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Original Article

Validation of a food frequency questionnaire for Japanese pregnant women with and without nausea and vomiting in early pregnancy

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ABSTRACT

Background: No previous study has shown the validity of a food frequency questionnaire (FFQ) in early pregnancy with consideration of nausea and vomiting during pregnancy (NVP). The aim of this study was to evaluate the validity of a FFQ in early pregnancy for Japanese pregnant women.
Method: We included 188 women before 15 weeks of gestation and compared estimated nutrient intake and food group intake based on a modified FFQ with that based on 3-day dietary records (DRs). Spearman's rank correlation coefficients, adjusting energy intake and attenuating within-person error, were calculated. Subgroup analysis for those with and without NVP was conducted. We also examined the degree of appropriate classification across categories between FFQ and DRs through division of consumption of nutrients and food groups into quintiles.
Results: Crude Spearman's correlation coefficients of nutrients ranged from 0.098 (sodium) to 0.401 (vitamin C), and all of the 36 nutrients were statistically significant. In 27 food groups, correlation coefficients ranged from −0.015 (alcohol) to 0.572 (yogurt), and 81% were statistically significant. In subgroup analysis, correlation coefficients in 89% of nutrients and 70% of food groups in women with NVP and 97% of nutrients and 74% of food groups in women without NVP were statistically significant. On average, 63.7% of nutrients and 60.4% of food groups were classified into same or adjacent quintiles according to the FFQ and DRs.
Conclusions: The FFQ is a useful instrument, regardless of NVP, for assessing the diet of women in early pregnancy in Japan.

Introduction

Nutrition during early pregnancy plays an important role in normal fetal development, contributing to organ development as well as long-term health of the offspring.[1] Fetal organ development can be inhibited by unbalanced or inadequate nutrient intake in early pregnancy. For example, folic acid deficiency increases the risk of neural tube defect,[2] and excess vitamin A increases the risk of central-neural-crest defects.[3] Unbalanced nutritional intakes during this period can also show their effects later in life, such as the associations of iodine deficiency with low child intelligence quotient[4] and overall malnutrition with coronal heart disease and obesity in adulthood,[5,6] and epigenetic changes that persist throughout the child's life.[7]

Food records or 24-h dietary recalls may provide accurate information on diet during pregnancy; however, they are expensive to administer and difficult to analyze in epidemiological studies. On the other hand, food frequency questionnaire (FFQ) is useful for assessing habitual diet in large epidemiological studies due to the low cost and ease of administration. Several studies have demonstrated the validity of FFQ in mid or late gestation.[8–11]

Nonetheless, using a FFQ to measure diet in early pregnancy may be challenging compared to doing so in the normal population,

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as a significant proportion of pregnant women could experience alteration in food preference due to nausea and vomiting during pregnancy (NVP). The FFQ queries food consumption during a period (usually the past 1–2 months) that may include time before and after this preference change. In addition to intra-individual changes over the assessment period, preference for women with NVP may be differ from that for women without NVP (inter-individual difference), for instance one study found that dietary intake in women with NVP differed from that in women without NVP in the consumption of carbohydrate and sugar.[12] Therefore, FFQ should ideally be validated in both women with NVP and women without NVP before using it in early pregnancy. To the best of our knowledge, none of the previous studies that validated the FFQ in early pregnancy did so.[8,13,14]

To that end, we conducted a validation study of a 167-item FFQ in women during early pregnancy, with consideration of the influence of NVP. We compared estimated intakes based on the FFQ with those based on a 3-day dietary record (DR).

Methods

Study design and subjects

This is a prospective cohort study conducted at the National Center for Child Health and development (NCCHD; Tokyo, Japan) to assess the validity of the FFQ for Japanese pregnant women. Participants were randomly recruited at the outpatient department during their first prenatal care visit in the early pregnancy period between April 2011 and March 2012. Participants were asked to complete a 3-day DR and subsequently fill out a questionnaire on social characteristics and the FFQ. A 3-day DR was chosen as the reference method because of its reliability in measuring actual food consumption and because the measurement errors of DR do not correlate with those of FFQ. A total of 248 women agreed to participate in our study. Sixty women were excluded because of incomplete FFQ or DR (n = 37), withdrawal (n = 21), and inability to eat due to NVP (n = 2). Ultimately, we analyzed 188 women. Since the sample size was similar or even larger than previous studies that validated the FFQ,[10,11,15] the current size can be considered sufficient for this validation study.

All participants provided written informed consent at recruitment. The study protocol was approved by the Hospital Ethics Committee at NCCHD (#467).

