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Dietary pattern changes in Fukushima residents after the Great East Japan Earthquake: the Fukushima Health Management Survey 2011–2013

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Abstract

Objective: Dietary patterns more closely resemble actual eating behaviours because multiple food groups, not a single food group or nutrient, are considered. The present study aimed to identify and assess changes of dietary patterns in Fukushima residents.

Design: Dietary data were collected using a short-form FFQ in annual Fukushima Health Management Survey between 2011 and 2013 after the Great East Japan Earthquake. Year- and sex-specific dietary patterns were determined by the principal component analysis.

Setting: Evacuation and nonevacuation zones in Fukushima, Japan.

Participants: Eligible participants aged ≥16 years answered the FFQ (*n* 67 358 in 2011, *n* 48 377 in 2012 and *n* 40 742 in 2013).

Results: Three identified dietary patterns were assessed similarly in men and women and among years: typical, juice and meat. In total participants, the Spearman's correlation coefficients between two survey years were 0·70–0·74 for the typical, 0·58–0·66 for the juice and 0·50–0·54 for the meat pattern scores. Adjusted for sociodemographic factors, evacuees had lower typical pattern scores, higher juice pattern scores and the same meat pattern scores compared with non-evacuees. The means of typical pattern scores in evacuees and it of juice pattern scores in non-evacuees continued declining over years. Similar profiles of dietary patterns and trends of pattern scores were observed in participants (*n* 22 805) who had provided three dietary assessments.

Conclusions: Changes of dietary patterns have been observed between 2011 and 2013. Careful investigation of those with low intake of typical pattern foods and promotion of them, particularly in evacuees, are needed.

Keywords
Dietary pattern
Food frequency questionnaire
Fukushima Health Management Survey
Evacuee
Principal component analysis

The Great East Japan Earthquake occurred on 11 March 2011, followed by a tsunami and a nuclear disaster, forcing the long-term evacuation of 185 000 residents from widespread surrounding areas. To monitor the long-term health of Fukushima residents, the prefectural government assigned the Fukushima Medical University to design and implement health management surveys for this population starting in May of 2011. Given that many evacuees who had moved to the government-designated evacuation zone could have changed their lifestyle, diet, exercise and other personal habits, their risk of developing lifestyle diseases, such as CVD, could have increased[1,2]. Having an understanding of residents' dietary stability after the disaster is important, particularly for Fukushima evacuees.

Changes in nutrient intake can be difficult to evaluate and might not be accurately reflected over time. Dietary

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patterns, however, more closely resemble actual eating behaviours for studying the synergistic effects of multiple food groups rather than single food groups or nutrients; thus, foods eaten in combination could be used to learn about changes in people's dietary habits[3]. Investigational methods of analysis of changes and/or the stability of dietary patterns identified by principal component analysis have been inconsistent in longitudinal studies[4]. The aim of this study was to determine whether dietary patterns changed between 2011 and 2013 in Fukushima residents after the 11 March disaster in terms of the Fukushima Health Management Survey (FHMS).

Methods

Study participants

The FHMS was initiated in 2011 after the great earthquake. The target population for the Mental Health and Lifestyle Survey, a part of FHMS, was 210 189 residents comprising those living along the radiation disclosure areas[5]. The evacuation zone was specified by the government according to spatial radiation dose rates, and residents in Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Futaba Town, Namie Town, Katsurao Village and Iitate Village, as well as those in some areas of Tamura City, Minami-Soma City, Kawamata Town and Date City, were defined as evacuees. Residents in rest areas of Tamura City, Minami-Soma City, Kawamata Town and Date City and those in municipalities other than the evacuation zone were defined as non-evacuees[2,5]. The details of the study protocol and the baseline profiles have been described in a previous publication[5]. We used data from the Mental Health and Lifestyle Survey conducted in 2011, 2012 and 2013, which contained a self-administered questionnaire on demographic characteristics, medical history, smoking habits, alcohol consumption, physical activity, occupation and other factors, as well as a FFQ. Participants (73 368 in 2011, 54 063 in 2012 and 45 233 in 2013) aged 16 years and older were assessed for this study.

