Infrequent home-cooked meal consumption is related to the inadequacy of dietary fibre and minerals intake among Japanese adults aged 18-64 years: analysis from the 2015 National Health and Nutrition Survey

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Research

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Abstract

Background: Consumption of home-cooked meals may lead to better nutritional intake. Few studies have examined the effect of frequency of home-cooked meal consumption on inadequacy of nutritional intake based on nutritional standards. We therefore aimed to examine the association between the frequency of home-cooked meal consumption and nutrient intake inadequacy among Japanese adults.

Methods: This study was a secondary analysis of the 2015 National Health and Nutrition survey in Japan, involving 921 men and 1300 women aged 18–64 years, a cross-sectional survey. The frequency of home-cooked meal consumption was determined using two questions enquiring about the frequency of eating out and take-away meals. Data on dietary intake were collected using a one-day semi-weighed household dietary record. The inadequacy of each nutrient intake was assessed by comparing estimated average requirement (EAR) level for 14 nutrients and the range of the dietary goal (DG) for seven nutrients according to the 2015 version of the Dietary Reference Intake for Japanese. Participants were stratified into three groups based on the frequency of consuming home-cooked meals. Group differences in EAR and DG were assessed using the covariate and logistic regression analysis, respectively.

Results: Among men and women, the proportion of participants who consumed home-cooked meals almost every day and meals prepared out of home at least once a day were 34.9% and 46.8%, and 14.7% and 6.3%, respectively. A higher frequency of consumption of home-cooked meals was associated with higher intake and adequacy of dietary fiber and minerals (iron, calcium, potassium etc.), and with higher intake of vegetables and lower intake of oils.

Conclusions: Low frequency of home-cooked meal consumption was associated with insufficient intake of dietary fiber and multiple mineral intakes among Japanese adults. Dietary fiber and mineral intake may need to the focus of interventions aimed at improving nutrient intake in individuals who predominantly eat food prepared away from home.

Background

The frequency of consuming meals prepared away from home has been reported to influence the quality of dietary intake.[1] Consuming meals prepared away from home is associated with higher intake of energy, fat, and sodium, and with lower intake of dietary fiber, vitamin C, and several minerals such as iron and calcium.[2–11] Additionally, meals prepared away from home has been linked to reduced consumption of healthy foods such as vegetables, fruit and dairy products. [12–16] Moreover, increased frequency of eating out and take-away meals was reported to be associated with an increase in body weight, body mass index (BMI), and waist circumference[12, 16–18], and increased risk of obesity[19–21], insulin resistance, diabetes mellitus[14, 21, 22], and depression.[9, 23, 24] These findings suggest that a higher frequency of eating meals prepared away from home can affect not only the quality of diet, but also physical health.

A shift from food prepared at home convenient/easy-to-prepare and away-from-home foods has been reported in the United States.[25] Additionally, high frequency of consuming food prepared away from home has been reported in high income countries such as United Kingdom, and Japan.[16, 26] Thus, it is crucial to examine the association between frequency of eating out or take-away meal consumption and overall dietary quality Few studies have examined the association between home-cooked meal intake and overall dietary quality. For example, a UK study observed better dietary intake indicators among those who had more home-cooked meals.[16] Fewer studies have analyzed nutritional adequacy (focusing on each nutrient or food) according to frequency of home-cooked meal consumption. It is important to describe how home-cooked meal consumption is associated with specific characteristics within overall dietary intake quality to identify effective public health nutritional interventions. Thus, we aimed to examine the relationship between the frequency of consuming home-cooked meals and inadequate nutrient intake among adult Japanese aged 18–64 years using data from the 2015 National Health and Nutrition Survey in Japan (NHNS).

Methods

Data source and study population

The NHNS is a nationally representative cross-sectional annual survey conducted by local public health centers under the supervision of the Ministry of Health, Labour, and Welfare. The present study was based on data from the 2015 NHNS conducted between November 1 to 30, 2015. Details of the 2015 NHNS has been described elsewhere.[29, 30] Briefly, the participants, who included households and family members (aged >1 year as of November 1, 2015) in 300 areas, were stratified and randomly extracted from the general census areas in the Comprehensive Survey of Living Conditions in 2015. The 2015 NHNS consisted of physical examination, dietary survey, and lifestyle questionnaire. A total of 3,507 out of 5,327 eligible households (65.8%) and 8,583 people participated in the survey. This current study included 5,048 adults aged 18–64 years. We excluded participants with missing data required for analysis in the present study, such as dietary information (n = 1,127), body weight (n = 592), smoking status or/and habitual alcohol consumption (n = 270). Moreover, we excluded those with missing data on the frequency of eating out and take-away meals (n = 5). We also excluded those who skipped breakfast, lunch, or/and dinner (n = 749), because meal skipping may affect nutrient and food intakes[31, 32], and lactating or pregnant women who may have changed their usual dietary habits (n = 84).[33] Thus, the final participants consisted of 2,221 Japanese adults aged 18–64 years (921 men and 1,300 women).

The permission to use the 2015 NHNS data was obtained from the Ministry of Health, Labour, and Welfare, and only anonymised information was availed for this study. As this survey was conducted according to the Health Promotion Act, all participants gave informed consent to the local government, and approval from Institutional Review Board was not required.

Dietary assessment

Dietary intake data was collected using a one-day semi-weighed household dietary record administered in November 2015, excluding Sundays and public holidays. Prior to completing the survey, trained fieldworkers (mainly registered dieticians) provided an outline of the survey and explained to the participants how to complete the dietary record. The main record-keepers in the household (members who are usually responsible for preparing meals) were instructed to weigh all foods and beverages consumed by the household members and the amount of food waste and leftovers and record their names and weights on recording forms. Additionally, the main record-keepers recorded the approximate proportions of the food consumed by each household member when members shared foods from the same dish to enable estimation of individual intake. If weighing was not possible because of eating out, the portion size consumed, or quantity of foods and details of any leftovers was recorded. Trained fieldworkers visited each household and checked for any missing information and errors. In accordance with the survey manual of the NHNS, the trained fieldworkers converted these estimates of portion sizes or quantity of foods into weights of foods and coded each food item, according to the NHNS food number lists based on the Standard Tables of Food Composition in Japan[34] to calculate the intake of energy and nutrients. The trained fieldworkers inputted collected dietary intake data using software specifically developed for the NHNS.

