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Demographics, lifestyles, health characteristics, and dietary intake among dietary supplement users in Japan

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Background The associations between supplement use and certain demographics, lifestyles, health characteristics, and dietary intakes have not been studied in a large population in non-Western societies. The objective of our study was to investigate the association between supplement use and demographics, lifestyles, health characteristics, and dietary intake in a population-based cohort study in Japan.

Methods Subjects were the 78 531 participants (45–74 years) who completed a self-administered questionnaire in 1995 or 1998 in a 5-year follow-up survey by the Japan Public Health Center-based prospective Study on cancer and cardiovascular disease. The questionnaire included enquiries about supplement use, occupation, height, weight, smoking, alcohol, physical activity, dietary behaviours, working hours, subjective stress, as well as intakes for 138 foods.

Results The supplement users were likely to have formerly smoked or never smoked. Female supplement users were likely to consume alcohol moderately. The prevalence of users was higher in the elderly, the self-employed, those with lower body mass index, greater physical activity, lower frequency of eating prepared food, higher frequency of eating out, and higher stress level in both sexes after mutual adjustment. Mean intakes of energy and nutrients were lower for users than for non-users.

Conclusion The demographics, lifestyles, health characteristics, and dietary intakes may need to be adjusted when evaluating the effect of dietary supplements on disease because they can become potential confounding factors.

Keywords Dietary supplements, characteristics, cohort study

Commercially available dietary supplements in Japan have seen tremendous growth over the last decade,[1] and their variety and number continue to increase. The prevalence of dietary supplement users differs depending on the study population as well as the definition of supplements and survey methods used. In the US, where dietary supplements are generally very popular, the prevalence varied from 21% to 55% among a number of different studies.[2] In our previous report for the baseline survey by the Japan Public Health Center-based prospective Study on cancer and cardiovascular disease (JPHC Study) in 1990 and 1993, the users who took vitamin supplements ⩾1 week ranged from 4.4% to 22.7% by area.[3]

In epidemiological studies, the use of dietary supplements is an exposure of interest because of its potential effect on disease. When dietary supplement use is associated with both diseases and demographic factors such as sex, age, race, and socio-economic status,[4] and health-related characteristics such as body mass index (BMI), smoking, and alcohol consumption,[5–7] as well as certain psychological factors,[8] it also becomes a confounding factor when determining other risk factors. These

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associations have been investigated extensively in Western countries where supplements have been widely used for decades. However, little is known about the characteristics of dietary supplement users in non-Western countries, including Japan.

In this report, we aimed to determine the characteristics of dietary supplement users among the participants in the JPHC Study cross-sectionally. The objective of our study was to investigate the possible association between supplement use and demographics, lifestyles, health characteristics, and dietary intakes.

Materials and Methods

Subjects

The study population of the JPHC Study were 140 420 adults (29 982 males and 31 613 females in Cohort I, and 38 740 males and 40 085 females in Cohort II) from 11 Public Health Center (PHC) areas in Japan. Cohort I started in 1990 with population-based cohorts of all 40–59 year old residents of four PHC areas (Yokote, Ninohe, Saku, and Ishikawa), together with a health check-up cohort in which all 40 and 50 year old residents of a PHC area (Katsushika) were invited to participate. Cohort II started in 1993 with population-based cohorts of all 40–69 year old residents of five PHC areas (Mito, Kashiwazaki, Chuo-higashi, Kamigoto, and Miyako), together with two health check-up cohorts (Suita 1 and Suita 2). Suita 1 comprised 40 and 50 year old residents of Suita City who participated in a comprehensive municipal health check-up programme. Suita 2 comprised 40–69 year old participants from the Suita Study, in which the participants were randomly selected from all 30–79 year old residents of Suita based on the population registry. The locations of study sites are shown in Figure 1. Study sites of the JPHC Study encompass the prefectures with the lowest and highest mortality rates. They were distributed throughout Japan and consisted of both urban and rural communities.[9] Katsushika and Suita are urban areas located in two major cities in Japan where a large proportion of subjects were engaged with manufacturing, trade, and service sectors. Other areas were rather rural, where farming and fishing were prominent. Baseline surveys were conducted in each cohort at the beginning of the study. Details on the selection of cohort participants and the baseline survey were presented elsewhere.[10]