Dietary intake assessment

A short-form FFQ was used to examine the food intake of nineteen food items during the preceding 6 months. The FFQ used in this study was a modified version of the one used in the Hiroshima and Nagasaki Life Span Study[6]. In the validation study of the original FFQ, the frequency of food intake as measured by the FFQ was moderately correlated with food intake as measured by the 24-h recall records, for example, the Spearman's correlation coefficient of fruit, milk, miso soup, beef/pork, rice and bread was between 0·14 and 0·34[6]. The nineteen food items were divided into six food groups: non-juice fruits/vegetables (fruit, green vegetables, red and orange vegetables, and light-coloured vegetables); fruit/vegetable juices; meat (chicken, beef, pork, ham and sausages); soya bean products (fermented soya beans, soya milk, miso soup, tofu, and boiled beans); fish (raw and cooked) and dairy products (milk, yogurt and lactobacillus drinks). Participants were asked how frequently they consumed individual food items, with six response choices: none, <1, 1–2, 3–4, 5–6 times/week or every day.

Statistical analysis

We excluded participants who had more than three missing pieces of responses regarding dietary items[7], leaving 156 477 participants (67 358 in 2011, 48 377 in 2012 and 40 742 in 2013) for this analysis (online Supplemental Figure S1). For the surveys with missing answers to the dietary questions (13·5 % missing one and 4·7 % missing two), we used the median value of frequency of that food item, by survey year and sex, to replace the missing values[7]. For the frequency of dietary intake for each food group, the daily midpoint for the frequency category was used, for example, 3–4 times per week was assessed as 0·5 times/d[7].

All the data were analysed using the SAS statistical software package ver. 9.4 for Windows (SAS Institute). Dietary patterns were derived from a year- and sex-specific factor analysis of nineteen food items without alcohol consumption by using the FACTOR Procedure of SAS. A varimax rotation was used for the identified factors to improve their interpretability. Factor numbers were selected mainly according to eigenvalues >1·5, scree plots and factor interpretability. Food items with absolute factor loadings ≥0·3 were considered to account for each component[8]. The derived dietary patterns (factors) were labelled based on food items with high factor loadings for each factor. Factor scores for each dietary pattern in an individual were estimated as a linear combination of standardised values for food items and standardised scoring coefficients. Dietary pattern scores (the factor scores) were calculated for available participants in 2010, 2011 and 2013, respectively.

Significant trends of dietary intake proportions were examined using the Cochran–Armitage test with setting up the frequency of ≥0·5 time/d as the cut-off value. The associations between individual dietary scores at the various time points were assessed using Spearman's correlation coefficient. The general linear regression models were applied to examine the difference of means of three dietary patterns' scores, respectively, between evacuees and non-evacuees. The lifestyle covariates of impact on dietary intake were selected based on the previous publications for FHMS[7,9], which including age (continuous), smoking habits (no, former or current), alcohol drinking (no, former or current), self-reported health condition (very good, good, normal, poor or very poor), educational level (elementary/junior high, high school, vocational college or undergraduate/graduate), physical activity (everyday, 2–4, 1 time/d or none), history of diagnosed chronic disease

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(at least one (hypertension, hyperlipidaemia, cancer, stroke, heart disease, diabetes or chronic hepatitis) or none), depression (weak (K6 < 13) or strong (K6 ≥ 13)) and employment (no change, unemployment or change a job). In each independent category variable, a reference was assigned and the multiple comparisons of difference were examined by Dunnett tests. Least square means of dietary pattern scores stratified by survey years, sex and evacuated status were calculated, with Tukey tests for examining the differences among categories, and the same other covariates for adjustment.

A sensitivity analysis was given to 22 805 participants who contributed FFQs for the above approaches for all 3 years, including the derivation of dietary patterns, examinations of correlation coefficients of each pattern scores among years and comparisons of means of dietary pattern scores between evacuees and non-evacuees and other groups of covariates by the general linear regression analysis. All *P* values reported were two-sided, and the significance level was set at <0.05.

