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Author(s)	Takabayashi, Saeka; Hirata, Takumi; Zhao, Wenjing; Kimura, Takashi; Ukawa, Shigekazu; Tsushita, Kazuyo; Wakai, Kenji; Kawamura, Takashi; Ando, Masahiko; Tamakoshi, Akiko
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Association of dietary diversity with all-cause mortality by body mass index in Japanese older adults: An age-specific prospective cohort study (NISSIN Project)

Saeka Takabayashi¹, Takumi Hirata^{2,3}, Wenjing Zhao^{2,4}, Takashi Kimura², Shigekazu Ukawa⁵, Kazuyo Tsushita⁶, Kenji Wakai⁷, Takashi Kawamura⁸, Masahiko Ando⁹, Akiko Tamakoshi^{1,2}

¹ Department of Public Health, Graduate School of Medicine, Hokkaido University, North 15 West 7, Kita-ku, Sapporo 060-8638, Japan,

² Department of Public Health, Hokkaido University Faculty of Medicine, North 15 West 7, Kita-ku, Sapporo 060-8638, Japan

³ Institute for Clinical and Translational Science, Nara Medical University, 840 Shijo-cho, Kashihara 634-8522, Japan

⁴ School of Public Health and Emergency Management, Southern University of Science and Technology, 1088 Xueyuan Avenue, Shenzhen 518055, P.R. China

⁵ Department of Social Services and Clinical Psychology, Graduate School of Human Life Science, Osaka City University, Sugimoto 3-3-138, Sumiyoshi-ku, Osaka 558-8585, Japan ⁶ Comprehensive Health Science Center, Aichi Health Promotion Public Interest Foundation
⁷ Department of Preventive Medicine, Nagoya University, Graduate School of Medicine,
Nagoya, Japan

⁸ Kyoto University Health Service, Yoshida Hon-machi, Sakyo-ku, Kyoto, Japan

⁹ Center for Advanced Medicine and Clinical Research, Nagoya University Hospital, Nagoya, Japan

Short title: Effect of dietary diversity on mortality

Corresponding author: Akiko Tamakoshi, Department of Public Health, Hokkaido University Graduate School of Medicine, North 15 West 7 Kita-ku, Sapporo, 060-8638, Japan

Tel: +81-11-706-5068

Fax: +81-11-706-7805

E-mail: tamaa@med.hokudai.ac.jp

Authorship: Saeka Takabayashi and Akiko Tamakoshi were in charge of the study design. Saeka Takabayashi analysed the data and wrote the manuscript. Akiko Tamakoshi, Kenji Wakai, Takashi Kawamura, and Masahiko Ando implemented the survey. Akiko Tamakoshi, Takumi Hirata, Wenjing Zhao, Takashi Kimura, Shigekazu Ukawa, Kazuyo Tsushita, Kenji

Wakai, Takashi Kawamura, and Masahiko Ando critically reviewed the manuscript.

1 ABSTRACT

2	Aim: Dietary diversity may reduce the risk of malnutrition, although it is also linked to
3	obesity. We examined whether dietary diversity is associated with all-cause mortality in
4	Japanese older adults based on their body mass index (BMI).
5	Methods: The current study included 2,944 people aged 64–65 years who participated in the
6	NISSIN project from 1996 to 2005. Dietary diversity was measured using the Food Variety
7	Score (FVS), which calculates the frequency of all food items consumed daily using a self-
8	administered food frequency questionnaire. Participants were divided into tertiles according
9	to their FVS (first: low, second: middle, third: high). Multivariate adjusted hazard ratios
10	(HRs) with 95% confidence intervals (CIs) were calculated using the Cox proportional
11	hazard regression model. For the stratified analysis, BMI was used to divide the participants
12	into three groups—lean (BMI <20), normal (BMI 20-24.9), and overweight/obese (BMI
13	≥25).
14	Results: Overall, 454 (30.7%) men and 222 (15.2%) women died over a median follow-up
15	period of 16.6 years. No significant association was observed between FVS and all-cause
16	mortality. However, when grouped by BMI, for the participants in the lean group, the
17	multivariate adjusted HRs were 0.56 (CI: 0.32–0.96) for the middle FVS and 0.50 (CI: 0.25–
18	1.02) for the high FVS, compared with the low FVS (p for trend=0.059). In overweight/obese
19	women, although not significant, total mortality was higher in the middle and high FVS.

- **Conclusions**: These findings indicate that dietary diversity should be promoted in lean older
- 21 Japanese adults.
- 23 Keywords: dietary diversity, mortality, body mass index, Food Variety Score, older adults

25 INTRODUCTION

Dietary diversity is a proxy measurement of nutrient adequacy¹ and is linked to a 26 decrease in all-cause mortality.²³⁴ Older adults have a higher risk of malnutrition⁵ because of 27 appetite loss,⁶ reduced chewing ability,⁷ or their socioeconomic conditions.⁸ Dietary diversity 28 may reduce the risks of malnutrition and loss of weight through both adequate nutrient intake 29 and an increase in total energy intake (TEI).⁹ However, that is also linked to obesity due to an 30 excessive TEI.^{10,11} Both high and low body mass index (BMI) are important predictors of all-31 cause mortality.¹² Thus, the association of dietary diversity with all-cause mortality may be 32 influenced by BMI, but no studies have examined the effect of BMI on the association of 33 dietary diversity with all-cause mortality. 34 35 This study examined the association of dietary diversity with all-cause mortality and 36 the effect of BMI in older adults. Dietary diversity was evaluated by the number of different types of food consumed, which increased the TEI.⁹ 37 38 **METHODS** 39 Study design and population 40 41 The study population was sampled from the New Integrated Suburban Seniority Investigation (NISSIN) Project, a prospective age-specific cohort study, from 1996 to 2005. 42 Details of this cohort have been reported elsewhere.¹³Briefly, residents of Nisshin city, Aichi 43