Data collection

We conducted a 5-year follow-up survey from the baseline in 1995 for Cohort I, and in 1998 for Cohort II. A food frequency questionnaire (FFQ) was collected from 103 769 subjects (45 019 for Cohort I, 58 750 for Cohort II). The response rates ranged from 77% to 90% in all areas except for the metropolitan areas Katsushika (40%), Suita 1 (43%), and Suita 2 (60%), and Ishikawa (63%). This FFQ with 138 food items had been developed to estimate dietary intake,[11] and validated for estimations of various nutrients and food groups.[12–14] It also included questions about dietary supplement use as well as demographics, lifestyles, and health characteristics such as occupation, height, weight, smoking, alcohol consumption, physical activity, dietary behaviours, working hours, and stress.

In the FFQ, general use of any vitamin supplements more than once a week, and use of specific supplements by five categories (Multivitamin, Beta-carotene, Vitamin C, Vitamin E, Others) were probed. For each category, the brand names, frequency, and duration of use were asked. Users of dietary supplements were defined as subjects who used at least one category of dietary supplement $\geqslant$1 week for $\geqslant$1 year. If a subject was a user of at least one category of supplement, he or she was regarded as an overall supplement user. To preclude the incorrect categorization of self-reported dietary supplements, all supplements in the FFQ were re-categorized by the authors using brand names according to the definition of dietary supplements in the Women's Healthy Eating and Living Study.[15] This method of defining the supplement users was validated in our previous study.[16] Recategorizing self-reported categories was shown to improve sensitivity in identifying dietary supplement users. The results from our validation study also indicated that our questionnaire could even identify non-vitamin supplement users to a certain extent (sensitivity of 75%), although we only enquired about vitamin supplement use.

Self-reported occupations were combined into the following six groups: farming, forestry, and fishing; employee and professional; housewife; self-employed; unemployed; and other occupations. The subjects with $\geqslant$2 occupations across those groups were classified as a combination group. Body mass index for each subject was computed based on self-reported height and weight by dividing weight (kg) by the square of height (m). The questionnaire covered smoking status, frequency of alcohol consumption, physical activity, 14 questions on dietary behaviours (frequency of eating miso soup, breakfast, eating out, consumption of prepared foods, fried foods, deep-fried foods, fat on meat, soup from noodle bowls, adding salt or soy sauce to foods at the table, types of vegetable oils used, frequently used cooking methods, well-doneness of cooked meat, eating charred parts of fish), working hours, and self-reported stress.

Individual intakes of energy and 33 nutrients were calculated from 138 food items in the FFQ. The algorithm of the calculation was reported elsewhere.[17] Intake from dietary supplements was not included in that calculation.

Statistical analysis

SAS version 8.02 (SAS Institute Inc., Cary, NC) was used to conduct all the statistical analyses. We excluded subjects who were confirmed to be ineligible during the follow-up because they were not Japanese nationals, had already moved away at the baseline, or were not in the intended age group for this study. Subjects were also excluded for the following reasons: BMI of $<$10 or $>$100; failure to supply data in the questionnaire for any of the variables used such as occupation, height, weight, smoking, alcohol consumption, physical activity, dietary behaviours, working hours, and stress; men with a total energy intake of $<$900 kcal or $\geqslant$4000 kcal; women with a total energy intake of $<$800 kcal, or $\geqslant$3600 kcal. Of 103 769 subjects who completed the questionnaire, a total of 78 531 subjects (37 298 men and 41 233 women) were finally included in the analysis. The proportion of demographic, lifestyle, health characteristics, and supplement use among those who were excluded was similar to those included in the analysis.