Energy and nutrients were calculated based on the 2010 Standard Tables of Food Composition in Japan, and foods were classified into 17 groups based on its food group table.[34] In this study, we adjusted the reported dietary intake based on the assumption that each participant reported the estimated energy requirement (EER) when their physical activity level was at the second level, to render the comparison between the reported nutrient intake and the Dietary Reference Intake for Japanese (DRIs)[28] values practically possible. The following calculation was used: dietary intake (unit/day) = reported dietary intake (unit/day)/reported energy intake (kcal/day) × EER (kcal/day). For protein, total fat, saturated fat, and carbohydrate, %energy for each nutrient was also calculated. Additionally, food intake values were energy-adjusted using the density method (i.e. their amounts per EER for food groups) to minimise the influence of dietary misreporting.

Frequency of home-cooked meals

The frequency of home-cooked meal consumption was assessed by the combination of two questions asking about the frequency of eating out and take-away meals. Participants reported the frequency of eating out and take-away meals (twice a day or more, once a day, 4–6 times per week, 2–3 times per week, once a week, less than once a week, seldom) in the lifestyle questionnaire. The classification of participants into three groups according to the frequency of home-cooked meals consumption is shown in Figure 1. Participants who answered, “twice a day or more” to either question and those who answered, “once a day,” “4–6 times a week” or “2–3 times a week” to both questions were classified into the Low group (low frequency of home-cooked meal consumption). Participants who responded to both questions “once a week,” “less than once a week,” “seldom” were classified in the High group (high frequency of home-cooked meal consumption). If none of the above applies to those, participants were classified into the Middle group.

Determination of inadequate nutrient intake

Inadequate intake of each nutrient was determined by comparing consumed nutrient levels with the relevant dietary reference value according to the Japanese DRIs, using a previously reported method.[35–37] In the Japanese DRIs, different types of dietary reference values were established according to their purpose. The estimated average requirement (EAR) is set to prevent insufficient intake of nutrients, whereas the tentative dietary goal to prevent lifestyle-related diseases (DG) is set to prevent non-communicable diseases.

Nutrient inadequacy was defined as follows: intake level below EAR was considered as inadequate using the cut-point method for the following 14 nutrients with known EARs: protein, vitamin A (as retinol activity equivalents), vitamin B1, vitamin B2, niacin (as niacin equivalent), vitamin B6, vitamin B12, folate, vitamin C, calcium, magnesium, iron, zinc, and copper. Regarding iron intake in menstruating women, we applied the value <9.3 mg/day as recommended by the World Health Organisation (WHO) (bioavailability of iron as 15%, probability of inadequacy as 50%)[38] for women aged 20–49 years because the cut-point method is less applicable to these populations.[39, 40] For the following seven nutrients, the intake level outside the range of DG values was considered as inadequate: protein (as % energy), total fat (as % energy), saturated fat (as % energy), carbohydrate (as % energy), total dietary fiber, sodium (as salt-equivalent), and potassium.

Other variables

Body height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) were measured for approximately 90% of the participants by trained field workers according to standardised procedures. For the remaining participants, height and weight were measured either by other household members at home or were self-reported. BMI was calculated as weight (kg) divided by height (m) squared. Smoking status and alcohol drinking habits during the preceding month were assessed by a self-administered questionnaire.

Statistical analysis

All statistical analyses were stratified by sex. The differences in characteristics among three groups according to the frequency of the home-cooked meal consumption were compared using the chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. Differences in daily nutrients and food intake among the three groups according to the frequency of home-cooked meal consumption were assessed by ANOVA in the crude model and a covariate analysis (ANCOVA) in the adjusted model. Dunnett test, with the high group as reference, was performed in the post-test. The nutritional inadequacy of each nutrient intake was represented as the proportion of participants whose intake was above the EAR or in the range of the DG in each group. Logistic regression analysis was used to examine the difference in the prevalence of meeting DRIs based on the Low and Middle groups according to the

frequency of the home-cooked meal consumption compared with the High group in the crude and adjusted model. Confounding factors considered in the adjusted model were age category (18–34, 35–50, and 51–64 years), occupation (professional/manager, sales/service/clerical, security/transportation/labour, student, housekeeper, and not in paid employment), living alone or not (yes or no), region (Hokkaido/Tohoku, Kanto, Hokuriku/Tokai, Kinki, Shikoku/Chugoku, Kyusyu), current smoker (yes or no) and habitual alcohol drinker (yes or no), which was reported as a factor affecting the frequency of consumption of meals prepared away from home[8, 27]. All statistical analyses were performed with SAS statistical software, version 9.4 (SAS Institute Inc., Cary, NC, USA). All reported P values were two-tailed, with a P-value <0.05 considered statistically significant.

Results

The basic characteristics of participants according to frequency of home-cooked meal consumption are shown in *Table 1.* The proportion of participants classified into the High, Middle, and Low groups were 34.9%, 50.5%, and 14.7% for men, and 46.8%, 46.9%, and 6.3% for women, respectively. There were significantly fewer young men and women in the high frequency of home-cooked meal consumption group. Additionally, men and women living alone had significantly less home-cooked meal consumption ($p < 0.001$). The region significantly differed in women, with more women in the Low group living in the urban Kanto area ($p = 0.002$). In the Low group, the proportion of people eating out or having take-away meals were approximately 90% of men and 70% of women, which was significantly higher both among men and women than in other groups. There were no differences in mean BMI, type of occupation, current smoking and consumption of snacks both among men and women.