Results

Participants' characteristics are shown in Table 1. Approximately 63·5 % of evacuees completed the surveys. Around half of the participants had a high school education, and more than 17 % of the participants reported having a poor health condition. Current smokers were more than 28 %, and alcohol drinkers were 60 % in men, whereas the rates were more than 8 and 25 % in women, respectively. Approximately 50 % of participants had at least one chronic disease historically diagnosed. About 55 % of participants had daily physical activity more than once. Both men and women had the

Table 1 Participants' characteristics, Fukushima Health Management Survey, 2011–2013 (*n* 156 477)

	Men (*n* 68 457)						Women (*n* 88 020)					
	2011 (*n* 29 343)		2012 (*n* 21 182)		2013 (*n* 17 932)		2011 (*n* 38 015)		2012 (*n* 27 195)		2013 (*n* 22 810)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	54·8	18·1	57·7	17·1	59·3	16·6	55	18·9	56·9	18·3	58	17·8
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Evacuation												
No	13 163	44·9	5838	27·6	6167	34·4	17 087	44·9	7180	26·4	7597	33·3
Yes	16 159	55·1	15 323	72·3	11 760	65·6	20 901	55·0	19 998	73·5	15 209	66·7
Education												
Elementary/junior high school	7192	24·5	5111	24·1	4109	22·9	8740	23·0	6100	22·4	4721	20·7
High school	14 462	49·3	10 209	48·2	8675	48·4	17 887	47·1	12 575	46·2	10 547	46·2
Vocational college	3096	10·6	2253	10·6	1922	10·7	7889	20·8	5814	21·4	5029	22·0
Undergraduate/graduate	3588	12·2	2793	13·2	2583	14·4	1957	5·1	1545	5·7	1469	6·4
Health condition												
Very good	1481	5·0	902	4·3	652	3·6	1296	3·4	849	3·1	699	3·1
Good	4698	16·0	3731	17·6	3201	17·9	4292	11·3	3621	13·3	3197	14·0
Normal	17 500	59·6	12 347	58·3	10 264	57·2	24 049	63·3	16 815	61·8	13 869	60·8
Poor	4604	15·7	3319	15·7	3022	16·9	6712	17·7	4563	16·8	3789	16·6
Very poor	613	2·1	382	1·8	329	1·8	808	2·1	505	1·9	439	1·9
Smoke												
No	8083	27·5	5388	25·4	4909	27·4	29 547	77·7	18 190	66·9	16 409	71·9
Former	11 052	37·7	7394	34·9	6966	38·8	3243	8·5	2041	7·5	1781	7·8
Current	9928	33·8	6312	29·8	5180	28·9	3969	10·4	2353	8·7	1857	8·1
Alcohol drink												
No	8849	30·2	6258	29·5	5177	28·9	26 061	68·6	17 953	66·0	15 137	66·4
Former	1643	5·6	980	4·6	816	4·6	715	1·9	417	1·5	348	1·5
Current	18 673	63·6	12 847	60·7	11 589	64·6	10 431	27·4	6835	25·1	6036	26·5
Physical activity												
Everyday	4887	16·7	3391	16·0	3066	17·1	4461	11·7	3042	11·2	2555	11·2
2–4 times/d	5601	19·1	4291	20·3	3689	20·6	7373	19·4	5706	21	5045	22·1
1 time/d	4252	14·5	3265	15·4	2785	15·5	4886	12·9	4248	15·6	3509	15·4
No	14 130	48·2	9894	46·7	8295	46·3	20 562	54·1	13 811	50·8	11 521	50·5
History of chronic disease												
No	11 694	39·9	7251	34·2	6139	34·2	18 264	48·0	11 650	42·8	9917	43·5
At least one*	17 545	59·8	13 850	65·4	11 735	65·4	19 560	51·5	15 428	56·7	12 805	56·1
Depression												
Week (K6 < 13)	25 557	87·1	18 841	88·9	16 201	90·3	31 354	82·5	23 241	85·5	20 008	87·7
Strong (K6 ≥ 13)	3481	11·9	2057	9·7	1494	8·3	6217	16·4	3545	13·0	2467	10·8
Employment												
No change	12 541	42·7	9327	44	8213	45·8	16 810	44·2	12 196	44·8	10 554	46·3
Unemployment	10 504	35·8	5710	27·0	4850	27·0	10 190	26·8	5022	18·5	4429	19·4
Change a job	5117	17·4	4179	19·7	3437	19·2	8297	21·8	6306	23·2	4981	21·8

*Hypertension, hyperlipidaemia, cancer, stroke, heart disease, diabetes or chronic hepatitis.