We calculated the prevalence of dietary supplement users for each of the demographic factors, lifestyles, and health

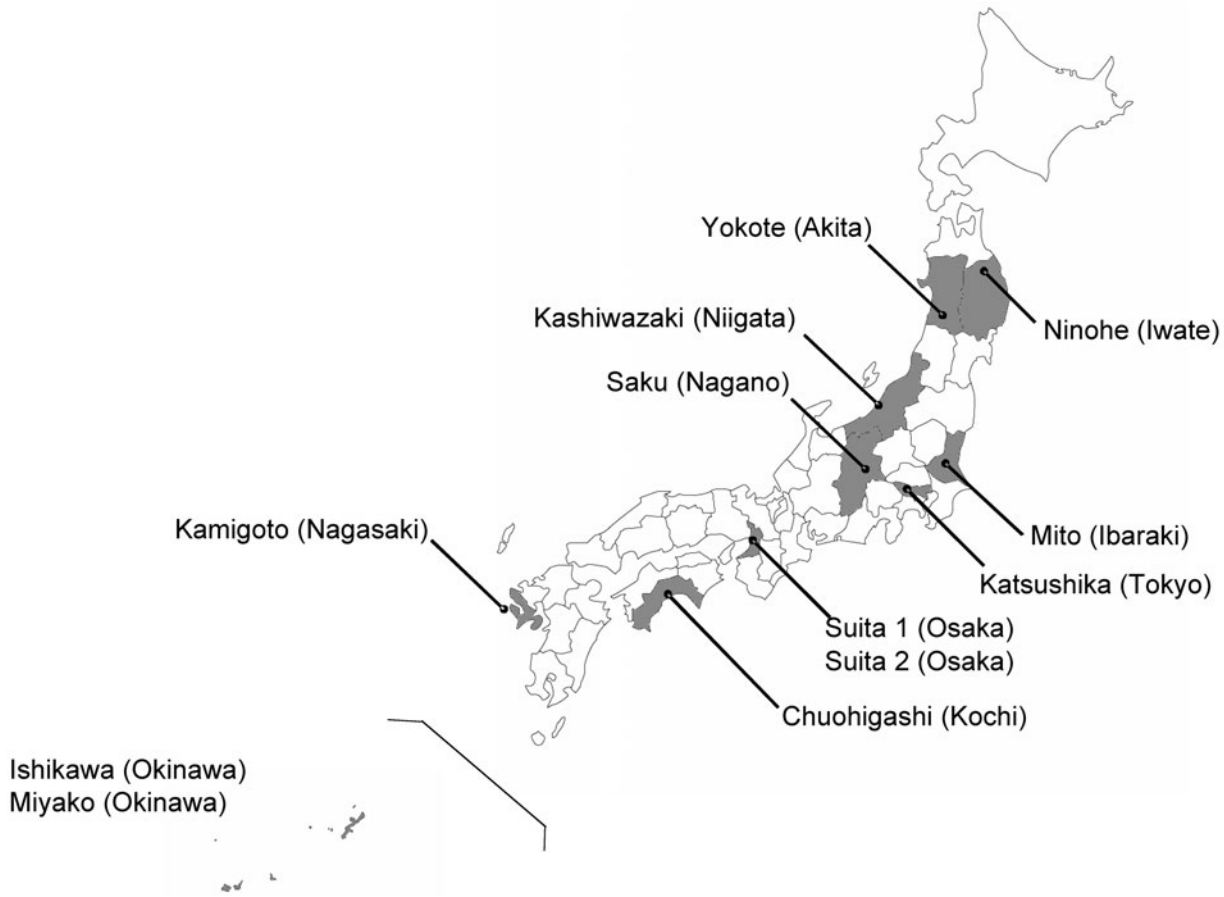

Figure 1 Study sites of the Japan Public Health Center-based prospective study on cancer and cardiovascular disease

characteristics by sex. The odds ratios (OR) with 95% CI were computed using a logistic regression model for the association between dietary supplement use and those factors. *P*-values for linear trends from the lowest to the highest levels of each variable were calculated using logistic regression.

Individual intakes of energy and nutrients were transformed using the natural log scale to normalize skewed distribution. Energy intake was adjusted for area, age group, occupation, smoking, alcohol consumption, physical activity, dietary behaviour, working hours, and stress level using LSMEANS of PROC GLM in SAS. Nutrient intakes were adjusted for the same variables and for energy intake using the same procedure. The geometric means of energy and nutrient intakes by sex were calculated for users and non-users of dietary supplements by the back-transformation of least-square means. The percentage difference was also calculated by dividing the difference in mean intakes between user and non-user by the mean intake of users.