Dietary assessment methods

FFQ

The FFQ, which is self-administrated questionnaire consisting of 167 food and beverage items and nine frequency categories, was derived from the food list initially developed for the Japan Public Health Center-based Prospective Study (JPHCPS).[16] Response items ranged from “almost never” to “7 or more times per day” (or “10 glasses per day” for beverages), and questions asked about the habitual consumption of listed foods within the past 2 months. For the purpose of our study, we removed regional food items from the list (e.g., bitter melon) and substituted these with six food items that were more likely to be consumed by young women (ground meat, pastry, cornflakes, pudding, jelly, and alcoholic cocktail). Portion size was specified for each food item using three standard sizes: medium (the standard amount), small (50% smaller), and large (50% larger). Intake of energy, 36 nutrients, and 27 food groups was calculated using a food composition table developed for the FFQ based on the Standardized Tables of Food Composition in Japan (2010 edition).[17]

3-Day DR

The 3-day DR was completed based on two weekdays and one day of the weekend, which were not always consecutive. Food portions were measured by each participant during meal preparation using digital scales and measuring spoons and cups, with detailed descriptions of each food, including the methods of preparation and recipes. Trained dietitians checked the records with the examinee via telephone and coded the food and weights. Food intakes were calculated for 27 food groups, and nutrient intakes were calculated using the Standard Tables of Food Composition in Japan (2010 edition)[17] for energy and 36 nutrients.

Definition of variables

Assessment of NVP

Information on NVP was collected based on answers to a question with a 7-point scale querying the degree of dietary intake and nausea in a questionnaire administered with the FFQ: “How did your appetite or food intake change because of nausea and vomiting during pregnancy?”. We classified mothers according to whether they had NVP based on the answer, that is, we defined “with NVP” if dietary intake decreased 50% or more (10%–40%, 50%–80%, or ≥80%), and “without NVP” if dietary intake did not decrease (increased due to NVP, did not experience NVP, had NVP but intake did not change). Participants who answered “they could not eat at all due to NVP” (n = 2) were excluded from the analysis.

Validity of the question for NVP was checked by comparing body weight change (kg) during pregnancy, and we confirmed that women with NVP showed significantly less body weight change during pregnancy than women without NVP (−0.25 vs. +0.82 kg, $p < 0.001$).

Other covariates

Information on socioeconomic status, including education and household income; pre-pregnancy BMI; and maternal smoking (never, former, current) was obtained from a questionnaire administered as an adjunct to the FFQ. Maternal age, parity, and past medical history were retrieved from medical records. Maternal age was categorized into four groups: “29 years and below”, “between 30 and 34 years”, “between 35 and 39 years”, and “40 years and above”. Parity was collapsed into two groups: “0” and “≥1”. Gestational week at the time of participation in this study was categorized into four groups: “under 8 weeks”, “8–10 weeks”, “11–12 weeks”, and “13–15 weeks”. Maternal educational level was categorized into three groups: “junior high school, high school or vocational training school”, “junior college”, and “college or more” Annual household income was categorized into four groups: “under 4 million yen”, “4–5 million yen”, “6–7 million yen”, “8–9 million yen”, and “above or equal 10 million yen”. Pre-pregnancy BMI was grouped as “<18.5 kg/m^2”, “18.5–25 kg/m^2”, and “above 25 kg/m^2”.

Statistical analysis

Mean and standard deviations for nutrients intakes and food group consumption were estimated using the FFQ and DR and calculated separately. We did not include nutritional intake from supplementation in either the FFQ or the DR. To meet normal distribution, all nutrients and food groups were log-transformed before analysis. We used formula $\log(x + 1)$ transform, because not all participants consumed each food group. The relationship between the FFQ and the DR were assessed using two statistical approaches.

First, we assessed the relationship between estimated intake of each nutrient and food group according to the FFQ and the DR using

Spearman's correlation coefficients. We performed crude and energy-adjusted models because food consumption and nutrients intake correlated with total energy intake. We used the residual method of Willett to adjust energy intake.[18] Further, to attenuate the effect of within-person error, de-attenuated correlations were also computed using within-person variance and between-person variance. The formula for the calculation of attenuation is expressed as:

$$r_1 = r_0\sqrt{\left(1 + \lambda_{x/n_x}\right)}.$$

where λ_x is the ratio of the variance within a person and person-to-person variance for x, and n_x is the number of replicates per person for the x variable. Further, Pearson correlation coefficients between each estimation of nutrient and food group intake using the FFQ and the DR were also calculated.[10]

Second, we categorized each variable into quintiles based on its log-distribution obtained from the FFQ and the DR, and compared them to check whether estimated quintiles for each nutrition and food category fell in the same category or adjacent category (cross-classification analysis). Further, these analyses were performed stratified by NVP (+) and NVP (−) status. We defined $p < 0.05$ as statistically significant. Statistical analyses were performed using the STATA statistical software package version 12 (STATA Corp, College Station, TX, USA).

Results

Characteristics of participants are shown in Table 1. The mean maternal age was 35.3 (standard deviation, 3.9) years old, and 64.9% of participants were primiparous. NVP was experienced by 101 participants (53.7%). Between NVP (+) and (−) groups, all characteristic variables, except for gestational weeks of pregnancy, were similar. For most nutrient and food group estimates using the DR, there was significant difference between NVP (+) and (−) groups, while differences were not observed for estimates using the FFQ (Tables 2 and 3). The ratio of estimated intake of each nutrient from the FFQ to those from the DR, which was calculated to assess prevalence of overestimation or underestimation, fell in the range of 0.8−1.2 for 97% of 36 nutrients; in NVP (+) and NVP (−) group, the ratios were 83% and 92%, respectively.