44	prefecture who were 65 years old when they participated in the survey from 1996 to 2005
45	were invited to participate in the free health examinations conducted annually by the local
46	government. The baseline survey consisted of a medical checkup, including somatometry and
47	blood tests, and a self-administered questionnaire, which included a food frequency
48	questionnaire (FFQ).
49	This cohort enrolled 3,073 participants who provided informed consent. The overall
50	response rate was 43.9%. The exclusion criteria were as follows: relocation from the city
51	prior to the start of the follow-up period ($n = 2$), not completing the entire FFQ ($n = 112$),
52	presence of extreme TEI estimated by the FFQ (<500 kcal or >5000 kcal daily, n= 10), ¹⁴ and
53	missing values for >40 of 90 items in the FFQ ($n = 5$). After applying the exclusion criteria,
54	2,944 (1,481 men and 1,463 women) were eligible for this study.
55	This study was approved by the Ethics Committees of Hokkaido University
56	Graduate School of Medicine (Medicine 14-037), the Ethics Committees of the National
57	Center for Geriatrics and Gerontology in Japan, the Ethics Committee of Nagoya University
58	Graduate School of Medicine, and the Ethics Committees of Aichi Medical University
59	School of Medicine. Informed consent was adopted in the form of an opt-out from 1996 to
60	2001 (and there were many such refusals) and written informed consent was required from
61	2002 to 2005.

63 Dietary assessment and dietary diversity

64 Dietary assessment was conducted using a validated self-administered FFQ, which contained 65 90-modern Japanese food items or dishes. Eight vitamins and other products were excluded because the frequency of intake was not asked and added rice with portion sizes.¹⁵ The 66 following food groups are included in the calculation of FSV; Rice, Bread, Noodles, Other 67 68 cereals, Potatoes, Sugar, Confectionery, Oils and fats, Nuts, Beans, Seafood, Meat, Eggs, 69 Dairy product, Fruits, Mushrooms, Algae, Seasoning, Green/Yellow vegetables, Other vegetables. The participants were asked to report the average frequency of consumption over 70 71 the past year. 72 There were nine options for questions about the frequency of food items or dishes: 73 less than once per month, once per month, 2–3 times per month, once per week, 2–4 times 74 per week, 5–6 times per week, once per day, 2–3 times per day, and more than 3 times per 75 day. To measure dietary diversity, we used the Food Variety Score (FVS), the most widely used measure of dietary diversity,¹⁶ which counts all the food items consumed in a day. To 76 calculate the FVS, the frequencies for once per month, 2–3 times per month, once per week, 77 2-4 times per week, and 5-6 times per week were converted to 1/30, 2.5/30, 1/7, 3/7, and 78 79 5.5/7 times. If the consumption frequency of the same food items or dishes was more than once per day, it was counted as 7/7 times. The TEI was calculated based on the FFQ in 80 81 accordance with the Japanese food composition table.¹⁵

82

Assessment of nutrient adequacy 83 To evaluate nutrient adequacy, the nutrient adequacy ratio (NAR), the ratio of a participant's 84 85 intake to the recommended dietary allowance (RDA) or tentative dietary goals (DG) according to the Dietary Reference Intakes for Japanese (2020),¹⁷ was calculated for each of 86 87 the 10 nutrients. Cholesterol was used as the recommended value, which is less than 200 mg/day is desirable for the purpose of preventing severe cases of dyslipidemia¹⁷ 88 89 was calculated as follows: $NAR = \frac{Actual nutrient intake of a nutrient (per day)}{RDA, DG or recommended value of a given nutrient}$ 90 91 Moreover, except for already energy adjusted saturated fat, we energy-adjusted NAR using estimated energy requirement (EER) and TEI (NAR \times EER (kcal/d) / TEI (kcal/d).¹⁸ 92 The physical activity to identify EER is assumed low.¹⁹ For eight nutrients (proteins, dietary 93 94 fiber, vitamin C, potassium, calcium, magnesium, iron, and zinc) in which a deficient supply 95 could pose health risks the NARs above 1 were set to 1 (Range: 0 to 1). This was because a nutrient with a high NAR could not compensate for a nutrient with a low NAR²⁰ when 96 calculating the mean adequacy ratio (MAR). Similarly, for two nutrients (saturated fat and 97

The NAR

98 cholesterol) in which excess supply could be a health risk, NARs below 1 were set to 1

99 (Range: ≥ 1). 100 The MAR was calculated as an overall measure of nutrient adequacy.¹⁶ The eight

101 nutrients were used and the MAR was calculated as follows (Range: 0 to 1).:

102
$$MAR = \frac{\sum NAR}{Number of nutrients(=8)}$$

103 The mean excess ratio (MER) was used as an indicator of nutrient restriction. ²¹

104 The two nutrients were used, and the MER was calculated as follows (Range: ≥ 0):

105
$$MER = \frac{\sum NAR}{Number of nutrients (= 2)} - 1$$

106

107 **Body mass index (BMI)**

108 Weight and height were measured during the medical checkup to calculate body mass index

109 (BMI, kg/m²). Using BMI, participants were divided into three groups: lean (BMI <20),

110 normal (BMI 20–24.9), and overweight/obese (BMI \geq 25), which is applied when

112

113 Covariates

114 A self-administered questionnaire was used to evaluate sociodemographic and lifestyle

115 factors. The medical status included hypertension, hyperlipidaemia, and diabetes mellitus;

- 116 Hypertension was identified as a systolic or diastolic blood pressure higher than 140 or 90
- 117 mmHg, respectively, or self-reported hypertension. Hyperlipidaemia was defined as total
- 118 cholesterol ≥220 mg/dL, LDL cholesterol (total cholesterol HDL cholesterol -

119	triglyceride/5) \geq 140 mg/dL, triglyceride \geq 150 mg/dL, HDL cholesterol <40 mg/dl, and/or
120	self-reported hyperlipidaemia. Diabetes mellitus was identified as haemoglobin A1c (HbA1c)
121	\geq 6.5%, fasting plasma glucose \geq 126 mg/dL, or self-reported diabetes mellitus.
122	Self-reported history of disease included clinically diagnosed heart disease (yes or no),
123	cerebrovascular disease (yes or no), and cancer (yes or no).
124	
125	Outcome follow-up
126	Each participant underwent an annual follow-up until death, transfer out of the city, or until
127	the end of the follow-up period (31 December 2019). The date of death and transfer out of the
128	city was confirmed using the resident registry. The transfer out of the city was treated as a
129	censored case.
130	
131	Statistical analysis
132	Participants were divided into tertiles according to their FVS (first: low, second: middle,
133	third: high): overall in sex-stratified tertiles, not in tertiles of men and women together. The
134	characteristics of each group were described. The differences in the characteristics among the
135	groups were examined using the Pearson's chi-square test (categorical variables), analysis of
136	variance (ANOVA) (continuous variables).

137	A multivariate Cox proportional hazards regression model was used to calculate hazard ratios
138	(HRs) and the corresponding 95% confidence intervals (CIs) of the risk of subsequent all-
139	cause mortality according to the FVS with participants in the low FVS being used as the
140	reference group. In the stratified analysis by BMI, participants were divided into three BMI
141	groups (lean, normal, overweight/obese). Two sensitivity analyses were performed: 1.
142	Excluding participants with a history of heart disease, cerebrovascular disease, and cancer, 2.
143	Excluding participants who died or moved within 3 years from baseline.
144	Analyses were carried out by the following models: adjusted for survey year and sex
145	(except for the stratified analysis by sex in Tables 2–3 and Supplemental Tables 2), (model
146	1); adjusted for living alone (yes, no, or unknown), education (lower than high school, high
147	school or above, or unknown), smoking status (never, former, current, or unknown), alcohol
148	consumption (never, current or unknown)), habitual exercise (seldom, <1 times/week, \geq 1
149	times/week or unknown).
150	In addition to model 1, model 2 was adjusted for history of heart disease (yes, no),
151	cerebrovascular disease (yes, no), cancer (yes, no) (except for the sensitivity analysis 1 in
152	Table 2 and Supplemental Table 2), medical status of hypertension (yes, no), hyperlipidaemia
153	(yes, no) and diabetes mellitus (yes, no). In addition to model 2, model 3 was adjusted for
154	BMI (lean, normal, overweight/obese) (except for Table 3, Supplemental Tables 2),
155	In addition to model 3, model 4 was adjusted for BMI category and TEI (continuous).

- 156 The *p* value for the trend across the mean values of the tertile of the FVS was calculated.
- 157 Statistical significance was set at p < 0.05. All statistical analyses were performed using JMP
- 158 Pro 16.0.0 for Mac (SAS Institute, Cary, NC, USA).
- 159
- 160 **RESULTS**
- 161 In total, 454 (30.7%) men and 222 (15.2%) women died over the median follow-up period of
 162 16.6 years and 17.6 years, respectively.
- Table 1 shows the baseline characteristics according to the tertile of their FVS. Compared to the participants in the low FVS, the participants in the high FVS were more likely to have a high school education or higher, exercise habitually and those were less likely to be living alone. The high FVS were fewer current smokers. In the analysis by BMI, the high FVS of all the BMI groups were more likely to have a high school education or higher (Supplemental Table 1).
- 169 FVS was positively associated with total nutrient adequacy, as indicated by MAR.
- 170 However, the FVS was also positively associated with MER which is an indicator of excess
- 171 nutrients. The results of the analysis by BMI were similar (Supplemental Table 1).
- 172 Table 2 shows the multivariate adjusted HRs and corresponding 95% CIs for the
- 173 association of FVS with all-cause mortality overall or by sex. No significant association of

the FVS with all-cause mortality was observed. This association did not change in the
sensitivity analyses 1–2.