Results

The percentage of dietary supplement users and OR in relation to the reference group by demographics, lifestyles, and health characteristics was shown in Table 1. Among the 12 areas of the JPHC Study, the prevalence was high in urban areas (Katsushika and Suita) and in mainland Okinawa (Ishikawa). Among the 5-year age groups, the prevalence of dietary supplements was lowest in the youngest group, 45–49 years. There was a significant linear increase in dietary supplement users among the higher age groups.

Among the six occupation groups, the self-employed were most likely, and the farming, forestry, and fishing group members were least likely to be supplement users after the adjustment. As for smoking, prevalence of users was significantly lower for current smokers in men, whereas it was significantly higher for former smokers in women. A difference in prevalence by the frequency of alcohol consumption was observed only in women. Women who drank moderately (once a month to 6 times a week) were most likely to be users. For BMI, there was a significant linear decrease of dietary supplement users for higher BMI groups in both sexes. Regarding exercise, there was a significant linear increase in those groups who exercise more frequently.

In the initial analysis of 14 dietary behaviours and the use of dietary supplements, no association was observed with the frequency of eating breakfast, consumption of fried foods, deep-fried foods, and fat on meat, of eating soup from noodle bowls, adding salt or soy sauce to foods at the table, types of vegetable oils used, frequently used cooking methods, well-doneness of cooked meat, and eating charred parts of fish (data not shown). Therefore, we included in the logistic model the only three variables as dietary habits associated with supplement use (frequency of eating miso soup, consumption of prepared foods

Table 1 Percentage of people in the 5-year follow-up survey in Japan Public Health Center-based prospective study on cancer and cardiovascular disease with indicated demographics, lifestyles, and health characteristics of subjects who used dietary supplements