Table 1
Characteristics of participants (n = 188).

Characteristics	Subjects (n, %)			
	Total n = 188	NVP (−) n = 87	NVP (+) n = 101	*p* value[a]
Maternal age, years				
≤29	18 (9.6)	6 (6.9)	12 (11.9)	0.59
30−34	58 (30.9)	26 (29.9)	32 (31.7)	
35−39	89 (47.3)	45 (51.7)	44 (43.6)	
≥40	23 (12.2)	10 (11.5)	13 (12.9)	
Parity				
0	122 (64.9)	55 (63.2)	67 (66.3)	0.66
≥1	66 (35.1)	32 (36.8)	34 (33.7)	
Gestational weeks of agreement to the study, weeks				
<8	9 (5.0)	8 (9.2)	1 (1.0)	0.03
8−10	74 (40.9)	35 (40.2)	39 (38.6)	
10−12	87 (48.1)	39 (44.8)	48 (47.5)	
13−15	18 (9.9)	5 (5.7)	13 (12.9)	
Educational level				
Junior high school, high school or vocational training school	34 (18.2)	11 (12.6)	23 (23.0)	0.09
Junior college	32 (17.1)	19 (21.8)	13 (13.0)	
College or more	121 (64.7)	57 (65.5)	64 (64.0)	
Missing	2	1	1	
Household income, million yen				
<4	12 (6.5)	6 (7.0)	6 (6.1)	0.34
4−5	34 (18.5)	14 (16.3)	20 (20.4)	
6−7	26 (14.1)	17 (19.8)	9 (9.2)	
8−9	30 (16.3)	13 (15.1)	17 (17.4)	
≥10	82 (44.6)	36 (41.9)	46 (46.9)	
Missing	4	1	3	
Pre-pregnant body mass index, kg/m^2				
<18.5	42 (22.5)	17 (19.8)	25 (24.8)	0.67
18.5−24.9	137 (73.3)	66 (76.7)	71 (70.3)	
≥25	8 (4.3)	3 (3.5)	5 (5.0)	
Past medical history				
Present diabetes mellitus	2 (1.1)	0 (0.0)	2 (2.0)	0.50
Present hypertension	3 (1.6)	2 (2.3)	1 (1.0)	0.60
Present thyroid disease	7 (3.7)	4 (4.6)	3 (3.0)	0.42
Appetite or food consumption by NVP				
Dietary intake was increased	39 (20.7)			
Women did not feel NVP and dietary intake did not decreased	17 (9.0)			
Women felt NVP but dietary intake did not decreased	31 (16.5)			
Dietary intake was decreased up to 10−50%	61 (32.5)			
Dietary intake was decreased up to 50−80%	27 (14.4)			
Dietary intake was decreased more than 80%	13 (6.9)			
Smoking during pregnancy				
Current	1 (0.5)	0 (0.0)	1 (1.0)	
Former	11 (5.9)	7 (8.2)	4 (4.0)	0.35

NVP, nausea and vomiting during pregnancy.
[a] *p* value comparing NVP (−) with NVP (+) by chi-squared test or Fisher's exact test.

Table 2
Estimated mean intakes of nutrients from DR and FFQ.