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decline tendency of strong depression over years. The proportion of unemployment in 2011 was 35·8 % in men and was 26·8 % in women, which were higher than those in 2012 and 2013, respectively.

The means of soya milk, boiled beans, fruit juice and vegetable juice intake were <0·17 times/d, and of miso soup, rice, vegetables and fish were >0·41 times/d both in men and women. Meanwhile, the means of yogurt and fruit intake were >0·4 times/d in women. Over the study years, the significantly increased trends of eating more than 0·5 times/d were observed in most of the dietary foods/food groups in both men and women, whereas the significantly decreased trends were rice and miso soup in men and rice, ham and miso soup in women. No significant trends of changes in frequency were observed for beef, bread and ham in men and for bread, tofu, white vegetables and fruit juice in women over 3 years (online Supplemental Table S1).

The factor loadings of food items were similar both in men and over 3 years (Fig. 1). The typical pattern included the main types of vegetables, tofu (bean curd), miso soup, fish, bean products and rice; the juice pattern included vegetable juice, fruit juice, yogurt, soya milk, boiled beans, fruit and milk; and the meat pattern included beef/pork, chicken and ham/sausage. Online Supplemental Table S2 shows the factor loadings for the identified dietary patterns.

Dietary scores were highly correlated for three patterns both in men and women over years (Table 2). In total participants, the Spearman's correlation coefficients between two survey years were 0·70–0·74 for the typical, 0·58–0·66 for the juice and 0·50–0·54 for the meat pattern scores. Both in the analysis of total participants and the sensitivity analysis, the coefficients of the typical and the meat pattern were slightly higher in women than those in men; and those of the juice pattern were lower in women than those in men. In total participants, the coefficients of scores among the 3 years were 0·72–0·75 for the typical pattern, 0·62–0·68 for the juice pattern and 0·52–0·55 for the meat pattern in non-evacuees, whereas they were 0·68–0·73, 0·57–0·65 and 0·49–0·54, respectively, for the corresponding pattern scores in evacuees. Consistent coefficients were observed for evacuees and non-evacuees in the sensitivity analysis (data not shown).

Table 3 shows the adjusted means and 95 % CIs of dietary pattern scores among sociodemographic factors. For most factor categories, the pattern scores were positive. The evacuees had negative typical pattern scores; the typical pattern scores were lower, but the juice pattern scores were higher than in non-evacuees. The higher the education level, the higher the scores of typical and juice patterns. As the health conditions declined, the typical and meat pattern scores declined. Current smokers had lower typical and meat pattern scores but higher juice pattern scores than non-smokers. Alcohol drinkers had higher scores of typical pattern but lower scores of juice and meat pattern than nondrinkers. Participants with more physical activities had higher scores in each pattern. Residents with strong depression had lower typical pattern scores but higher juice pattern scores comparing to residents with weak depression. In addition, the unemployed and those changed a job after disaster had lower typical pattern scores than those without changes. Furthermore, the distributions of pattern scores were not affected by the subsample of the total 22 805 participants who completed three consecutive surveys (data not shown).