	Male						Female					
	n	User (%)	Odds ratio[a]	95% CI		*P*-value[b]	n	User (%)	Odds ratio[a]	95% CI		*P*-value[b]
Area						–						–
Ninohe	3683	5.6	0.59	0.50	0.70		4362	10.0	0.81	0.72	0.92	
Yokote	5063	10.4	1.09	0.96	1.23		6070	14.5	1.11	1.00	1.23	
Saku	4278	9.4	0.95	0.83	1.08		4390	12.6	0.92	0.82	1.04	
Ishikawa	2996	14.5	1.48	1.29	1.69		3134	24.2	2.12	1.89	2.37	
Katsushika	775	18.6	1.75	1.43	2.15		1178	24.9	1.71	1.46	1.99	
Mito	6792	10.8	1.00[c]				6667	14.7	1.00[c]			
Kashiwazaki	1115	8.5	0.81	0.65	1.02		1105	11.0	0.76	0.62	0.94	
Chuo-higashi	2662	11.1	1.11	0.96	1.29		2921	17.2	1.30	1.15	1.47	
Kamigoto	2979	8.8	0.95	0.81	1.11		3349	13.3	1.03	0.91	1.16	
Miyako	3793	7.4	0.72	0.62	0.84		4215	13.4	1.03	0.92	1.16	
Suita 1	1737	21.9	2.07	1.78	2.41		1954	30.6	2.19	1.92	2.49	
Suita 2	1425	24.0	2.03	1.74	2.37		1888	34.3	2.43	2.15	2.76	
Age (years)						< 0.001						< 0.001
–49	9906	9.1	1.00[c]				10 539	15.0	1.00[c]			
50–54	7151	9.4	1.17	1.05	1.31		7707	15.6	1.24	1.13	1.35	
55–59	8569	13.4	1.52	1.38	1.67		9801	19.0	1.40	1.29	1.51	
60–64	7091	11.3	1.75	1.57	1.96		7807	15.4	1.49	1.36	1.63	
65–69	2667	12.6	2.00	1.71	2.35		3014	17.5	1.71	1.51	1.94	
70–	1914	12.6	2.05	1.71	2.47		2365	17.0	1.73	1.51	1.99	
Occupation												
Farming, forestry, and fishing	6837	6.7	0.66	0.59	0.75		4948	8.6	0.56	0.50	0.63	
Employee or professional	16 225	11.8	1.00[c]				9775	17.2	1.00[c]			
Housewife	–	–	–	–	–		10 594	18.9	0.97	0.89	1.06	
Self-employed	6397	13.0	1.16	1.06	1.27		3814	21.6	1.26	1.14	1.39	
Unemployed	2269	14.1	1.04	0.87	1.24		1695	14.6	0.76	0.65	0.89	
Other occupation	2144	10.4	0.94	0.81	1.10		2299	16.6	0.92	0.81	1.04	
Combination[d]	3426	10.4	1.06	0.94	1.20		8108	14.9	0.88	0.80	0.96	
Smoking						–						–
Current	17 443	9.9	0.87	0.80	0.94		2347	19.4	1.00	0.89	1.12	
Former	6809	13.1	1.06	0.96	1.16		470	28.1	1.40	1.13	1.73	
Never	13 046	11.4	1.00[c]				38 416	16.1	1.00[c]			
Alcohol consumption						0.29						< 0.001
None	8518	10.8	1.00[c]				32 398	15.2	1.00[c]			
1/month–2/week	6299	11.4	1.07	0.96	1.20		5026	20.4	1.26	1.16	1.36	
3–6 times/week	7537	11.8	1.05	0.95	1.16		2350	22.0	1.21	1.08	1.35	
Daily	14 944	10.5	0.97	0.88	1.06		1459	21.3	1.12	0.98	1.28	
Body mass index (kg/m^2)						< 0.001						< 0.001
<19	1557	12.1	1.12	0.94	1.33		2512	19.8	1.15	1.03	1.29	
19–<21	5183	11.5	1.06	0.95	1.18		6585	19.5	1.14	1.05	1.24	
21–<23	9145	11.1	1.00[c]				10 923	16.9	1.00[c]			
23–<25	10 785	11.3	1.01	0.92	1.10		9982	16.1	0.96	0.89	1.04	
25–<27	6417	10.7	0.91	0.82	1.01		6187	14.0	0.83	0.76	0.91	
27–<30	3426	9.4	0.80	0.70	0.92		3800	13.3	0.78	0.70	0.87	
⩾30	785	8.8	0.75	0.58	0.97		1244	13.7	0.75	0.63	0.89	
Exercise						< 0.001						< 0.001
Never	21 709	9.5	1.00[c]				27 798	14.8	1.00[c]			
1/month–2/week	11713	12.3	1.19	1.11	1.29		9024	19.2	1.22	1.14	1.30	
3 times/week–daily	3876	15.3	1.50	1.35	1.66		4411	21.3	1.38	1.27	1.50	
Miso soup						0.58						0.32
⩽2/week	4330	14.0	1.02	0.92	1.14		5508	21.4	1.03	0.95	1.12	
3–6 times/week	9366	12.4	1.03	0.95	1.11		11 426	18.6	1.04	0.98	1.11	
Daily	23 602	9.9	1.00[c]				24 299	14.3	1.00[c]			
Prepared food						< 0.05						< 0.001
Never	10 418	12.0	1.00[c]				17 118	17.0	1.00[c]			
1/month–2/week	24 453	10.6	0.91	0.85	0.98		23 172	16.1	0.91	0.86	0.96	
3 times/week–daily	2427	10.5	0.91	0.78	1.05		943	15.7	0.83	0.69	1.00	
Eating out						< 0.001						< 0.001
Never	11 795	8.1	1.00[c]				16 800	12.3	1.00[c]			
1–3 times/month	12 816	10.9	1.29	1.18	1.41		17 771	18.0	1.42	1.33	1.51	
1–2 times/week	4690	12.6	1.42	1.26	1.59		3960	23.4	1.69	1.54	1.86	
3 times/week–daily	7997	14.6	1.57	1.41	1.74		2702	21.9	1.61	1.44	1.80	

Table 1 continued

	Male						Female					
	n	User (%)	Odds ratio[a]	95% CI		*P*-value[b]	n	User (%)	Odds ratio[a]	95% CI		*P*-value[b]
Working hours						< 0.005						0.60
<5 hours	5099	12.3	1.00[c]				13 724	17.5	1.00[c]			
5–9 hours	24 124	10.3	0.97	0.85	1.11		22 668	15.5	0.93	0.87	0.99	
⩾9 hours	8075	12.3	1.13	0.98	1.31		4841	17.8	1.08	0.98	1.19	
Stress level						< 0.001						< 0.001
Low	6891	10.4	1.00[c]				7690	15.3	1.00[c]			
Medium	22 886	10.3	1.06	0.97	1.16		25 941	15.5	1.08	1.00	1.16	
High	7521	13.7	1.42	1.27	1.58		7602	20.6	1.47	1.35	1.61	
Total	37 298	11.0					41 233	16.4				

[a] Variables were mutually adjusted.