Table 1

Characteristics of 2221 Japanese adults aged 18-64 years according to frequency of home-cooked meal consum

	Men							Women			
	High (n=321)		Middle (n=465)		Low (n=135)		p*	High (n=608)		Middle (n=610)	
Age (years), Mean (SD)	49.6	(11.8)	47.5	(12.4)	44.8	(12.1)	0.001	48.8	(11.0)	47.	
Age category, n (%)							0.005				
18-34 years	44	(13.7)	82	(17.6)	33	(24.4)		67	(11.0)	95	
35-50years	103	(32.1)	173	(37.2)	52	(38.5)		244	(40.1)	241	
51-64 years	174	(54.2)	210	(45.2)	50	(37.0)		297	(48.9)	274	
Body mass index (kg/m^2), Mean (SD)	23.8	(3.4)	23.8	(3.5)	24.5	(4.4)	0.132	22.0	(3.4)	22.	
Body mass index category, n (%)							0.269				
Underweight (<18.5)	6	(1.9)	19	(4.1)	5	(3.7)		59	(9.7)	80	
Normal (18.5 - 25)	202	(62.9)	302	(65.0)	80	(59.3)		449	(73.9)	424	
Overweight (25≤)	113	(35.2)	144	(31.0)	50	(37.0)		100	(16.5)	106	
Occupation, n (%)							0.104				
Professional / manager	105	(32.7)	162	(34.8)	55	(40.7)		99	(16.3)	84	(13.8)
Sales / service / clerical	65	(20.3)	117	(25.2)	36	(26.7)		232	(38.2)	263	(43.1)
Security / transportation / labour	119	(37.1)	135	(29.0)	29	(21.5)		66	(10.9)	45	(7.4)
Student	3	(0.9)	10	(2.2)	4	(3.0)		7	(1.2)	14	(2.3)
Housekeeper	3	(0.9)	6	(1.3)	2	(1.5)		193	(31.7)	194	(31.8)
Not in paid employment	26	(8.1)	35	(7.5)	9	(6.7)		11	(1.8)	10	(1.6)
Living alone, n (%)	11	(3.4)	44	(9.5)	22	(16.3)	<0.001	39	(6.4)	41	(6.7)
Region, n (%)							0.093				
Hokkaido and Tohoku	41	(12.8)	47	(10.1)	15	(11.1)		63	(10.4)	56	(9.2)
Kanto	89	(27.7)	176	(37.9)	42	(31.1)		172	(28.3)	207	(33.9)
Hokuriku and Tokai	60	(18.7)	81	(17.4)	21	(15.6)		101	(16.6)	132	(21.6)
Kinki	53	(16.5)	82	(17.6)	31	(23.0)		126	(20.7)	100	(16.4)
Shikoku and Chugoku	39	(12.2)	34	(7.3)	11	(8.2)		67	(11.0)	54	(8.9)
Kyusyu	39	(12.2)	45	(9.7)	15	(11.1)		79	(13.0)	61	(10.0)
Current smoker, n (%)	102	(31.8)	140	(30.1)	54	(40.0)	0.094	47	(7.7)	55	(9.0)
Habitual alcohol drinker, n (%)	117	(36.5)	172	(37.0)	45	(33.3)	0.736	49	(8.1)	77	(12.6)
Frequency of home-cooked meal consumption on the							<0.001				

dietary recording day											
1 time or less, n (%)	18	(5.6)	67	(14.4)	52	(38.5)		14	(2.3)	49	(8.0)
2 times, n (%)	106	(33.0)	219	(47.1)	68	(50.4)		128	(21.1)	233	(38.2)
3 times, n (%)	197	(61.4)	179	(38.5)	15	(11.1)		466	(76.6)	328	(53.8)
Consumption of snack on the dietary recording day, n (%)	118	(36.8)	172	(37.0)	82	(60.7)	0.870	476	(78.3)	460	(75.4)

SD, standard deviation
* Means for continuous values were compared by an analysis of variance and proportions for categorical values were compared by the chi-square test betwe groups.

Table 2 shows the nutrient intakes on the dietary recording day according to the frequency of home-cooked meal consumption. Among men, the intake of protein, calcium, iron, copper, dietary fiber and potassium was significantly lower in the Low group than in the High group (p = 0.020, 0.044, 0.008, 0.027, 0.002 and 0.004, respectively). While in women, the intake of folate, calcium, magnesium, iron and potassium in the Middle group was significantly lower than in the High group (p = 0.046, 0.036, 0.014, 0.001 and 0.026, respectively). Dietary fiber intake was higher in the High group compared the Middle and Low groups (p = 0.005).

Table 2

Nutrient intakes on the dietary recording day among 2221 Japanese adults aged 18-64 years according to frequency of home-cooked meal consump

	Men						P§	P¶	Women					
	High (n=492)		Middle (n=294)		Low (n=135)				High (n=492)		Middle (n=294)		Low (n=135)	
Energy, kcal/d	2314	(592)	2302	(571)	2241	(554)	0.454	0.282	1771	(430)	1785	(423)	1799	(499)
Nutrients with EAR														
Protein, g/d	91	(18)	91	(17)	87	(19)*	0.031	0.020	73	(14)	73	(13)	72	(15)
Vitamins														
Vitamin A, µg RE/d	614	(727)	662	(751)	527	(366)	0.136	0.181	617	(910)	559	(424)	469	(248)
Vitamin B_1, mg/d	1.1	(0.41)	1.1	(0.42)	1.1	(0.44)	0.455	0.319	0.9	(0.31)	0.90	(0.30)	0.93	(0.34
Vitamin B_2, mg/d	1.4	(0.46)	1.4	(0.48)	1.4	(0.51)	0.524	0.453	1.3	(0.46)	1.2	(0.39)	1.3	(0.48
Niacin, mg/d	35	(9.8)	36	(11.2)	33	(10.5)	0.058	0.075	28	(7.6)	28	(7.5)	28	(8.5)
Vitamin B_6, mg/d	1.4	(0.42)	1.4	(0.42)	1.3	(0.69)	0.135	0.291	1.2	(0.38)	1.2	(0.37)	1.1	(0.37
Vitamin B_{12}, µg/d	7.7	(7.7)	7.8	(7.7)	6.5	(6.2)	0.184	0.333	6.0	(6.1)	5.8	(6.1)	6.2	(5.5)
Folate, µg/d	352	(135)	363	(153)	334	(148)	0.120	0.225	335	(144)	319	(123)*	307	(119)
Vitamin C, mg/d	103	(70)	103	(66)	87	(61)	0.032	0.162	110	(71)	103	(69)	92	(71)
Minerals														
Calcium, mg/d	580	(258)	578	(263)	519	(245)*	0.045	0.044	561	(230)	525	(223)*	523	(243)
Magnesium, mg/d	315	(93)	315	(88)	294	(89)	0.046	0.084	271	(75)	260	(71)*	256	(74)
Iron, mg/d	9.5	(2.9)	9.7	(2.8)	8.9	(2.6)*	0.007	0.008	8.6	(2.8)	8.0	(2.2)*	7.9	(2.5)
Zinc, mg/d	10.7	(2.2)	10.8	(2.5)	10.5	(2.5)	0.635	0.398	8.4	(1.8)	8.4	(1.8)	8.2	(1.9)
Copper, mg/d	1.5	(0.32)	1.5	(0.34)	1.4	(0.38)*	0.029	0.027	1.2	(0.29)	1.2	(0.29)	1.2	(0.34
Nutrients with DG														
Protein, %energy	14.3	(2.9)	14.3	(2.6)	13.5	(3.0)*	0.005	0.015	15.0	(3.0)	14.9	(2.8)	14.6	(3.0)
Fat, %energy	25.1	(6.7)	26.3	(6.9)	26.9	(6.8)	0.020	0.141	28.0	(7.1)	28.8	(7.2)	28.5	(7.3)
Saturated fat, %energy	6.6	(2.4)	6.8	(2.4)	7.0	(2.7)	0.212	0.673	7.6	(2.6)	7.9	(2.8)	7.8	(2.8)
Carbohydrate, %energy	60.5	(8.0)	59.5	(8.1)	59.7	(7.2)	0.173	0.283	57.0	(8.1)	56.3	(8.1)	56.8	(8.4)
Dietary fiber, g/day	18.1	(6.8)	17.9	(6.6)	15.9	(5.5)*	0.002	0.002	16.5	(6.0)	15.6	(6.0)*	14.8	(5.1)
Sodium (salt-equivalent), day	13.0	(4.1)	13.1	(4.2)	13.4	(3.9)	0.603	0.760	10.3	(3.4)	10.3	(3.1)	10.6	(3.9)
Potassium, mg/d	2831	(832)	2799	(801)	2547	(908)*	0.003	0.004	2545	(739)	2444	(704)*	2372	(705)