Nutrients	FFQ							DR						
	Total		NVP (−) n = 87		NVP (+) n = 101		p value[a]	Total		NVP (−) n = 87		NVP (+) n = 101		p value
	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	
Energy, Kcal	1744	560	1764	581	1727	560	0.66	1643	403	1784	362	1522	398	<0.01
Total carbohydrate, g	242.2	79.9	243.6	82.9	241.1	77.6	0.83	227.6	57.4	242.1	53.8	215.1	57.7	<0.01
Protein, g	59	22	61	23	58	20	0.33	60	17	67	15	54	17	<0.01
Total fat, g	56	24	57	25	55	23	0.68	53	19	59	19	48	18	<0.01
Cholesterol, g	238.6	124.1	247.4	138.8	231.0	110.1	0.37	258.1	120.3	297.0	120.4	224.6	110.3	<0.01
Saturated fatty acids, g	18.1	9.1	18.1	8.7	18.1	9.6	0.99	15.8	6.6	17.5	6.7	14.3	6.1	<0.01
Monounsaturated fatty acids, g	19.3	8.4	19.5	8.7	19.0	8.1	0.69	19.6	7.9	22.0	7.6	17.5	7.6	<0.01
Polyunsaturated fatty acids, g	11.7	5.0	12.1	5.0	11.4	5.0	0.40	10.0	4.0	11.1	3.6	9.1	4.0	<0.01
Sodium, mg	3013.9	1336.9	3004.1	1285.2	3022.3	1386.3	0.93	3391.1	1090.0	3679.4	886.4	3142.7	1188.0	<0.01
Potassium, mg	2454.8	1067.6	2469.9	917.0	2441.9	1186.5	0.86	2378.8	868.9	2673.2	735.1	2125.2	898.2	<0.01
Calcium, mg	519.6	337.8	511.3	263.0	526.8	392.2	0.76	493.7	184.8	542.4	193.4	451.8	166.9	<0.01
Magnesium, mg	230.2	87.8	234.1	81.3	226.9	93.3	0.57	228.2	77.7	254.1	59.7	205.9	84.5	<0.01
Phosphorus, mg	945.3	391.2	961.4	374.6	931.5	406.3	0.60	900.4	257.4	996.5	226.3	817.7	254.8	<0.01
Iron, mg	6.9	2.7	7.2	2.9	6.6	2.4	0.14	6.3	2.8	7.0	2.2	5.7	3.0	<0.01
Zinc, mg	7.2	2.6	7.4	2.8	6.9	2.4	0.20	6.6	2.4	7.5	2.4	6.6	2.4	<0.01
Copper, mg	1.0	0.4	1.1	0.4	1.0	0.4	0.24	1.0	0.3	1.1	0.3	0.9	0.3	<0.01
Manganese, mg	2.5	1.2	2.5	1.3	2.4	1.1	0.49	2.4	1.0	2.7	1.1	2.1	0.8	<0.01
Selenium, μg	44.5	21.6	46.4	23.0	42.7	21.6	0.26	48.6	20.5	53.4	21.9	44.4	18.3	<0.01
Iodine, μg	437.5	167.9	443.0	160.0	432.7	175.0	0.68	321.0	95.2	353.1	93.2	293.3	88.3	<0.01
Total retinol, μg	326.9	512.6	369.3	711.8	290.4	229.5	0.29	281.8	518.0	397.0	733.5	182.5	132.5	<0.01
β-carotene, μg	3515.4	2415.0	3170.6	2076.0	2906.2	2143.7	0.39	3786.7	3028.0	4042.4	2626.3	3566.4	3332.9	0.28
Vitamin A, mg	909.8	701.2	974.9	888.1	853.7	484.1	0.24	995.3	821.8	1151.6	980.1	860.7	630.3	<0.01
Vitamin D, mg	4.2	2.8	4.5	2.9	4.0	2.7	0.18	5.2	4.9	6.1	4.8	4.5	4.9	0.03
α-tocopherol, mg	7.2	3.4	7.4	3.0	7.1	3.7	0.57	6.7	2.7	7.5	2.5	6.0	2.7	<0.01
Vitamin K, μg	219.3	143.9	244.3	141.3	197.8	143.3	0.03	209.0	147.9	257.0	153.9	167.6	129.7	<0.01
Vitamin B1, μg	0.9	0.3	0.9	0.3	0.9	0.3	0.68	0.9	0.3	1.0	0.3	0.8	0.3	<0.01
Vitamin B2, μg	1.1	0.6	1.1	0.6	1.1	0.6	0.68	1.0	0.4	1.2	0.3	0.9	0.3	<0.01
Niacin, mg	13.3	5.3	13.7	5.6	12.9	4.9	0.30	12.5	4.9	14.1	4.2	11.2	5.1	<0.01
Vitamin B6, mg	1.2	0.4	1.2	0.4	1.1	0.5	0.48	1.1	0.4	1.2	0.4	1.0	0.4	<0.01
Vitamin B12, mg	4.2	2.6	4.4	2.9	4.1	2.4	0.41	4.2	3.9	5.0	4.6	3.5	3.1	<0.01
Folate, mg	284.3	128.2	302.1	140.0	269.0	115.6	0.08	294.5	123.0	346.2	119.6	249.9	108.1	<0.01
Pantothenic acids, μg	6.0	2.4	6.1	2.4	5.9	2.4	0.52	5.4	1.7	6.1	1.5	4.8	1.6	<0.01
Vitamin C, mg	111.4	60.9	111.8	51.3	110.9	68.4	0.92	119.9	66.2	138.4	74.2	103.9	54.0	<0.01
Water-soluble fiber, g	3.1	1.5	3.2	1.4	3.1	1.6	0.57	3.1	1.8	3.6	2.0	2.7	1.5	<0.01
Non-water-soluble fiber, g	8.0	3.5	8.3	3.7	7.7	3.3	0.20	9.0	4.0	10.0	2.9	8.1	4.6	<0.01
Total dietary fiber, g	11.4	5.0	11.8	5.2	11.0	4.9	0.24	13.1	5.9	14.6	4.6	11.8	6.5	<0.01

DR, dietary records; FFQ, food frequency questionnaire; SD, standard deviation.
[a] $p < 0.05$ comparing with NVP(−) group with NVP(+) group.

Crude Spearman's correlations for nutrients among all women ranged from 0.202 for sodium to 0.401 for vitamin C, and correlations for all of 36 nutrients were statistically significant (Table 4). On average, 63.6% of nutrients were classified into the same or adjacent categories, and only 4.3% were classified into extreme quintiles according to cross-classification analysis. In subgroup analyses, statistically significant correlations were found in 97% and 89% of 36 nutrients among NVP (−) women and NVP (+) women, respectively. Energy adjustment and de-attenuation improved correlations in both NVP (−) and (+) groups. The average rate of re-categorization in the same or adjacent categories or an extreme category of nutrients was 64.3% and 3.5%, respectively, among NVP (−) women, and 63.2% and 5.3%, respectively, among NVP (+) women.