[b] *P*-values for linear trend from the lowest to the highest group using logistic regression.

[c] Ref.

[d] Subjects with multiple occupations.

such as freeze-dried noodles and retort-pouched foods, and eating out). For miso soup, although the prevalence of dietary supplement users was highest in the subjects who consumed the least, the difference was not significant after the adjustment for other variables. For prepared foods, the prevalence of users was highest in subjects who never used them. The prevalence of users was highest in the groups with the highest frequency of eating out. There was also a significant linear increase of users in the groups of subjects who eat out more frequently.

Working hours were not associated with dietary supplement use after adjustment for other variables. For stress level, the groups reporting high stress were most likely to be users.

The geometric means of energy and nutrient intakes from diet for users and non-users of any dietary supplement and their percentage difference by sex are shown in Table 2. The mean intake was significantly lower for users as was intake of energy and most nutrients except for sodium and niacin for both sexes, carbohydrate for men, and polyunsaturated fatty acids (PUFA) and selenium for women.

Discussion

In this study, the prevalence of dietary supplement use and its association with demographics, lifestyles, and health characteristics were investigated. The demographics, lifestyle factors, and health characteristics associated with dietary supplement use were sex, age, area of residence, occupation, smoking, BMI, physical activity level, frequency of using prepared foods or eating out, and self-reported stress level. Frequency of alcohol intake was associated only in women. Dietary intake tended to be lower for users of dietary supplements.

A high prevalence of dietary supplement users was observed in metropolitan regions (Suita and Katsushika) and in areas strongly influenced by Western lifestyles (Ishikawa) with ready access to dietary supplements. Associations between supplement use and other demographic factors (sex, age, and occupation) were consistent with results in other studies.[2,4,18–23] In terms of occupation, the lower prevalence in the farming, forestry, and fishing group might reflect their conservative health habits. It might be also a case of one's occupation serving as a surrogate for one's socioeconomic status (SES). A number of studies have indicated a strong association between supplement use and higher income level,[2,4,5,7,20,23] social class,[19] and education.[4,5,20,23,24] Educational background, another factor for SES available only for Cohort I, was also associated with the supplement use.

As for lifestyle and health characteristics, supplement use was associated with healthy lifestyle, which was similar to the earlier-reported tendency for smoking,[4,22,24] BMI, and physical activity.[2,4,7,24,25] Dietary supplement use did not associate with alcohol consumption in men, and was higher in women who drink moderately. Prior studies had reported alcohol consumption in dietary supplement users as either having no association[24] or as showing more users among moderate drinkers.[4,22,26] Supplement users have been characterized as having a positive attitude towards their health. In our study, however, users also showed negative lifestyle factors such as frequent eating out and stressful life. It was assumed that these associations, including moderate drinking among female supplement users, were influenced by urban lifestyle. Such people might be aware of their unhealthy behaviour, and therefore intentionally seek to compensate for it with dietary supplements.

Our results indicated that dietary supplement use could confound the association between dietary intake and disease even after every possible related factor was adjusted. Several earlier studies had found that supplement users consume a more nutrient-dense diet, i.e. low in energy and high in micronutrients.[7,22] In the present study, intakes of both energy and most nutrients were significantly lower for users than non-users of dietary supplements after various factors were adjusted. The results did not change when adjustment was made only for biological factors (age and BMI). The contradiction in the results was assumed to be caused by the complex characteristics of supplement users. Although the SES is usually associated positively with the quality of the diet, some factors such as eating out, which is influenced greatly by SES, can make the association negative.[27] The subgroup analysis in our study indicated that high dietary intake with a higher frequency of eating out made intake of users higher, while low intake with intensive labour such as in farming, forestry, and fishing made intake of users relatively lower.