DG, tentative dietary goal for preventing lifestyle-related disease; EAR, estimated average requirement; SD, standard deviation.

† Nutrients expressed as amount per day were energy-adjusted by using the following equation: energy-adjusted intake (unit/d) = observed intake (unit/d) × E Requirement (EER, kcal/d) / observed energy intake (kcal/d).

‡ Sum of retinol, β-carotene/12, α-carotene/24, and cryptoxanthin/24.

§ Sum of niacin and protein/6000.
The p values are shown for an analysis of variance to analyze differences of nutrient intake between three groups.
¶ The p values are shown for covariate analysis to analyze difference of nutrient intake between three groups adjusted for confounding variables of age cate 51-64 years), occupation (professional / manager, sales / service / clerical, security / transportation / labour, student, housekeeper, and not in paid employme no), region (Hokkaido and Tohoku, Kanto, Hokuriku and Tokai, Kinki, Shikoku and Chugoku and Kyusyu), current smoker (yes or no) and habitual alcohol drin significant difference by Dunnett test compared with High group in the adjusted model.

The multivariate-adjusted odds ratios (ORs) for nutrient intake adequacy according to the frequency of home-cooked meal consumption are shown in *Table 3.* Only few men and women had inadequate intake of protein, niacin and copper compared with EAR. Among men, the proportion of those having inadequate intake of iron, protein %energy, dietary fiber, and potassium in the Low group was significantly higher than in the High group. The multivariate-adjusted ORs [95% confidence interval (CI)] in the Low group compared with the High group (reference) were 2.03 [1.03—4.01], 1.58 [1.03—2.40], 1.91 [1.17—3.12], and 2.17 [1.33—3.55], respectively. Women in the Low group significantly took inadequate Vitamin C compared to women in the High group (OR [95% CI]; 1.72 [1.05–2.80]). For magnesium and dietary fiber, the ORs were significantly higher in the Middle group than in the High group (ORs [95% CI); 1.31 [1.03—1.65] and 1.32 [1.03—1.69]).

Table 3

Multivariate-adjusted ORs for the presence of inadequate nutrient intake (based on EAR and DG) compared with the meeting EAR and DG for frequency of hon cooked meal consumption among 2221 Japanese adults aged 18-64 years.

	Men						Women					
	High (n=492)		Middle (n=294)		Low (n=135)		High (n=900)		Middle (n=318)		Low (n=82)	
Nutrients with EAR												
Protein, *n*, %	3	0.9	2	0.4	0	0	3	0.2	0	0	0	0
Crude OR (95% CI)	-		-		-		-		-		-	
Adjusted OR (95% CI)	-		-		-		-		-		-	
Vitamins												
Vitamin A, *n*, %	216	67.3	289	62.2	100	74.1	325	53.5	325	53.3	48	58.5
Crude OR (95% CI)	1.00 (Reference)		0.80 (0.59 - 1.08)		1.39 (0.89 - 2.18)		1.00 (Reference)		0.99 (0.79 - 1.24)		1.23 (0.77 - 1.96)	
Adjusted OR (95% CI)	1.00 (Reference)		0.81 (0.60 - 1.10)		1.41 (0.88 - 2.24)		1.00 (Reference)		0.97 (0.77 - 1.22)		1.18 (0.73 - 1.90)	
Vitamin B_1, *n*, %	197	61.4	288	61.9	96	71.1	362	59.5	362	59.3	43	52.4
Crude OR (95% CI)	1.00 (Reference)		1.02 (0.76 - 1.37)		1.55 (1.00 - 2.39)		1.00 (Reference)		0.99 (0.80 - 1.25)		0.75 (0.47 - 1.19)	
Adjusted OR (95% CI)	1.00 (Reference)		1.00 (0.74 - 1.34)		1.44 (0.92 - 2.25)		1.00 (Reference)		1.01 (0.80 - 1.27)		0.77 (0.48 - 1.23)	
Vitamin B_2, *n*, %	136	42.4	182	39.1	70	51.9	178	29.3	173	28.4	25	30.5
Crude OR (95% CI)	1.00 (Reference)		0.88 (0.66 - 1.17)		1.47 (0.98 - 2.19)		1.00 (Reference)		0.96 (0.75 - 1.23)		1.06 (0.64 - 1.75)	
Adjusted OR (95% CI)	1.00 (Reference)		0.86 (0.64 - 1.16)		1.46 (0.96 - 2.22)		1.00 (Reference)		0.92 (0.71 - 1.18)		1.00 (0.60 - 1.66)	
Niacin, *n*, %	1	0.3	0	0	0	0	0	0	0	0	0	0
Crude OR (95% CI)	-		-		-		-		-		-	
Adjusted OR (95% CI)	-		-		-		-		-		-	
Vitamin B_6, *n*, %	107	33.3	154	33.1	59	43.7	212	34.9	221	36.2	32	39.0
Crude OR (95% CI)	1.00 (Reference)		0.99 (0.73 - 1.34)		1.55 (1.03 - 2.34)		1.00 (Reference)		1.06 (0.84 - 1.34)		1.20 (0.74 - 1.92)	
Adjusted OR (95% CI)	1.00 (Reference)		0.95 (0.70 - 1.30)		1.36 (0.88 - 2.09)		1.00 (Reference)		1.04 (0.82 - 1.32)		1.17 (0.72 - 1.90)	
Vitamin B_{12}, *n*, %	46	14.3	53	11.4	18	13.3	138	22.7	123	20.2	17	20.7
Crude OR (95% CI)	1.00 (Reference)		0.77 (0.50 - 1.17)		0.92 (0.51 - 1.65)		1.00 (Reference)				0.89 (0.51 - 1.57)	
Adjusted OR (95% CI)	1.00 (Reference)		0.75 (0.49 - 1.15)		0.85 (0.46 - 1.56)		1.00 (Reference)		0.82 (0.62 - 1.07)		0.76 (0.43 - 1.36)	
Folate, *n*, %	26	8.1	46	9.9	20	14.8	78	12.8	85	13.9	18	22.0
Crude OR (95% CI)	1.00 (Reference)		1.25 (0.75 - 2.06)		1.97 (1.06 - 3.67)		1.00 (Reference)		1.10 (0.79 - 1.53)		1.91 (1.08 - 3.39)	
Adjusted OR (95% CI)	1.00 (Reference)		1.15 (0.69 - 1.93)		1.65 (0.87 - 3.16)		1.00 (Reference)		1.03 (0.74 - 1.45)		1.80 (1.00 - 3.27)	
Vitamin C, *n*, %	153	47.7	217	46.7	79	58.5	258	42.4	296	48.5	48	58.5
Crude OR (95% CI)	1.00 (Reference)		0.96 (0.72 - 1.28)		1.55 (1.03 - 2.33)		1.00 (Reference)		1.28 (1.02 - 1.60)		1.92 (1.20 - 3.06)	