Similarly, the crude Spearman's correlations for food groups among all women ranged from −0.015 for alcohol to 0.572 for yogurt, and correlations for 81% of 27 food groups were statistically significant (Table 5). On average, 61.3% of nutrients were classified into the same or adjacent categories and only 5.3% were classified into extreme quintiles in cross-classification analysis. In subgroup analyses, statistically significant correlation was found for 74% and 70% of 27 food groups among NVP (−) women and NVP (+) women, respectively. Energy adjustment and de-attenuation improved correlations in both NVP (−) and (+) groups. For food groups, the average rate of re-categorization in the same or adjacent categories or an extreme category was 61.3% and 5.3%, respectively, among NVP (−) women, and 62.7% and 5.0%, respectively, among NVP (+) women.

Pearson correlation coefficients were calculated for sensitivity analysis. We found energy adjusted and de-attenuated correlation coefficients were similar in each variable. The differences of correlation coefficients with Spearman's correlation coefficients ranged from −0.092 to 0.061 in nutrients (eTable 1) and from −0.166 to 0.094 in food groups (eTable 2).

Discussion

This study demonstrated the validity of our 167-item FFQ among Japanese women in early pregnancy. To the best of our knowledge, this is the first study that shows the validity of a FFQ in early pregnancy with a consideration of the status of NVP, which could have a substantial impact on diet during that period. Even for women with NVP, most nutritional assessment in early pregnancy using our FFQ was considered sufficiently valid.

For our FFQ, we used a food list that was slightly modified from the one developed for the JPHCPS[16] for use in the general

Table 3
Estimated mean intakes of food groups (g/day) from DR and FFQ.

Food group	FFQ							DR						
	Total		NVP (−) n = 87		NVP (+) n = 101		*p* value	Total		NVP (−) n = 87		NVP (+) n = 101		*p* value
	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	
Cereals	405.8	156.2	421.4	163.8	392.4	148.9	0.21	320.7	103.0	354.1	94.3	292.0	102.0	<0.01
Rice	246.0	121.2	265.8	115.0	229.0	124.4	0.04	176.8	98.6	200.7	106.3	156.3	86.9	<0.01
Bread	47.3	57.6	49.3	77.5	45.5	32.0	0.66	41.1	30.6	39.4	30.6	42.5	30.7	0.49
Noodles	121.5	77.6	115.8	75.2	126.5	79.5	0.35	66.1	51.5	75.5	56.3	58.0	45.7	0.02
Potato	20.5	15.6	21.4	16.7	19.8	14.5	0.49	29.7	29.9	30.1	28.3	29.3	31.3	0.86
Sugar, sweets	2.6	2.9	2.9	3.3	2.4	2.5	0.21	5.3	5.5	5.1	4.8	5.4	6.1	0.66
Bean	66.3	70.6	72.6	60.6	60.8	78.0	0.25	45.9	52.1	47.0	45.8	44.9	57.3	0.79
Vegetables	179.2	110.4	192.4	105.0	167.9	114.2	0.13	246.8	148.9	282.7	153.6	215.9	138.1	<0.01
Folate vegetables	21.0	19.1	25.0	21.2	17.6	16.3	<0.01	32.4	31.4	39.3	30.6	26.6	31.0	<0.01
Pickled vegetables	8.5	10.5	8.3	9.9	8.6	11.0	0.83	6.9	10.9	9.2	12.7	4.9	8.7	<0.01
Fruit	110.4	113.3	107.7	101.3	112.8	123.1	0.76	193.6	152.6	205.4	140.9	183.4	162.0	0.33
Seaweed	5.8	6.1	6.7	6.8	5.0	5.4	0.06	7.3	11.7	10.7	14.2	4.5	8.2	<0.01
Seafood	33.0	22.6	35.7	21.1	30.7	23.6	0.13	39.1	30.8	44.7	32.2	34.2	28.8	0.02
Fatty fish	10.9	10.3	12.3	10.0	9.7	10.3	0.08	12.5	16.4	16.3	18.0	9.3	14.1	<0.01
Lean fish	13.4	11.9	14.8	11.7	12.2	12.0	0.15	24.2	24.3	25.5	24.3	23.0	24.3	0.49
Meat	67.8	45.2	70.7	50.2	65.3	40.5	0.41	67.9	41.3	77.0	40.8	60.0	40.2	<0.01
Red meat	43.3	30.7	44.7	34.2	42.2	27.5	0.58	36.8	32.4	45.0	37.8	29.8	25.1	<0.01
White meat	16.9	15.7	17.8	15.4	16.1	16.1	0.47	18.4	21.0	20.5	22.5	16.5	19.6	0.19
Processed meat	7.6	7.2	8.3	7.4	7.0	7.0	0.21	12.7	17.0	11.5	11.2	13.6	20.8	0.40
Egg	21.8	20.4	22.5	22.1	21.0	18.9	0.62	24.9	19.8	28.5	20.0	21.9	19.3	0.02
Dairy product	216.3	262.3	201.3	176.1	229.2	318.9	0.47	152.7	103.0	161.4	105.2	145.2	100.9	0.28
Yogurt	80.3	141.1	74.5	70.2	85.2	181.5	0.61	55.1	59.3	56.0	56.6	54.3	61.9	0.84
Confectionery	65.4	44.1	64.7	42.9	66.1	45.4	0.83	37.9	35.6	40.9	40.1	35.4	31.2	0.29
Alcohol	46.8	159.0	41.5	131.2	51.4	180.1	0.67	6.6	24.4	6.1	5.6	7.1	33.0	0.78
Tea	249.1	312.3	250.6	325.8	247.7	301.9	0.95	322.2	309.8	363.8	343.5	286.3	274.3	0.09
Juice	257.4	272.0	213.7	164.2	294.9	334.7	0.04	102.0	128.6	88.5	113.7	113.7	139.6	0.18
Coffee	47.3	77.9	50.9	79.3	44.2	76.9	0.56	20.3	55.0	25.6	62.8	15.8	47.1	0.22