176	The interaction between FVS and BMI was significant ($p < 0.001$). Table 3 shows the
177	multivariate adjusted HRs and the corresponding 95% CIs for the association of FVS with
178	all-cause mortality by BMI (lean, normal, overweight/ obese) or by sex and BMI. In the lean
179	group, although it contains non-significant results, the multivariate adjusted HRs were 0.56
180	(CI: 0.32–0.96) for the middle FVS and 0.50 (CI: 0.25–1.02) for the high FVS, compared
181	with the low FVS (p for trend=0.059). This association did not change in sensitivity analyses
182	1-2 (Supplemental Tables 2). No consistent association was found among BMI standards and
183	overweight/obesity.
184	In men, the interaction between FVS and BMI was not significant $(p \text{ for } p)$
185	interaction=0.182); however, in women, this interaction was significant (p for
186	interaction<0.001). In women lean/standard BMI, all-cause mortality was lower in the
187	medium/high FVS than in the low FVS, although this was not statistically significant.
188	Conversely, overweight/obese women had higher all-cause mortality in the medium/high
189	FVS than in the low FVS, although the association was not significant. This association did
190	not change in the sensitive analysis 1-2 (Supplemental Tables 2).
191	

DISCUSSION

193	This is the first study to examine the association between dietary diversity and all-cause
194	mortality among older adults, along with the effect of modification by BMI. No significant
195	association was observed between FVS and all-cause mortality. However, in the stratified
196	analysis by BMI, in the lean group, although it contains non-significant results, including
197	sensitivity analyses, all-cause mortality was consistently lower in the medium and high FVS
198	than in the low FVS. Moreover, in women, although the association was not significant,
199	overweight/obesity had consistently higher all-cause mortality in the medium/high FVS than
200	in the low FVS.
201	In the stratified analysis by BMI, all-cause mortality was lower in the medium/high
202	FVS compared to the low FVS in the lean group. One possible reason for this is that an
203	increase in the FVS raised the MAR, which indicated the overall nutrient adequacy and
204	reduced deficiencies of nutrients with antioxidant and anti-inflammatory functions, leading to
205	a reduction in all-cause mortality. ²³ Another reason might be the necessity to obtain and
206	prepare various foods to consume different types of foods. Individuals with a higher dietary
207	diversity have a lower decline in higher functional capacity ²⁴ . Furthermore, dietary diversity
208	is associated with greater lean mass and improved physical functions. ²⁵ The maintenance of
209	these functional capacities through a higher FVS may have had a protective effect on all-
210	cause mortality. These considerations suggest that it was more plausible to have more
211	significant results for women who are generally the primary cooks in the home. ²⁶ Among

212	women, in addition to the lean group, this may be one reason why all-cause mortality was
213	lower in the medium/high FVS compared to the low FVS, even in the BMI standard group.
214	In contrast, overweight/obese women had higher all-cause mortality in the
215	medium/high FVS than in the low FVS. In women, the association between dietary diversity
216	and all-cause mortality was shown to have a different effect with modification by BMI. One
217	reason for this may be that the nutritional characteristics of the FVS in this study were
218	positively associated with the MER, an indicator of the nutrients that should be restricted. A
219	recent review also points out current evidences didn't support higher dietary diversity as an
220	effective strategy to promote healthy eating patterns among middle-aged adults. ²⁷ Saturated
221	fat intake is associated with cardiovascular disease in a high-risk population for
222	cardiovascular disease. ²⁸ Obesity is a risk factors for cardiovascular disease, ²⁸ and thus, in the
223	overweight and obese group of women, saturated fat intake may have increased total
224	mortality through increased cardiovascular disease. Regarding dietary cholesterol, there is a
225	positive linear association between dietary cholesterol intake and all-cause mortality, ²⁹ with a
226	significantly higher association for women than for men. ²⁹ Thus, the effects of increased risk
227	factors for total mortality and increased MER in overweight and obese women may have
228	outweighed the preventive effects of dietary diversity seen in the lean group.
229	The strength of this study was its design, which was an age-specific cohort with a
230	long follow-up period. Dietary diversity changes begin around 65 years of age for the

231	Japanese population, ³⁰ and people at this turning point were recruited for this study.
232	Adjustments for a history of heart disease, cerebrovascular disease, cancer, hypertension,
233	hyperlipidaemia, and diabetes mellitus, which may affect dietary intake, improved the
234	validity of this study's findings. Moreover, the analysis excluded participants who died or
235	moved within 3 years from baseline, and this did not change the findings.
236	This study has several limitations. First, a response rate of 43.9% suggested a
237	possible selection bias. Generalizing our results to Japanese older adult populations requires
238	caution. Moreover, since the study may be conducted in a relatively health-conscious
239	population because of this response rate, the impact of dietary diversity may have been
240	overestimated. Second, residual confounding may have been likely, although we adjusted for
241	several covariates. Third, the relatively small sample size and small number of deaths did not
242	allow this study to analyse the relationship between the FVS and specific cause of death
243	although the FVS is known to reduce mortality in coronary heart disease. ² Future studies to
244	examine the relationship would be helpful. Fourth, using self-reported dietary and lifestyle
245	questionnaires and the FFQ may have resulted in some misclassification and residual
246	confounding. However, using a 4-day dietary record validated the FFQ for food groups. ¹⁵
247	In conclusion, these findings indicate that dietary diversity should be promoted in lean older
248	adults. BMI may influence the association between dietary diversity and all-cause mortality.
249	

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258 **Disclosure statement:** All authors declare that there are no conflicts of interest.