Adjusted OR (95% CI)	1.00 (Reference)		0.87 (0.65 - 1.17)		1.25 (0.82 - 1.92)		1.00 (Reference)		1.20 (0.95 - 1.52)		1.72 (1.05 - 2.80)	
Minerals												
Calcium, *n*, %	189	58.9	267	57.4	91	67.4	327	53.8	364	59.7	52	63.4
Crude OR (95% CI)	1.00 (Reference)		0.94 (0.70 - 1.26)		1.44 (0.95 - 2.21)		1.00 (Reference)		1.27 (1.01 - 1.60)		1.49 (0.93 - 2.40)	
Adjusted OR (95% CI)	1.00 (Reference)		0.93 (0.69 - 1.26)		1.42 (0.91 - 2.20)		1.00 (Reference)		1.24 (0.98 - 1.56)		1.44 (0.88 - 2.35)	
Magnesium, *n*, %	156	48.6	225	48.4	76	56.3	222	36.5	263	43.1	34	41.5
Crude OR (95% CI)	1.00 (Reference)		0.99 (0.75 - 1.32)		1.36 (0.91 - 2.04)		1.00 (Reference)		1.32 (1.05 - 1.66)		1.23 (0.77 - 1.97)	
Adjusted OR (95% CI)	1.00 (Reference)		0.99 (0.74 - 1.33)		1.27 (0.83 - 1.93)		1.00 (Reference)		1.31 (1.03 - 1.65)		1.22 (0.75 - 1.98)	
Iron, *n*, %	23	7.2	26	5.6	19	14.1	237	39.0	270	44.3	44	53.7
Crude OR (95% CI)	1.00 (Reference)		0.77 (0.43 - 1.37)		2.12 (1.11 - 4.04)		1.00 (Reference)		1.24 (0.99 - 1.56)		1.81 (1.14 - 2.88)	
Adjusted OR (95% CI)	1.00 (Reference)		0.75 (0.41 - 1.36)		2.03 (1.03 - 4.01)		1.00 (Reference)		1.13 (0.84 - 1.51)		1.35 (0.74 - 2.46)	
Zinc, *n*, %	24	7.5	42	9.0	14	10.4	36	5.9	26	4.3	7	8.5
Crude OR (95% CI)	1.00 (Reference)		1.23 (0.73 - 2.07)		1.43 (0.72 - 2.86)		1.00 (Reference)		0.71 (0.42 - 1.19)		1.48 (0.64 - 3.45)	
Adjusted OR (95% CI)	1.00 (Reference)		1.24 (0.72 - 2.13)		1.57 (0.75 - 3.29)		1.00 (Reference)		0.63 (0.37 - 1.08)		1.22 (0.50 - 2.99)	
Copper, *n*, %	0	0	2	0.4	1	0.7	2	0.3	3	0.5	0	0
Crude OR (95% CI)	-		-		-		-		-		-	
Adjusted OR (95% CI)	-		-		-		-		-		-	
Nutrients with DG												
Protein, *n*, %	110	34.3	159	34.2	63	46.7	182	29.9	186	30.5	31	37.8
Crude OR (95% CI)	1.00 (Reference)		1.00 (0.74 - 1.35)		1.68 (1.12 - 2.53)		1.00 (Reference)		1.03 (0.80 - 1.31)		1.42 (0.88 - 2.30)	
Adjusted OR (95% CI)	1.00 (Reference)		0.97 (0.72 - 1.32)		1.58 (1.03 - 2.40)		1.00 (Reference)		1.00 (0.78 - 1.28)		1.30 (0.80 - 2.11)	
Fat, *n*, %	134	41.7	222	47.7	61	45.2	325	53.5	326	53.4	49	59.8
Crude OR (95% CI)	1.00 (Reference)		1.28 (0.96 - 1.70)		1.15 (0.77 - 1.73)		1.00 (Reference)		1.00 (0.80 - 1.25)		1.29 (0.81 - 2.07)	
Adjusted OR (95% CI)	1.00 (Reference)		1.28 (0.96 - 1.71)		1.12 (0.74 - 1.71)		1.00 (Reference)		1.00 (0.80 - 1.26)		1.31 (0.81 - 2.11)	
Saturated fat, *n*, %	121	37.7	200	43.0	59	43.7	338	55.6	361	59.2	46	56.1
Crude OR (95% CI)	1.00 (Reference)		1.25 (0.93 - 1.67)		1.28 (0.85 - 1.93)		1.00 (Reference)		1.16 (0.92 - 1.45)		1.02 (0.64 - 1.62)	
Adjusted OR (95% CI)	1.00 (Reference)		1.23 (0.91 - 1.65)		1.18 (0.77 - 1.80)		1.00 (Reference)		1.15 (0.91 - 1.44)		1.01 (0.63 - 1.61)	
Carbohydrate, *n*, %	121	37.7	167	35.9	43	31.9	219	36.0	204	33.4	32	39.0
Crude OR (95% CI)	1.00 (Reference)		0.93 (0.69 - 1.24)		0.7 (0.50 - 1.18)		1.00 (Reference)		0.89 (0.71 - 1.13)		1.14 (0.71 - 1.83)	
Adjusted OR (95% CI)	1.00 (Reference)		0.95 (0.70 - 1.28)		0.80 (0.52 - 1.25)		1.00 (Reference)		0.88 (0.69 - 1.11)		1.22 (0.75 - 1.98)	
Dietary fiber, *n*, %	211	65.7	319	68.6	107	79.3	399	65.6	440	72.1	60	73.2
Crude OR (95% CI)	1.00 (Reference)		1.14 (0.84 - 1.54)		1.99 (1.24 - 3.21)		1.00 (Reference)		1.36 (1.06 - 1.73)		1.43 (0.85 - 2.39)	

