lard
109. Chili oil

Beverages
110. Beer
111. Ardent spirit
112. Green tea[c]
113. Coffee[a]

Condiments
114. Soy
115. Vinegar
116. Chili powder
117. Broad bean sauce
118. Monosodium glutamate
119. White sugar[a]

a)Included only in the urban version.
b)Included only in the rural version.
c)Additional items by authors.