DR, dietary records; FFQ, food frequency questionnaire; SD, standard deviation.

population. As this FFQ focused on pregnant women who are younger than the subjects in the JPHCPS, and since our setting is limited to an urban area, we removed regional food items that are unlikely to be commonly eaten by pregnant women in our study. Instead, we included ground meat, pastry, cornflakes, pudding, jelly, and alcoholic cocktail. We evaluated 36 nutrients and 27 food groups, in contrast to only 17 nutrients in the JPHCPS, and found that most nutrients and food groups showed statistically significant correlation between estimated intake using the FFQ and the DR, similar to the findings of the JPHCPS. However, correlation coefficients in this study were comparatively lower than those in the JPHCPS, which may be due to slight dietary changes in early pregnancy (i.e., women might change their diet due to pregnancy), or because the FFQ assessed dietary habit before notice of pregnancy and the DR assessed dietary habits after notice of pregnancy. For instance, correlation for alcohol was poor compared to the JPHCPS, which may be because many participants quit drinking alcohol after becoming aware of their pregnancy. Additionally, correlation coefficients for a number of food groups and nutrients in this study were lower than those reported in another validation study of the FFQ among pregnant women.[10] The difference may have occurred due to the mothers consuming a wider variation of food or because the DR covered a shorter period in this study.

Although a significant number of women experience NVP in early pregnancy, evaluation of dietary intake during this period is difficult. Hence, we conducted stratification by NVP status before analysis to exclude the influence of NVP. Consequently, we found that the FFQ was valid for many food groups and nutrients in both statuses, in contrast to previous studies, which could only validate in mid to late pregnancy.[10,11,15,19–21] One study reported that means of energy-adjusted nutritional intake from food did not change significantly from mid to late pregnancy,[22] which supports our finding that good correlations between the FFQ and DR remained even for women with NVP. Although dietary changes detected in early pregnancy can induce differences in absolute intakes between the NVP (+) group and the NVP (−) group, composition of nutrients and food group intakes between NVP (+) and NVP (−) women during pregnancy may not differ substantially, as we confirmed good correlation in energy-adjusted estimates. Many previous studies reported that FFQ was more likely to overestimate intake compared to DR.[10,11,15] In our study, however, the ratio of estimated intake of each nutrient from the FFQ to those from the DR was up to 1.36, which was below the criteria of overestimation (<1.6).[10] The discrepancy of estimated intake in previous studies may be due to difference in portion sizes,[23] whereas portion size used in our FFQ reference might be standardized for Japanese pregnant women.

In our validation study, energy-adjusted correlation coefficients between the FFQ and the DR were not significant for three nutrients (polyunsaturated acid, selenium, and iodine) and five food groups (potato, sugar, seafood, white meat, and alcohol). There are several conceivable reasons for this issue. The rich iodine content in some food, especially in dried seaweed, seems to cause discrepancy between the estimated intake from the FFQ and DR because of infrequent consumption. As the intake of polyunsaturated acid is influenced strongly by cooking oil, which could not be estimated using our FFQ, the correlation coefficient might be insignificant. For food groups, the cause for the insignificant correlation seems to be that some participants did not take those in the 3-day DR period.

We also succeeded in logically categorizing NVP status through a single question. Previous validation studies of questionnaire for NVP[24,25] had used the physical, mental, and social impact score from 12-item Short-Form Health Survey[26] as reference. Although our assessment of NVP was much simpler, we found that it correlated significantly with measured maternal weight change in early pregnancy and was nutritionally valid. Hence, our method may be more useful in estimating the diet during early pregnancy

Table 4
Spearman correlation coefficients and cross classification assessment between daily intakes of nutrients estimated from FFQ and DR.