259

260 **Data Availability Statement:** Data cannot be shared for privacy or ethical reasons.

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- 380 Supplemental Table 1. Baseline characters of participants according to FVS by BMI group or
- 381 by sex and BMI group.
- 382 Supplemental Table 2. Multivariate-adjusted HRs and corresponding 95% CIs for the
- association of FVS with all-cause mortality by BMI group or by sex and BMI group
- 384 excluding participants with history of heart disease, cerebrovascular disease, and cancer or
- 385 excluding participants died or moved within 3 years from baseline.

			FVS						
	A	LL	1 st (low)		2 nd (middle)		3 rd (high)		P value
ALL									
Number of participants	2,944		981	33.3	983	33.4	980	33.3	
FVS (mean, SD)	20.9	7.6	13.5	3.4	20.4	2.9	29.0	5.6	< 0.001
Women (n, %)	1,463	49.7	487	49.6	489	49.8	487	49.7	1.0
Living alone (n, %)	117	4.0	54	5.5	36	3.7	27	2.8	0.028
Education \geq High School (n, %)	2,016	68.5	576	58.7	715	72.7	725	74.0	< 0.001
Current Smoking (n, %)	521	17.7	208	21.2	169	17.2	144	14.7	< 0.001
Current Drinking (n, %)	1,305	44.3	433	44.1	443	45.1	429	43.8	0.667
Habitual Exercise (≥ 1 times/week) (n, %)	1,486	50.5	440	44.9	504	51.3	542	55.3	< 0.001
Heart Disease (Yes) (n, %)	107	3.6	44	4.5	30	3.1	33	3.4	0.204
Cerebrovascular disease (Yes) (n, %)	129	4.4	37	3.8	45	4.6	47	4.8	0.506
Cancer (Yes) (n, %)	111	3.8	32	3.3	40	4.1	39	4.0	0.589
Hypertension (Yes) (n, %)	1,354	46.0	476	48.5	451	45.9	427	43.6	0.089
Hyperlipidemia (Yes) (n, %)	1,903	64.6	629	64.1	643	65.4	631	65.4	0.819
Diabetes mellitus (Yes) (n, %)	318	10.8	104	10.6	110	11.2	104	10.6	0.891
BMI <20 (kg/m ²) (n, %)	371	12.6	125	12.7	119	12.1	127	13.0	0.025
BMI ≥ 25 (kg/m ²) (n, %)	662	22.5	252	25.7	195	19.8	215	21.9	0.025
TEI (kcal/day) (mean, SD)	1,909	611	1,481	395	1,841	437	2,406	583	< 0.001
MAR (mean, SD)	0.87	0.10	0.81	0.11	0.88	0.08	0.92	0.06	< 0.001
MER (mean, SD)	0.29	0.31	0.21	0.31	0.30	0.31	0.36	0.28	< 0.001
Men									
Number of participants	1,481	100.0	494	33.4	494	33.4	493	33.3	
FVS (mean, SD)	17.6	6.7	10.6	2.5	17.1	1.6	25.1	4.6	< 0.001
Living alone (n, %)	26	1.8	15	3.0	6	1.2	5	1.0	0.099
Education \geq High School (n, %)	1,064	71.8	333	67.4	373	75.7	358	72.6	0.048
Current Smoking (n, %)	467	31.5	174	35.2	153	31.0	140	28.4	0.239
Current Drinking (n, %)	1,019	68.8	334	67.6	352	71.3	333	67.6	0.330
Habitual Exercise (≥ 1 times/week) (n, %)	757	51.1	228	46.2	256	51.8	273	55.4	0.072

Table 1. Baseline characters of participants according to the tertile of their FVS overall or by sex.