Adjusted OR (95% CI)	1.00 (Reference)	1.14 (0.83 - 1.56)	1.91 (1.17 - 3.12)	1.00 (Reference)	1.32 (1.03 - 1.69)	1.31 (0.77 - 2.23)
Sodium (salt-equivalent), *n*, %	297 92.5	427 91.8	129 95.6	522 85.9	532 87.2	69 84.2
Crude OR (95% CI)	1.00 (Reference)	0.91 (0.53 - 1.55)	1.74 (0.69 - 4.35)	1.00 (Reference)	1.12 (0.81 - 1.56)	0.87 (0.46 - 1.65)
Adjusted OR (95% CI)	1.00 (Reference)	0.95 (0.55 - 1.64)	1.88 (0.73 - 4.84)	1.00 (Reference)	1.11 (0.80 - 1.55)	0.86 (0.45 - 1.64)
Potassium, *n*, %	202 62.9	305 65.6	107 79.3	348 57.2	383 62.8	49 59.8
Crude OR (95% CI)	1.00 (Reference)	1.12 (0.84 - 1.51)	2.25 (1.40 - 3.62)	1.00 (Reference)	1.26 (1.00 - 1.59)	0.88 (0.55 - 1.41)
Adjusted OR (95% CI)	1.00 (Reference)	1.13 (0.83 - 1.53)	2.17 (1.33 - 3.55)	1.00 (Reference)	1.23 (0.97 - 1.56)	1.01 (0.62 - 1.65)

CI, confidence interval; DG, tentative dietary goal for preventing lifestyle-related disease; DRI, Dietary Reference Intakes; EAR, estimated average requirement; OR, odd ratio.
Percentage of subjects whose intake was in the range of DG or above the EAR. Each energy-adjusted nutrient intake (unit/d) was compared with each DRI value (unit/d), using the cut-point method.
The probability of inadequacy >50% for menstruating women whose bioavailability of iron is 15% (<9.3 mg/d) was considered inadequate for women aged 20-49 y.
* Adjusted for confounding variables of age category (18-34, 35-50, and 51-64 years), occupation (professional / manager, sales / service / clerical, security / transportation / labour, student, housekeeper, and not in paid employment), living alone (yes or no), region (Hokkaido and Tohoku, Kanto, Hokuriku and Tokai, Kinki, Shikoku and Chugoku and Kyusyu), current smoker (yes or no) and habitual alcohol drinker (yes or no).

Table 4 shows food group intakes according to the frequency of home-cooked meal consumption. For both men and women, vegetable intake in the High groups was higher than that of the Low group (p = 0.004 and p = 0.012, respectively). Fat and oil intake in the High group was lower than the Middle and Low groups among men (p = 0.002); significant difference was observed only between the High and Middle groups in women. Among men, a higher intake of mushrooms was observed in the High group than in the Low group (p = 0.015). Among women, a higher intake of potatoes and lower intake of meat and poultry were observed in the High group than in the Middle group (p = 0.002 and p = 0.032, respectively).

Table 4
Food group intake on the dietary recording day among 2221 Japanese adults aged 18-64 years according to frequency of home-cooked meal consumption [Mean (SD)]†