Adjusted means of dietary pattern scores in evacuees and non-evacuees were plotted along survey years in Fig. 2 (a, for total participants; b, for those who provided all three dietary assessments). Distributions of each dietary pattern scores between men and women were very similar. Both in men and women, means of typical pattern scores were higher in non-evacuees than in evacuees ($P < 0·001$ in each year), while those of juice pattern were lower in non-evacuees than in evacuees ($P < 0·001$ in each year, except for women in 2011, $P = 0·061$). The typical pattern scores were positive and declining in non-evacuees (2013 *v.* 2011: $P = 0·001$ in men and $P = 0·021$ in women), while they were negative and more sharply declining in evacuees over years (2013 *v.* 2011: $P < 0·001$ both in men and women). The juice pattern scores significantly decreased in non-evacuees (2013 *v.* 2011: $P < 0·001$ both in men and women) but not in evacuees (2013 *v.* 2011: $P = 0·151$ in men and $P = 0·142$ in women) over years. Meat pattern scores showed significantly increasing both in men and women regardless of the evacuation status.

For sensitivity analysis, the same three dietary patterns were identified and the distributions of means of pattern scores were similar to the results of total participants (Fig. 2(b)). However, evacuees had the significant decline of typical pattern scores (2013 *v.* 2011: $P < 0·001$ in men and $P < 0·001$ in women), while non-evacuees had the significant decline of juice pattern scores (2013 *v.* 2011: $P = 0·013$ in men and $P = 0·006$ in women). In contrast, there were no significant differences among means of typical pattern scores in non-evacuees (2013 *v.* 2011: $P = 0·846$ in men and $P = 0·833$) and of juice pattern score in evacuees (2013 *v.* 2011: $P = 0·883$ in men and $P = 0·894$ in women).

Discussion

We identified three dietary patterns: the typical, the juice and the meat pattern, and we examined the dietary stability over the years as a whole. The analysis results suggested that there was little variation in food consumption patterns in both men and women over the years. Based on the dietary scores, we described the discrepancy of dietary patterns among sociodemographic factors.

The Japanese dietary pattern consists of a combination of dietary staples, side dishes and soup[10]. Although direct