Heart Disease (Yes) (n, %)	72	4.9	26	5.3	20	4.1	26	5.3	0.589
Cerebrovascular disease (Yes) (n, %)	77	5.2	20	4.1	28	5.7	29	5.9	0.365
Cancer (Yes) (n, %)	49	3.3	7	1.4	19	3.9	23	4.7	0.012
Hypertension (Yes) (n, %)	762	51.5	275	55.7	249	50.4	238	48.3	0.057
Hyperlipidemia (Yes) (n, %)	859	58.0	288	58.3	289	58.5	282	57.2	0.906
Diabetes mellitus (Yes) (n, %)	155	10.5	45	9.1	53	10.7	57	11.5	0.453
BMI <20 (kg/m ²) (n, %)	144	9.7	54	10.9	45	9.1	45	9.1	0.115
BMI \ge 25 (kg/m ²) (n, %)	372	25.1	140	28.3	110	22.3	122	24.8	0.115
TEI (kcal/day) (mean, SD)	1,909	604	1,512	425	1,845	466	2,369	568	< 0.001
MAR (mean, SD)	0.84	0.10	0.77	0.11	0.86	0.08	0.90	0.06	< 0.001
MER (mean, SD)	0.34	0.35	0.24	0.36	0.36	0.36	0.42	0.31	< 0.001
Women									
Number of participants	1,463	100.0	487	33.3	489	33.4	487	33.6	
FVS (mean, SD)	23.3	7.6	15.4	3.1	22.7	1.9	31.9	5.0	< 0.001
Living alone (n, %)	91	6.2	39	8.0	30	6.1	22	4.5	0.209
Education \geq High School (n, %)	952	65.1	243	49.9	342	69.9	367	75.4	< 0.001
Current Smoking (n, %)	54	3.7	34	7.0	16	3.3	4	0.8	< 0.001
Current Drinking (n, %)	286	19.6	99	20.3	91	18.6	96	19.7	0.790
Habitual Exercise (≥ 1 times/week) (n, %)	729	49.8	212	43.5	248	50.7	269	55.2	< 0.001
Heart Disease (Yes) (n, %)	35	2.4	18	3.7	10	2.0	7	1.4	0.058
Cerebrovascular disease (Yes) (n, %)	52	3.6	17	3.5	17	3.5	18	3.7	0.979
Cancer (Yes) (n, %)	62	4.2	25	5.1	21	4.3	16	3.3	0.358
Hypertension (Yes) (n, %)	592	40.5	201	41.3	202	41.3	189	38.8	0.632
Hyperlipidemia (Yes) (n, %)	1,044	71.4	341	70.0	354	72.4	349	71.7	0.703
Diabetes mellitus (Yes) (n, %)	104	7.1	32	6.5	42	8.6	30	6.2	0.283
BMI <20 (kg/m ²) (n, %)	227	15.5	71	14.6	74	15.2	82	16.8	0.211
BMI \geq 25 (kg/m ²) (n, %)	290	19.8	112	23.0	85	17.4	93	19.1	0.211
TEI (kcal/day) (mean, SD)	1,910	16	1,451	360	1,837	406	2,441	597	< 0.001
MAR (mean, SD)	0.89	0.08	0.84	0.09	0.91	0.07	0.93	0.06	< 0.001
MER (mean, SD)	0.24	0.25	0.18	0.25	0.24	0.25	0.31	0.24	< 0.001

FVS: Food Variety Score, TEI: total energy intake, BMI: body mass index, MAR: mean adequacy ratio, MER: mean excess ratio

Differences in characters across FVS were examined by Pearson's chi-square test (categorical variables) or ANOVA (continuous variables).

			F	VS			
	1 st (lo	w)	2 nd (m	niddle)	3 rd	(high)	P for tren
All (n=2,944)							
FVS mean, SD	13.5	3.4	20.4	2.9	29.0	5.6	
Person-year	15,75	55	16,	100	1:	5,472	
Cases	245	5	20	08		223	
Model1 ¹	1.00)	0.84	(0.70-1.00)	0.95	(0.79-1.14)	0.618
Model2	1.00)	0.88	(0.73-1.06)	1.00	(0.84-1.21)	0.870
Model3 ¹	1.00)	0.87	(0.72-1.05)	1.02	(0.85-1.23)	0.759
Model4	1.00)	0.84	(0.69-1.02)	0.93	(0.74-1.18)	0.579
Excluding participants with	history of heart diseas	e, cerebrovascu	lar disease, and ca	ncer (n=2,615)			
FVS mean, SD	13.5	3.5	20.4	3.0	29.0	5.7	
Person-year	14,048		14,329		13,837		
Cases	215		1′	179		187	
Model1 ¹	1.00)	0.82	$(0.67 - 1.00)^*$	0.89	(0.73-1.08)	0.280
Model2	1.00)	0.87	(0.71-1.07)	0.96	(0.78-1.16)	0.613
Model3 ²	1.00)	0.87	(0.71-1.07)	0.97	(0.79-1.18)	0.706
Model4	1.00)	0.86	(0.69-1.06)	0.92	(0.71-1.19)	0.393
Excluding participants died	or moved within 3 yea	rs from baselin	e (n=2,825)				
FVS mean, SD	13.5	3.4	20.3	2.9	28.9	5.6	
Person-year	15,58	83	15,	15,921		5,633	
Cases	232	2	19	195		210	
Model1 ¹	1.00)	0.83	(0.68-1.00)	0.92	(0.76-1.10)	0.409
Model2	1.00)	0.87	(0.72-1.05)	0.97	(0.80-1.17)	0.794
Model3 ¹	1.00)	0.86	(0.71-1.04)	0.98	(0.81-1.19)	0.915
Model4	1.00)	0.84	(0.69-1.03)	0.93	(0.73-1.19)	0.581
Men							
All (n=1,481)							
FVS mean, SD	11.6	2.5	18.1	1.6	26.1	4.6	

Table 2. Multivariate-adjusted HKS and corresponding 95% CIS for the association of FVS with all-cause mortality overall or D