Food groups (g/1000kcal)	Men			P‡	P§	Women			P‡	P§
	High (n=492)	Middle (n=294)	Low (n=135)			High (n=900)	Middle (n=318)	Low (n=82)		
Grains	637.8 (178.1)	636.2 (181.8)	668.0 (196.3)	0.187	0.372	431.9 (143.5)	434.7 (143.4)	468.6 (171.2)	0.099	0.148
Potatoes	66.5 (79.7)	56.8 (66.6)	52.7 (67.7)	0.086	0.063	59.3 (75.8)	44.5 (56.0)*	52.6 (74.1)	0.001	0.002
Sugars	7.9 (11.0)	7.1 (8.9)	7.7 (8.2)	0.507	0.694	7.1 (8.3)	7.1 (8.9)	5.5 (6.3)	0.226	0.292
Pulses	79.9 (101.3)	76.4 (83.3)	67.9 (92.8)	0.441	0.526	75.4 (91.6)	64.8 (74.7)	65.6 (90.3)	0.079	0.077
Sesame and nuts	2.2 (5.7)	3.3 (12.2)	1.7 (5.2)	0.119	0.202	2.4 (5.4)	2.8 (8.3)	1.9 (4.8)	0.378	0.376
Vegetables	354.3 (186.5)	362.4 (204.3)	294.2 (171.8)*	0.001	0.004	322.2 (171.6)	312.0 (161.7)	262.1 (160.8)*	0.009	0.012
Fruits	94.6 (149.3)	84.0 (114.6)	56.4 (125.3)	0.016	0.076	109.8 (120.0)	104.8 (130.6)	95.1 (123.3)	0.546	0.815
Mushrooms	22.9 (37.9)	18.6 (30.4)	13.1 (23.0)*	0.010	0.015	20.2 (28.7)	18.7 (30.3)	16.1 (25.7)	0.423	0.422
Seaweeds	15.5 (25.8)	12.0 (19.8)	11.9 (20.1)	0.068	0.086	11.4 (21.2)	10.1 (19.5)	11.0 (22.2)	0.541	0.593
Fish and shellfishes	88.5 (84.6)	87.7 (77.2)	71.7 (78.8)	0.091	0.276	67.7 (64.0)	66.1 (68.2)	67.1 (66.9)	0.913	0.856
Meat and poultry	131.1 (87.3)	134.8 (96.3)	38.2 (100.8)	0.739	0.988	91.5 (64.9)	101.1 (71.5)*	87.4 (66.4)	0.027	0.032
Eggs	48.8 (46.7)	45.4 (41.3)	43.3 (41.2)	0.391	0.419	41.4 (38.0)	39.3 (38.0)	38.0 (38.5)	0.536	0.597
Dairy products	100.9 (143.8)	104.3 (139.9)	97.0 (163.1)	0.863	0.744	124.5 (140.1)	124.5 (130.8)	124.0 (135.1)	0.999	0.992
Fat and oils	13.4 (10.2)	15.9 (11.0)*	17.5 (10.8)*	<0.001	0.002	11.0 (9.0)	12.9 (9.5)*	13.2 (8.2)	0.001	0.001
Confectionaries	19.5 (42.0)	21.6 (43.2)	22.6 (54.1)	0.728	0.806	32.9 (47.6)	28.5 (44.3)	31.8 (40.5)	0.247	0.339
Beverages	1124.5 (684.1)	1146.0 (755.8)	1207.4 (748.5)	0.541	0.513	939.4 (544.3)	930.6 (542.6)	1000.7 (615.3)	0.554	0.491
Seasonings	115.5 (108.0)	135.7 (125.0)	147.4 (144.0)	0.016	0.084	84.9 (77.4)	93.6 (86.4)	97.4 (120.0)	0.139	0.125

† Food groups expressed as amount per day were energy-adjusted by using the following equation: energy-adjusted intake (g/d) = observed intake (g/d) × Estimated Energy Requirement (EER, kcal/d) / observed energy intake (kcal/d).

‡ The p values are shown for an analysis of variance to analyze differences of nutrient intake between three groups.

§ The p values are shown for covariate analysis to analyse difference of nutrient intake between three groups adjusted for confounding variables of age category (18-34, 35-50, and 51-64 years), occupation (professional / manager, sales / service / clerical, security / transportation / labour, student, housekeeper, and not in paid employment), living alone (yes or no), region (Hokkaido and Tohoku, Kanto, Hokuriku and Tokai, Kinki, Shikoku and Chugoku and Kyusyu), current smoker (yes or no) and habitual alcohol drinker (yes or no).

* There is significant difference by Dunnett test compared with High group in the adjusted model.

Discussion

The present study examined the association between the frequency of home-cooked meal consumption and nutrient inadequacy among Japanese adults aged 18–64 years. We found that inadequate intake of dietary fiber and several minerals was associated with a higher frequency of eating out or take-away meal. To the best of our knowledge, this study is the first to examine the relationship between the frequency of home-cooked meal consumption and nutrient inadequacy, based on dietary reference values among Japanese adults.

In this study, participants were classified into three groups (Low group, Moderate group, and High group according to the frequency of the home-cooked meal consumption) based on the response to questions about the frequency of eating out and take-away meals. The results by the questionnaire on the frequency of habitual eating out and take-away meals assessed was comparable to results in the dietary survey, despite being based on one-day dietary record method.

Several factors increased the likelihood of eating food prepared away from home. Men and younger people had a lower frequency of consuming home-cooked meal. These results were consistent with those from previous studies that showed a higher frequency of eating out among men and younger adults when compared with that among older adults[13, 41], or higher proportion of eating out in men than women[13]. Similar to a previous study among Japanese university students [36], living alone was associated with a higher frequency of eating meals prepared away from home. In addition, women living in urban areas had less home-cooked meal consumption, which is consistent with the result of a Vietnamese study.[42] Thus, the current results may indicate that younger adults, especially men, are more likely to consume meals prepared away from home in Japan as well as other countries.

The association between the frequency of consuming home-cooked meals and nutrients intake has been reported in several studies. An Australian study that used a 24-hour dietary recall reported that adults with a higher frequency of consuming foods prepared outside the home has lower iron and calcium intakes[2], which is similar to the results of iron and calcium intakes in the present study. However, inadequate intake of these nutrients based on dietary reference values was not observed except for iron among men in the present study. According to a previous Japanese study, approximately more than 50% of Japanese adults had inadequate intake of calcium.[43] Also, another study showed that the proportion of Japanese women who met the standard value of iron intake was low, whereas a large percentage of Japanese men met the standard.[44] Japanese usual insufficient intake status may reflect to the present results, regardless of the frequency of home-cooked meal consumption. In contrast, Japanese people rarely lack copper and protein[43], which may explain the no difference in inadequacy of these nutrients according to the frequency of home-cooked meal consumption. Of note, EAR is set by the perspective of avoiding insufficient intake, whereas DG is set for the prevention of non-communicable diseases, which may have determined differently the definition of inadequacy of each nutrient intake.

Dietary fiber was the only nutrient that significant differed depending on the frequency of home-cooked meal consumption. This finding was largely consistent with the previous studies that reported the association the frequency of eating out with dietary fiber intake.[2, 8] Lower dietary fiber intake was observed in the Low group in men, and the Middle group in women; this trend was similar for other nutrients. It has been reported that women in Japan and elsewhere cook more often than men.[27, 45] Higher income is associated with a higher frequency of eating out and take-away meals.[41] Additionally, better diets are seen in women compared with men [46] and high educated individuals have greater dietary fiber and healthy food intake despite more frequent eating out and take-away.[8] These reports may partly explain our present finding that lower frequency of home-cooked meals is associated with lower nutrients intakes and inadequacy of nutrient intake compared with that in the High group. Socioeconomic factor may be one of the important factors associated to home-cooked meals consumption Unfortunately, other than occupation, we did not consider other socioeconomic indicators. While the proportion of professional, manager, sales, service, and clerics differed among men and women, and was higher in the Low group, there was no significant different in occupation among the groups. Thus, future studies should consider socioeconomic factors such as educational background and income level.