Table 2 Nutrient intake by supplement users and non-users in the 5-year follow-up survey in Japan Public Health Center Study Cohort II

	Male				**Female**			
	Users	Non-users			Users	Non-users		
	Mean[c]	Mean[c]	% difference[a]	*P*-value[b]	Mean[c]	Mean[c]	% difference[a]	*P*-value[b]
n	4103	33 195			6776	34 457		
Energy (kcal/day)	1972	2019	–2.4	< 0.01	1774	1829	–3.1	< 0.01
Protein (g/day)	69.8	71.0	–1.8	< 0.01	63.3	64.0	–1.1	< 0.01
Total fat (g/day)	52.0	53.6	–2.9	< 0.01	50.2	51.0	–1.6	< 0.01
Total fatty acid (g/day)	46.4	47.8	–3.0	< 0.01	44.8	45.6	–1.7	< 0.01
SFA[d] (g/day)	15.2	15.9	–4.6	< 0.01	14.7	15.3	–3.9	< 0.05
MUFA[e] (g/day)	19.4	19.9	–2.5	< 0.01	18.7	18.9	–0.9	< 0.05
PUFA[f] (g/day)	11.1	11.4	–2.0	< 0.01	10.8	10.8	–0.5	0.12
n-3 PUFA[f] (g/day)	2.7	2.7	–2.2	< 0.01	2.6	2.6	–0.7	0.12
n-6 PUFA[f] (g/day)	8.4	8.5	–2.0	< 0.01	8.1	8.1	–0.5	0.12
Carbohydrate (g/day)	266.8	266.5	0.1	0.70	228.8	227.5	0.5	< 0.01
Calcium (mg/day)	446	481	–7.8	< 0.01	443	479	–8.3	< 0.01
Phosphorus (mg/day)	1090	1120	–2.7	< 0.01	1000	1028	–2.8	< 0.01
Iron (mg/day)	8.6	8.9	–2.7	< 0.01	8.3	8.4	–1.6	< 0.01
Sodium (mg/day)	3991	4028	–0.9	0.07	3815	3812	0.1	0.83
Potassium (mg/day)	2488	2602	–4.5	< 0.01	2425	2523	–4.0	< 0.01
Retinol (μg/day)	350	362	–3.6	< 0.05	290	309	–6.5	< 0.01
Carotene (μg/day)	1759	1918	–9.0	< 0.01	2023	2148	–6.2	< 0.01
α-carotene (μg/day)	211	235	–11.4	< 0.01	242	261	–7.8	< 0.01
β-carotene (μg/day)	1326	1435	–8.2	< 0.01	1561	1655	–6.0	< 0.01
Lycopene (μg/day)	1173	1417	–20.7	< 0.01	853	1079	–26.5	< 0.01
Vitamin B_1 (mg/day)	1.03	1.05	–2.3	< 0.01	0.95	0.97	–1.8	< 0.01
Vitamin B_2 (mg/day)	1.36	1.44	–5.4	< 0.01	1.32	1.39	–5.5	< 0.01
Niacin (mg/day)	16.7	16.8	–0.8	0.05	15.2	15.2	–0.2	0.60
Vitamin C (mg/day)	101	107	–6.8	< 0.01	107	113	–5.2	< 0.01
Cholesterol (mg/day)	260	268	–3.4	< 0.01	235	239	–1.9	< 0.01
Vitamin B_6 (mg/day)	1.55	1.57	–1.3	< 0.01	1.38	1.40	–1.7	< 0.01
Vitamin B_{12} (μg/day)	8.2	8.4	–2.6	< 0.01	7.4	7.5	–1.5	< 0.05
Folate (μg/day)	251	260	–3.4	< 0.01	243	249	–2.6	< 0.01
Selenium (μg/day)	104	106	–1.6	< 0.01	95	96	–0.7	0.07
Total dietary fibre (g/day)	10.5	11.0	–5.0	< 0.01	10.4	10.9	–4.3	< 0.01
Water-soluble fibre (g/day)	1.5	1.6	–7.8	< 0.01	1.6	1.7	–6.4	< 0.01
Water-insoluble fibre (g/day)	7.0	7.3	–4.2	< 0.01	7.1	7.4	–3.7	< 0.01
Daidzein (mg/day)	8.4	8.9	–5.6	< 0.01	8.0	8.5	–6.4	< 0.01
Genistein (mg/day)	13.8	14.6	–6.0	< 0.01	13.2	14.1	–6.7	< 0.01

[a] % difference was calculated by dividing mean nutrient intake of users minus non-users by mean nutrient intake of users.