Person-year	7,666	5	7,8	392	7	,349	
Cases	158		13	37		159	
Model1 ²	1.00		0.84	(0.67-1.06)	1.07	(0.86-1.33)	0.494
Model2	1.00		0.89	(0.71-1.12)	1.12	(0.90-1.40)	0.268
Model3 ¹	1.00		0.88	(0.70-1.11)	1.14	(0.91-1.43)	0.205
Model4	1.00		0.85	(0.66-1.08)	1.03	(0.78-1.36)	0.797
Excluding participants with	history of heart disease	, cerebrovascu	lar disease, and ca	ncer (n=1,292)			
FVS mean, SD	11.4	2.6	17.9	1.6	25.9	4.5	
Person-year	6,626	5	6,8	378	6	,502	
Cases	138		12	20		130	
Model1 ²	1.00		0.85	(0.66-1.08)	0.97	(0.76-1.23)	0.847
Model2	1.00		0.90	(0.70-1.15)	1.02	(0.80-1.30)	0.823
Model3 ²	1.00		0.91	(0.71-1.17)	1.04	(0.82-1.33)	0.688
Model4	1.00		0.87	(0.67-1.13)	0.96	(0.71-1.30)	0.823
Excluding participants died	or moved within 3 year	rs from baselin	e (n=1,414)				
FVS mean, SD	11.6	2.5	18.0	1.6	25891	4.4	
Person-year	7,534	ŀ	7,7	70	7	,487	
Cases	150		12	29		149	
Model1 ²	1.00		0.84	(0.66-1.07)	1.02	(0.81-1.28)	0.811
Model2	1.00		0.89	(0.70-1.13)	1.06	(0.85-1.34)	0.540
Model3 ¹	1.00		0.88	(0.69-1.12)	1.08	(0.86-1.36)	0.439
Model4	1.00		0.86	(0.67-1.10)	1.04	(0.78-1.39)	0.737
Women							
All(n=1,463)							
FVS mean, SD	15.4	3.1	22.7	1.9	31.9	5.0	
Person -year	8,090)	8,2	208	8	,123	
Cases	87		7	1		64	
Model1 ²	1.00		0.81	(0.59-1.11)	0.73	(0.53-1.01)	0.059
Model2	1.00		0.86	(0.62-1.19)	0.78	(0.56-1.10)	0.157
Model3 ¹	1.00		0.85	(0.61 - 1.17)	0.81	(0.58 - 1.14)	0.223

Model4	1.00		0.82	(0.58-1.16)	0.74	(0.47-1.16)	0.186
Excluding participants with his	story of heart disease, o	cerebrovascul	ar disease, and ca	ncer (n=1,323)			
FVS mean, SD	15.4	3.1	22.9	1.9	32.0	5.0	
Person -year	7,421		7,4	51	7	,335	
Cases	77		5	9		57	
Model1 ²	1.00		0.77	(0.55-1.08)	0.75	(0.53-1.06)	0.109
Model2	1.00		0.80	(0.57-1.14)	0.79	(0.55-1.13)	0.215
Model3 ²	1.00		0.79	(0.55-1.12)	0.80	(0.56-1.14)	0.227
Model4	1.00		0.77	(0.53-1.12)	0.76	(0.47-1.22)	0.254
Excluding participants died or	moved within 3 years	from baseline	e (n=1,411)				
FVS mean, SD	15.37	3.02	22.64	1.85	31.87	5.10	
Person -year	8,050		8,1	.51	8	,146	
Cases	82		6	6		61	
Model1 ²	1.00		0.80	(0.57-1.10)	0.73	(0.52-1.02)	0.058
Model2	1.00		0.82	(0.59-1.15)	0.76	(0.54-1.07)	0.129
Model3 ¹	1.00		0.82	(0.58-1.14)	0.79	(0.56-1.12)	0.238
Model4	1.00		0.77	(0.54-1.10)	0.69	(0.44-1.10)	0.164

HR, hazard ratio; CI, confidence interval; FVS, food variety score; TEI, total energy intake; BMI, body mass index.

p*<0.05, *p*<0.01

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Analysed by Cox proportional hazard regression model

Model 1¹ (adjusted for sex, survey year)

Model 1² (adjusted for survey year)

Model 2 (model 1 plus adjusted for living alone, education, smoking, drinking, habitual exercise)

Model 3¹ (model 2 plus adjusted for history of heart disease, cerebrovascular disease, cancer, and medical status of hypertension, hyperlipidaemia, and diabetes mellitus)

Model 3² (model 2 plus adjusted for medical status of hypertension, hyperlipidaemia, and diabetes mellitus)

Model 4 (model 3 plus adjusted for BMI category, TEI)

p for trend is calculated across the mean values of FVS.

	FVS						
	1 st (low)		2 nd (middle)		3 rd (high)		P for trend
All (n=2,944)							
BMI <20 group (n=371)							
FVS mean, SD	14.1	3.6	20.9	3.3	30.2	6.0	
Person-year	1,927		2,033		1,858		
Cases	37			30		29	
Model1 ¹	1.00		0.60	$(0.37 - 0.99)^*$	0.64	(0.39-1.06)	0.105
Model2	1.00		0.65	(0.39-1.08)	0.67	(0.40-1.12)	0.157
Model3	1.	.00	0.62	(0.37-1.04)	0.67	(0.40-1.13)	0.164
Model4	1.00		0.56	$(0.32-0.96)^*$	0.50	(0.25-1.02)	0.059
BMI 20-24.9 group (n=1,911)							
FVS mean, SD	13.8	3.3	20.5	2.8	29.0	5.5	
Person-year	10,310		10,513			10,232	
Cases	164			117		142	
Model1 ¹	1.00		0.74	$(0.58-0.94)^*$	0.92	(0.74-1.16)	0.579
Model2	1.	.00	0.78	$(0.61-0.99)^*$	0.99	(0.79-1.25)	0.942
Model3	1.	.00	0.79	(0.62-1.00)	1.02	(0.81-1.28)	0.801
Model4	1.	.00	0.78	(0.61-1.00)	0.98	(0.73-1.30)	0.909
BMI \geq 25 group (n=662)							
FVS mean, SD	12.3	3.3	19.6	3.1	28.4	5.5	
Person-year	3,:	514		3,601		3,340	
Cases	2	47		53		57	
Model1 ¹	1.	.00	1.05	(0.71-1.56)	1.27	(0.86-1.87)	0.215
Model2	1.	.00	1.07	(0.72-1.59)	1.25	(0.84-1.86)	0.256
Model3	1.	.00	1.12	(0.75-1.68)	1.25	(0.84-1.88)	0.276
Model4	1.00		1.08	(0.70 - 1.66)	1.16	(0.69 - 1.95)	0.585