The frequency of eating out and take-away meals has been associated with a lower intake of vegetable and a higher intake of fat and oils. [8, 16] These results are consistent with the present study. Low intake of vegetables may partly explain the inadequate intake of potassium among men, and inadequate intake of magnesium and vitamin C among women. There has been no report on potassium and magnesium intake and inadequacy based on frequency of home-cooked meals consumption. These results highlights the need for health promotion for people with a higher frequency of eating out or take-away meals, as well as for food industry.

In this study, approximately 45% of men and 30% of women regularly ate out or had take-away meal consumption. In Japan, the government has called for voluntary efforts among food industry to improve the food environment so that people can eat well-balanced meals, whether they eat out or prepare for themselves. Example of such effort include “Increase in number of corporation in food industry that supply food products low in salt and fat.”[47] However, the current recommendation focuses on preventing excess intake. Further efforts by the government is needed to increase the population intake of dietary fiber and minerals.

The study had some limitations. First, the participants were randomly selected from nationally representative households in Japan; therefore, the individual level response rate was unknown. This might have introduced some bias in the estimation of average intake in Japanese adults. Second, a dietary intake derived from one-day weighed dietary record is unlikely to represent the usual intake. Therefore, the variability in the dietary intake of individuals over a period of several days might have influenced the findings. It is noted that the one-day household-based dietary record method used in NHNS has been compared with individual dietary records among Japanese participants, and the correlation coefficients of the intakes of total energy and macronutrients, such as protein, fat, and carbohydrates were high (0.89 to 0.91). Thus, this method is fairly valid for the estimation of individual intake[48]. Third, it could have been difficult for participants to accurately weigh food consumption in the case of eating out, take-away, or ready-meal use, unlike when they consumed home-cooked meals and could weigh all the foods and beverages, including the amounts of food waste and leftovers. Therefore, nutrient and food intakes may not have been accurately assessed. Fourth, we limited the participants to those who had three meals a day in the present analysis, because we wanted to assess nutrient intake and nutrition adequacy by the difference in the frequency of home-cooked meals consumption. This might have induced some bias in the nutrient intakes. Finally, factors other than the frequency of home-cooked meals consumption may also affect the adequacy of nutrient intake. Future studies should examine the causes of nutrient intake inadequacy.

Conclusions

This cross-sectional study indicated that Japanese adults aged 18–64 years with lower frequency of home-cooked meal consumption were less likely to meet the standard values of dietary fiber and mineral intake. Our findings suggest that dietary fiber and mineral intake may be the focus of an interventional approach to improve the nutrient intake status of those with low home-cooked meal consumption among Japanese adults. Further studies targeting food environment, including the food industry, are needed to improve nutritional adequacy for those with higher frequency of eating out or consuming take-away meals.

Abbreviations

ANCOVA, covariate analysis; ANOVA, analysis of variance; BMI, body mass index; DG, tentative dietary goal to prevent lifestyle-related diseases; DRIs, Dietary Reference Intake for Japanese; EAR, estimated average requirements; EER, estimated energy requirements; NHNS, National Health and Nutrition Survey in Japan; OR, odd ratio; 95% CI, 95% confidence interval.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

This study was a secondary analysis of the 2015 National Health and Nutrition Survey in Japan and was conducted with the permission of the Ministry of Health, Labour and Welfare, in Japan.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors designed research. M. M. and A. S. analyzed the data. M. M. wrote the first draft. A. S., C. O. and E. O. took part in the interpretation of the data and provided critical revisions of the manuscript for important intellectual content. H. T. had primary responsibility for final content. All authors read and approved the final manuscript.

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Figures

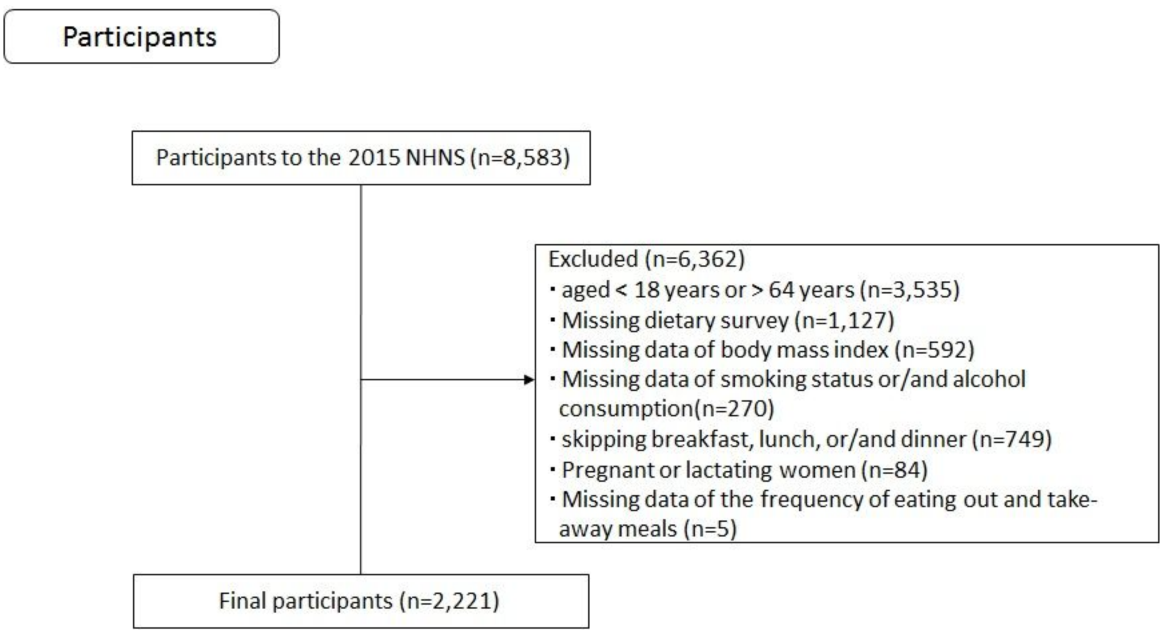

Figure 1

Classification of study participants based on frequency of consuming home cooked meals

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