Nutrients	Total			NVP (−) n = 87			NVP (+) n = 101		
	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR
	Crude	Attenuation and energy adjusted	Same or adjacent category	Crude	Attenuation and energy adjusted	Same or adjacent category	Crude	Attenuation and energy adjusted	Same or adjacent category
Energy, Kcal	0.300***		60.6%	0.289**		62.1%	0.332***		63.4%
Protein, g	0.302***	0.258**	67.6%	0.410***	0.291*	65.5%	0.245*	0.267*	68.3%
Total fat, g	0.324***	0.278**	69.1%	0.349***	0.250	67.8%	0.320**	0.289*	70.3%
Cholesterol, g	0.342***	0.360***	67.6%	0.365***	0.473**	66.7%	0.317**	0.403**	62.4%
Saturated fatty acids, g	0.316***	0.430***	64.9%	0.420***	0.329**	71.3%	0.256**	0.468***	64.4%
Monounsaturated fatty acids, g	0.339***	0.227**	70.2%	0.331**	0.207*	65.5%	0.344***	0.261*	72.3%
polyunsaturated fatty acids, g	0.241***	0.098	60.6%	0.145	−0.046	54.0%	0.295**	0.197	67.3%
Total carbohydrate, g	0.286***	0.335***	63.3%	0.265*	0.282*	59.8%	0.326***	0.378***	63.4%
Sodium, mg	0.202**	0.228**	62.8%	0.271*	0.106	63.2%	0.162	0.330**	61.4%
Potassium, mg	0.331***	0.370***	69.1%	0.439***	0.488***	65.5%	0.253*	0.300**	63.4%
Calcium, mg	0.367***	0.593***	68.6%	0.410***	0.474***	69.0%	0.340***	0.687***	64.4%
Magnesium, mg	0.278***	0.433***	63.8%	0.311**	0.469***	65.5%	0.273**	0.373***	57.4%
Selenium, µg	0.294***	0.168	61.2%	0.242*	0.194*	63.2%	0.325***	0.125	60.4%
Phosphorus, mg	0.313***	0.387***	59.6%	0.385***	0.374**	70.1%	0.267**	0.416***	63.4%
Iron, mg	0.246***	0.272**	62.8%	0.277**	0.337*	56.3%	0.213*	0.225*	60.4%
Zinc, mg	0.256***	0.227*	62.8%	0.276**	0.193	62.1%	0.241*	0.257*	61.4%
Copper, mg	0.338***	0.354***	66.0%	0.280***	0.238*	59.8%	0.363**	0.321***	64.4%
Manganese, mg	0.329***	0.400***	63.8%	0.380***	0.465***	71.3%	0.336***	0.374***	64.4%
Iodine, µg	0.260***	0.169	61.2%	0.285**	0.054	70.1%	0.237*	0.282**	61.4%
Total retinol, µg	0.247***	0.438***	61.7%	0.369***	0.516***	65.5%	0.134	0.269*	56.4%
β-carotene, µg	0.282***	0.317***	57.4%	0.307**	0.353**	64.4%	0.241*	0.315**	66.3%
Vitamin A, µg	0.208**	0.246**	61.7%	0.293**	0.307*	62.1%	0.101	0.186	62.4%
Vitamin D, µg	0.319***	0.360***	61.7%	0.341**	0.390**	63.2%	0.257**	0.303*	60.4%
α-tocopherol, µg	0.393***	0.406***	64.9%	0.336**	0.243*	63.2%	0.408***	0.482***	61.4%
Vitamin K, µg	0.337***	0.379***	68.1%	0.309**	0.343**	66.7%	0.281**	0.363**	66.3%
Vitamin B1, µg	0.341***	0.284***	67.0%	0.438***	0.248*	70.1%	0.294**	0.267*	60.4%
Vitamin B2, µg	0.327***	0.519***	60.6%	0.390***	0.407***	66.7%	0.301**	0.519**	62.4%
Niacin, mg	0.290***	0.191*	64.4%	0.372***	0.318**	62.1%	0.220*	0.228*	60.4%
Vitamin B6, µg	0.362***	0.376***	64.4%	0.428***	0.404***	69.0%	0.329***	0.346***	67.3%
Vitamin B12, µg	0.246***	0.348***	58.0%	0.247*	0.296*	60.9%	0.248*	0.342*	60.4%
Folate, µg	0.324***	0.392***	63.8%	0.327**	0.426***	65.5%	0.279**	0.344**	64.4%
Pantothenic acids, µg	0.280***	0.307***	61.7%	0.336**	0.354**	56.3%	0.231*	0.332**	65.3%
Vitamin C, µg	0.401***	0.382***	63.3%	0.297**	0.293*	65.5%	0.467***	0.447***	68.3%
Water-soluble fiber, g	0.235**	0.410***	61.2%	0.313**	0.547***	65.5%	0.143	0.253*	58.4%
Non-Water-soluble fiber, g	0.286***	0.313***	65.4%	0.295**	0.412**	63.2%	0.269**	0.232*	60.4%
Total dietary fiber, g	0.285***	0.349***	62.8%	0.331**	0.447***	65.5%	0.240*	0.268*	62.4%

DR, dietary records; FFQ, food frequency questionnaire; NVP, nausea and vomiting during pregnancy.
Significance: *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

Table 5
Spearman correlation coefficients and cross classification assessment between daily intakes of food groups estimated from FFQ and DR.