[b] *P*-value for difference of geometric mean nutrient intakes between users and non-users.

[c] Geometric mean intake from foods. Energy intake was adjusted for area of residence, age, occupation, smoking, frequency of alcohol consumption, body mass index, physical activity, frequency of miso soup and prepared foods, eating-out, work hours, and stress level. Other nutrients were also adjusted for energy intake in addition to those variables.

[d] Saturated fatty acid.

[e] Monounsaturated fatty acid.

[f] Polyunsaturated fatty acid.

To our knowledge, the present study is the first investigation into the supplement use and its associations with demographics, lifestyles, and health characteristics in a large population in Japan. Only a few smaller studies have so far reported the characteristics of dietary supplement users in Japan.[16,28] The strengths of our study were its population-based large sample, and various and extensive data on potential confounding factors such as demographics, lifestyles, and health characteristics of individuals, as well as dietary supplement use. Those factors can be adjusted later on when the association between supplement use and mortality or disease is investigated. Furthermore, if such association is found, supplement use itself may need to be adjusted when investigating the association between those factors and disease.

One of the limitations of our study was its lack of sensitive SES data, such as income or education level of the participants. Socioeconomic status is strongly associated with supplement use as a result of difference in perception of health and economic status. The positive association with frequency of eating out might be the influence of higher SES level in users, whereas the negative association with prepared food, which tended to be consumed by those who eat at home, might be the influence of low SES.

Generalization of the results could be limited because of the non-respondents to the questionnaire, as well as the representativeness of the study sample. A difference in mortality was observed between the respondents and non-respondents to our baseline questionnaire.[29] For the rural areas where the response rate was 77–90%, the results were probably good estimates for those populations. For the urban areas, however, where the response rate was as low as 40%, supplement use might have been lower in the non-respondents since both the respondents and supplement users tended to have a healthier lifestyle. Furthermore, the overall prevalence might not represent general population in Japan because no statistical weighting

was made for population estimates. However, the characteristics of supplement users were presumably generalizable because the results of subgroup analysis were similar among all areas.

In the present study, we only focused on dichotomous information on dietary supplement use (i.e. user versus non-user) since we aimed to characterize the behaviour of individuals who use dietary supplements. Although we did not examine the amounts consumed or length of dietary supplement use, they may well be of great importance because the association with a disease might depend on them. Further investigation should be done using available data on brand names, frequency, and duration of usage in our study. The development of a database for supplement composition is necessary since it is not currently available.

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KEY MESSAGES

- Dietary supplement users had a healthier and more urban lifestyle than non-users in the Japan Public Health Center-based prospective study on cancer and cardiovascular disease (JPHC Study).
- Dietary supplement use was associated with sex, age, area of residence, smoking, body mass index, physical activity level, frequency of eating prepared food and eating-out, self-reported stress level, and dietary intake. Frequency of alcohol consumption was associated only in women.
- The demographics, lifestyles, health characteristics, and dietary intakes might be adjusted when evaluating the effect of dietary supplements on disease since they can become potential confounding factors. The use of supplements may also become a confounding factor when investigating the association between disease and demographics, lifestyles, health characteristics, or dietary intakes.

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Commentary: Vitamin supplement use and confounding by lifestyle

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The role of micronutrients in the development of chronic disease remains unclear. A number of observational studies have suggested a protective effect of various nutrients—e.g. folic acid and vitamin E with coronary heart disease, antioxidant vitamins, and cancer. However, recent reviews of the literature have described inconsistencies among studies and conflict between the results of observational research and clinical trials.[1,2] One explanation for these discrepant findings is that results from observational studies of micronutrient intake and disease may be confounded by variables associated with a 'healthy lifestyle'.[3–6] As one review of supplement use and cancer put it, '[s]upplement use may be a behavioral marker for other factors related to cancer risk … Control in analyses for

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