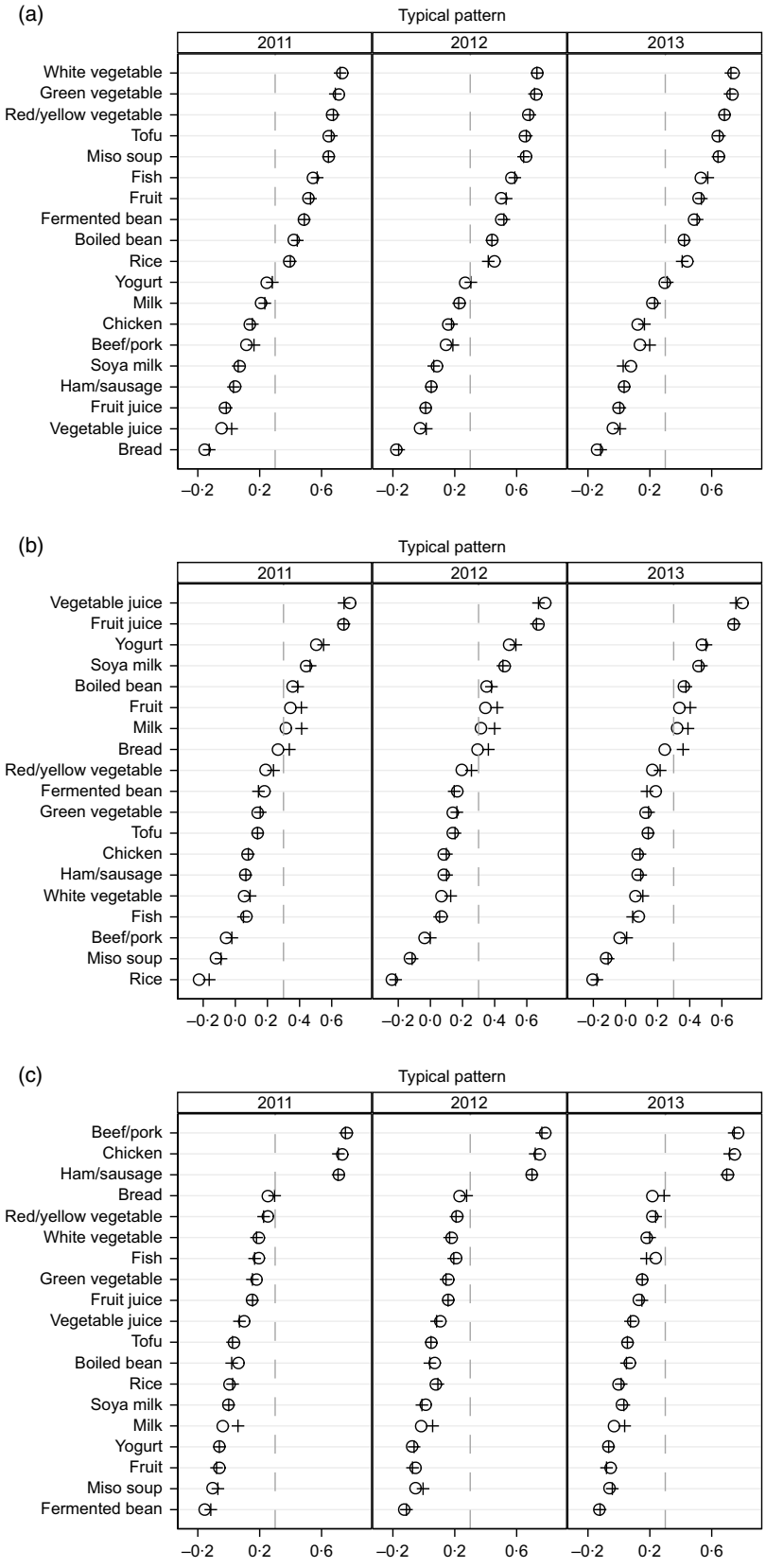

Fig. 1 Factor loadings of food items by sex and survey years. (a and c) ○, Men; +, women; (b) ○, women; +, men

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Table 2 Spearman's correlation coefficients between dietary pattern scores, Fukushima Health Management Survey, 2011–2013

	Typical			Juice			Meat		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
All participants									
Men									
2011	1·00			1·00			1·00		
2012	0·70	1·00		0·63	1·00		0·52	1·00	
2013	0·68	0·73	1·00	0·59	0·68	1·00	0·48	0·52	1·00
Women									
2011	1·00			1·00			1·00		
2012	0·72	1·00		0·62	1·00		0·54	1·00	
2013	0·71	0·75	1·00	0·58	0·65	1·00	0·52	0·56	1·00
Participants with all three dietary assessments									
Men									
2011	1·00			1·00			1·00		
2012	0·71	1·00		0·65	1·00		0·52	1·00	
2013	0·68	0·73	1·00	0·60	0·68	1·00	0·49	0·53	1·00
Women									
2011	1·00			1·00			1·00		
2012	0·73	1·00		0·62	1·00		0·55	1·00	
2013	0·72	0·76	1·00	0·58	0·65	1·00	0·52	0·57	1·00

comparisons could not be made across publications, the three patterns derived in our study had dietary categories similar to other studies[11]. For example, compared with other studies, the identified typical pattern in this study corresponded to the 'traditional Japanese'[12,13] or 'healthy' pattern[14–16]; the meat pattern to the 'animal food'[12,13,17] or 'Western' pattern[14] and the juice pattern to the 'high dairy'[12], 'bread-dairy'[13] or 'bread' pattern[14]. After the great earthquake, a study from the neighbouring prefecture identified a 'prudent pattern' and a 'meat pattern' by a short-form FFQ, in which the prudent pattern was similar to the typical and juice pattern in our study[17]. Some studies explored dietary patterns including alcoholic drinks, tea or coffee[12,16]. The Osaki cohort study identified nine Japanese Diet Index Scores by a FFQ with thirty-nine food items, which included rice, miso soup, seaweed, pickles, green and yellow vegetables, fish, green tea, beef and pork, and coffee[12]. Another dietary study identified more patterns, such as 'dessert'[14]. As we know, for FFQs with different food items and/or surveyed in different populations, the dietary patterns identified might be different. Nevertheless, the study FFQ, although it was short-form, the similar coverage of main food groups could be used to clarify the stability of dietary patterns in this study population over the years.