Food group	Total (n = 188)			NVP (−) (n = 87)			NVP (+) (n = 101)		
	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR	Spearman correlation coefficients between FFQ and DR		Cross classification assessment between FFQ and DR
	Crude	Attenuation and energy adjusted	Same or adjacent category	Crude	Attenuation and energy adjusted	Same or adjacent category	Crude	Attenuation and energy adjusted	Same or adjacent category
Cereals	0.413***	0.436***	63.8%	0.279**	0.505***	59.8%	0.490***	0.413***	67.3%
Rice	0.383***	0.323***	60.1%	0.373***	0.481***	64.4%	0.333***	0.228	60.4%
Bread	0.481***	0.581***	72.3%	0.591***	0.695***	77.0%	0.374***	0.388**	67.3%
Noodles	0.236**	0.293*	54.3%	0.275*	0.328*	64.4%	0.222*	0.174	52.5%
Potato	0.155*	0.117	52.1%	0.170	0.051	56.3%	0.136	0.166	57.4%
Sugar, sweets	0.103	0.131	53.2%	0.049	0.111	56.3%	0.153	0.206	52.5%
Bean	0.308***	0.366***	63.3%	0.269*	0.418**	66.7%	0.297**	0.339**	65.3%
Vegetables	0.331***	0.244**	66.0%	0.430***	0.410***	67.8%	0.229*	0.119	60.4%
Folate vegetables	0.343***	0.358***	66.5%	0.307**	0.416**	66.7%	0.294**	0.208	57.4%
Pickled vegetables	0.192**	0.229*	52.7%	0.165	0.252	54.0%	0.225*	0.232	49.5%
Fruit	0.313***	0.358***	66.5%	0.078	0.140	60.9%	0.494***	0.510***	71.3%
Seaweed	0.397***	0.471***	69.1%	0.391***	0.461***	69.0%	0.363***	0.455***	64.4%
Seafood	0.213**	0.159	64.9%	0.200	0.161	63.2%	0.191	0.123	66.3%
Fatty fish	0.219**	0.283*	54.8%	0.247*	0.246	55.2%	0.201*	0.310*	61.4%
Lean fish	0.329***	0.429***	58.0%	0.264*	0.363*	60.9%	0.313**	0.366**	57.4%
Meat	0.221**	0.242*	58.0%	0.269*	0.281*	59.8%	0.169	0.140	58.4%
Red meat	0.305***	0.248**	60.6%	0.352***	0.207	62.1%	0.314**	0.267*	61.4%
White meat	0.097	0.205	53.2%	0.143	0.294	55.2%	0.014	0.142	49.5%
Processed meat	0.405***	0.485***	66.0%	0.439***	0.541**	67.8%	0.365***	0.400**	65.3%
Egg	0.405***	0.515***	66.5%	0.442***	0.546***	71.3%	0.413***	0.524***	68.3%
Dairy product	0.540***	0.651***	73.4%	0.541***	0.575***	75.9%	0.534***	0.681***	73.3%
Yogurt	0.572***	0.613***	76.1%	0.463***	0.560***	69.0%	0.633***	0.686***	74.3%
Confectionery	0.159*	0.334***	58.0%	0.178	0.280*	64.4%	0.137	0.367**	55.4%
Alcohol	−0.015	−0.006	41.0%	0.033	0.127	41.4%	−0.033	−0.030	38.6%
Tea	0.204**	0.272***	59.6%	0.391***	0.419***	64.4%	0.066	0.141	49.5%
Juice	0.362***	0.474***	62.8%	0.327**	0.430***	60.9%	0.386***	0.417***	64.4%
Coffee	0.380***	0.345***	61.3%	0.460***	0.445***	57.5%	0.300**	0.333**	69.3%

DR, dietary records; FFQ, food frequency questionnaire; NVP, nausea and vomiting during pregnancy.
Significance: *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

compared to previous methods, which considered body weight change.

Nonetheless, our study has several limitations. First, it was conducted at a single center located in an urban area; therefore, the background of the participants may not necessarily reflect the general Japanese pregnant women population. For example, socioeconomic status and age were higher for participants in this study compared to the general population. However, higher education and age may also have contributed to the accuracy of responses to both the FFQ and DR. Second, although the sample size was adequate for overall analysis in this study, it was insufficient to conduct sub-group analysis to consider the wide seasonal variation in Japanese food. Third, in our study, early pregnancy was defined as 15 weeks or before, although it is more commonly defined as up to 14 weeks. However, this 1-week difference may not induce measurement error, as the change from early to mid-pregnancy is not likely to cause a drastic change in dietary pattern. Fourth, we used 3-day DR as a reference method, which was shorter than the DR used in some studies.[10,11] Fifth, NVP (+) women were more likely to provide overestimated dietary consumption from the FFQ than the 3-day DR, suggesting that a 3-day record conducted when with nausea may underestimate overall intake of a longer period that includes time when the mother did not have nausea.

In conclusion, this study demonstrated that, at least for the assessment of consumption of certain nutrients and food groups with higher correlation coefficients, the FFQ can be used by Japanese pregnant women in their early pregnancy, regardless of the status of NVP. The FFQ can be a useful tool for future studies on nutritional status of Japanese pregnant women in early pregnancy.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.je.2016.06.004.

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