 Table 3. Multivariate-adjusted HRs and corresponding 95% CIs for the association of FVS with all-cause mortality by BMI group or by sex and BMI group.

 group.

Men (n=1,481)

BMI <20 group (n=144)

FVS mean, SD	10.99	2.48	17.52	1.87	26.49	5.88	
Person-year	691			740		626	
Cases	2	22		21		20	
Model1 ²	1.	1.00		(0.39-1.35)	0.76	(0.40-1.42)	0.426
Model2	1.	1.00		(0.46-1.69)	0.84	(0.43-1.64)	0.622
Model3	1.	1.00		(0.38-1.45)	0.85	(0.43-1.67)	0.716
Model4	1.00		0.63	(0.31-1.27)	0.53	(0.21-1.34)	0.188
BMI 20-24.9 group (n=965)							
FVS mean, SD	11.9	2.5	18.3	1.5	26.0	4.3	
Person-year	5,128			5,211		4,947	
Cases	103			78		102	
Model1 ²	1.00		0.80	(0.60-1.08)	1.10	(0.83-1.45)	0.351
Model2	1.00		0.84	(0.62-1.13)	1.17	(0.89-1.54)	0.185
Model3	1.00		0.86	(0.64-1.17)	1.20	(0.91-1.58)	0.144
Model4	1.00		0.86	(0.63-1.18)	1.19	(0.85-1.68)	0.238
BMI \geq 25 group (n=372)							
FVS mean, SD	11.09	2.64	17.61	1.92	26.12	4.74	
Person-year	1,8	346		1,942		1,775	
Cases	3	3		34		41	
Model1 ²	1.	00	0.89	(0.55-1.44)	1.22	(0.77-1.94)	0.325
Model2	1.	00	0.92	(0.56-1.49)	1.19	(0.74-1.91)	0.426
Model3	1.	00	0.96	(0.59-1.57)	1.16	(0.71-1.91)	0.526
Model4	1.	00	0.85	(0.50-1.43)	0.91	(0.49-1.69)	0.812
Women (n=1,463)							
BMI <20 group (n=227)							
FVS mean, SD	16.13	2.57	23.04	2.03	32.52	4.87	

Person-year	1,236			1,293		1,232	
Cases	15	5		9		9	
Model1 ²	1.00		0.39	(0.16-0.94)*	0.52	(0.21-1.28)	0.151
Model2	1.00		0.36	$(0.13-0.97)^*$	0.68	(0.27-1.68)	0.339
Model3	1.00		0.37	(0.13-1.04)	0.62	(0.23-1.65)	0.297
Model4	1.00		0.35	(0.12-1.06)	0.54	(0.14-2.06)	0.339
BMI 20-24.9 group (n=946)							
FVS mean, SD	15.7	3.0	22.7	1.7	31.9	5.1	
Person-year	5,1	82		5,302		5,285	
Cases	61	l		39		40	
Model1 ²	1.0	00	0.63	$(0.42-0.94)^*$	0.64	(0.43-0.96)*	0.031
Model2	1.0	00	0.67	(0.44-1.01)	0.69	(0.46-1.05)	0.088
Model3	1.0	00	0.67	(0.44-1.02)	0.72	(0.48-1.10)	0.136
Model4	1.0	00	0.62	$(0.40-0.96)^*$	0.58	(0.33-1.00)	0.049
BMI \geq 25 group (n=290)							
FVS mean, SD	13.8	3.4	22.3	2.3	31.4	5.0	
Person-year	1,6	68		1,659		1,565	
Cases	14	1		19		16	
Model1 ²	1.0	00	1.34	(0.67-2.69)	1.34	(0.65-2.78)	0.431
Model2	1.0	00	1.49	(0.72-3.10)	1.33	(0.61-2.90)	0.483
Model3	1.0	00	1.46	(0.69-3.10)	1.26	(0.56-2.81)	0.597
Model4	1.0	00	1.96	(0.85-4.51)	2.18	(0.75-6.30)	0.162

HR, hazard ratio; CI, confidence interval; FVS, food variety score; TEI, total energy intake; BMI, body mass index.

*P<0.05, **P<0.01

Analysed by Cox proportional hazard regression model

Model 1¹ (adjusted for sex, survey year)

Model 1² (adjusted for survey year)

Model 2 (model 1 plus adjusted for living alone, education, smoking, drinking, habitual exercise)

Model 3 (model 2 plus adjusted for history of heart disease, cerebrovascular disease, cancer, and medical status of hypertension, hyperlipidaemia, and diabetes mellitus)

Model 4 (model 3 plus adjusted for TEI)