The advantage of this study is that the abundant data provided for an analysis with a strong statistical power. Although the response rate to the FFQ survey was 60·7 % overall in 2011, among 67 358 participants in the 2011 survey, 63·4 % completed the surveys in 2011 and 2012, and 33·9 % participants completed all three rounds of surveys, showing similar results. The original FFQ was moderately correlated with the 24-h dietary records; our study by using the slightly modified FFQ could assess the changes of dietary food patterns among sociodemographic groups. The present study showed moderate-to-higher correlations between dietary pattern scores over 3 years, which were similar to other studies[4,8,11,18]. Further, by the sequential annual surveys, we could closely monitor residents' dietary status.

Mulder *et al.*[19] had reported that the stability in dietary score after 4 years was moderate (correlations of 0·61), but stability varied according to lifestyle behaviour. It is important to include repeated measures of dietary assessment over time to incorporate individual changes in complex dietary behaviour[18]. In general, we observed that dietary pattern scores were lower in the evacuees than in the non-evacuees. The FMHS has reported that living in nonhome conditions has been associated with a poor dietary intake of fruits and vegetables, meat, soya bean products and dairy products[7]. Our analysis showed similar but more comprehensive results, for example, higher intakes of the juice pattern in evacuees than in non-evacuees. A French study has shown that migrant status was associated with a risk of low-frequency consumption of fruits and vegetables, meat, seafood, eggs and dairy products[20]. Non-evacuees or those who lived in a relative's home would be more familiar with nearby living environment and perceived better access to supermarkets, promoting a more balanced daily dietary intake[7,20,21]. This result might reflect the fact that the evacuees who were living at shelters after the disaster did not have full access to or consume enough fresh vegetables. It has been reported that 79·1 % of shelters at the first month after the earthquake had a food supply shortage, for example, each day 18·8 % of shelters had three dishes of vegetables, including soup, and 14·5 % of shelters had three dishes of meat and fish, 13·0 % shelters had two dishes of fruits, meat and fish and only 15·9 % of shelters had milk and dairy products once a day[22]. The Fukushima neighbouring

Table 3 Least square means and 95 % CI of dietary pattern scores, Fukushima Health Management Survey (*n* 123 088)*

		Typical			Juice			Meat		
	N	Mean	95 % CI	*P* values	Mean	95 % CI	*P* values	Mean	95 % CI	*P* values
Year										
2011	57 861	0·02	0·01, 0·04	Ref.	0·18	0·17, 0·20	Ref.	0·05	0·03, 0·06	Ref.
2012	34 196	–0·03	–0·04, –0·01	<0·0001	0·14	0·12, 0·16	<0·0001	0·07	0·06, 0·09	<0·001
2013	31 031	–0·07	–0·09, –0·05	<0·0001	0·15	0·13, 0·16	<0·0001	0·10	0·09, 0·12	<0·0001
Sex										
Men	56 735	–0·01	–0·03, 0·003	Ref.	0·20	0·18, 0·22	Ref.	0·08	0·06, 0·10	Ref.
Women	66 353	–0·04	–0·06, –0·02	<0·0001	0·11	0·10, 0·13	<0·0001	0·07	0·05, 0·09	0·297
Evacuation										
No	45 200	0·03	0·01, 0·05	Ref.	0·13	0·11, 0·15	Ref.	0·08	0·06, 0·09	Ref.
Yes	77 888	–0·08	–0·10, –0·07	<0·0001	0·18	0·17, 0·20	<0·0001	0·08	0·06, 0·09	0·997
Education level										
Elementary/junior high school	25 162	–0·15	–0·17, –0·13	Ref.	–0·06	–0·08, –0·04	Ref.	0·07	0·05, 0·09	Ref.
High school	62 399	–0·06	–0·07, –0·04	<0·0001	0·13	0·11, 0·15	<0·0001	0·04	0·02, 0·06	<0·001
Vocational college	22 783	0·04	0·02, 0·06	<0·0001	0·22	0·2, 0·24	<0·0001	0·11	0·09, 0·13	<0·0001
Undergraduate/graduate	12 744	0·06	0·04, 0·08	<0·0001	0·35	0·32, 0·37	<0·0001	0·08	0·06, 0·10	0·438
Health condition										
Very good	4998	0·12	0·09, 0·14	Ref.	0·14	0·11, 0·17	Ref.	0·14	0·11, 0·17	Ref.
Good	19 739	0·08	0·06, 0·10	0·044	0·12	0·10, 0·14	0·703	0·09	0·07, 0·11	<0·001
Normal	76 604	–0·01	–0·02, 0·01	<0·0001	0·12	0·10, 0·13	0·295	0·05	0·04, 0·07	<0·0001
Poor	19 598	–0·10	–0·11, –0·08	<0·0001	0·17	0·15, 0·18	0·160	0·05	0·03, 0·06	<0·0001
Very poor	2149	–0·22	–0·26, –0·18	<0·0001	0·24	0·20, 0·29	<0·0001	0·05	0·01, 0·09	<0·0001
Smoke										
No	68 495	0·07	0·06, 0·09	Ref.	0·24	0·22, 0·26	Ref.	0·06	0·04, 0·07	Ref.
Former	27 823	0·002	–0·02, 0·02	<0·0001	0·20	0·18, 0·22	<0·0001	0·06	0·04, 0·08	0·891
Current	26 770	–0·15	–0·17, –0·13	<0·0001	0·04	0·02, 0·06	<0·0001	0·11	0·09, 0·13	<0·0001
Alcohol drink										
No	61 965	–0·04	–0·05, –0·02	Ref.	0·15	0·13, 0·16	Ref.	0·08	0·06, 0·09	Ref.
Former	3794	–0·01	–0·04, 0·02	0·210	0·30	0·27, 0·34	<0·0001	0·11	0·08, 0·15	0·044
Current	57 329	–0·02	–0·04, –0·01	0·018	0·02	0·004, 0·03	<0·0001	0·04	0·02, 0·05	<0·0001
Physical activity										
Everyday	15 751	0·18	0·16, 0·20	Ref.	0·29	0·27, 0·31	Ref.	0·12	0·10, 0·14	Ref.
2–4 times/d	23 480	0·04	0·02, 0·06	<0·0001	0·25	0·23, 0·27	<0·0001	0·07	0·05, 0·09	<0·0001
1 time/d	18 030	–0·10	–0·12, –0·08	<0·0001	0·14	0·12, 0·16	<0·0001	0·03	0·01, 0·05	<0·0001
No	65 827	–0·23	–0·24, –0·21	<0·0001	–0·05	–0·07, –0·03	<0·0001	0·09	0·07, 0·10	0·002
History of chronic disease†										
No	55 669	–0·01	–0·03, 0·002	Ref.	0·15	0·13, 0·16	Ref.	0·10	0·08, 0·11	Ref.
At least one	67 419	–0·04	–0·05, –0·02	0·0001	0·17	0·15, 0·19	0·001	0·05	0·04, 0·07	<0·0001
Depression										
Week (K6 < 13)	108 652	0·01	–0·01, 0·02	Ref.	0·12	0·11, 0·14	Ref.	0·07	0·05, 0·09	Ref.
Strong (K6 ≥ 13)	14 436	–0·06	–0·08, –0·04	<0·0001	0·19	0·17, 0·21	<0·0001	0·08	0·06, 0·10	0·184
Employment										
No change	59 608	–0·02	–0·03, –0·001	Ref.	0·16	0·15, 0·18	Ref.	0·10	0·08, 0·11	Ref.
Unemployment	35 780	–0·03	–0·05, –0·01	0·037	0·16	0·14, 0·18	0·857	0·08	0·06, 0·10	0·069
Change a job	27 700	–0·03	–0·05, –0·01	0·046	0·15	0·13, 0·17	0·278	0·05	0·03, 0·07	<0·0001

*Adjusted for age (continuous) at survey year and all covariates above in the regression model as the main effect.
†Diagnosis of hypertension, hyperlipidaemia, cancer, stroke, heart disease, diabetes or chronic hepatitis.

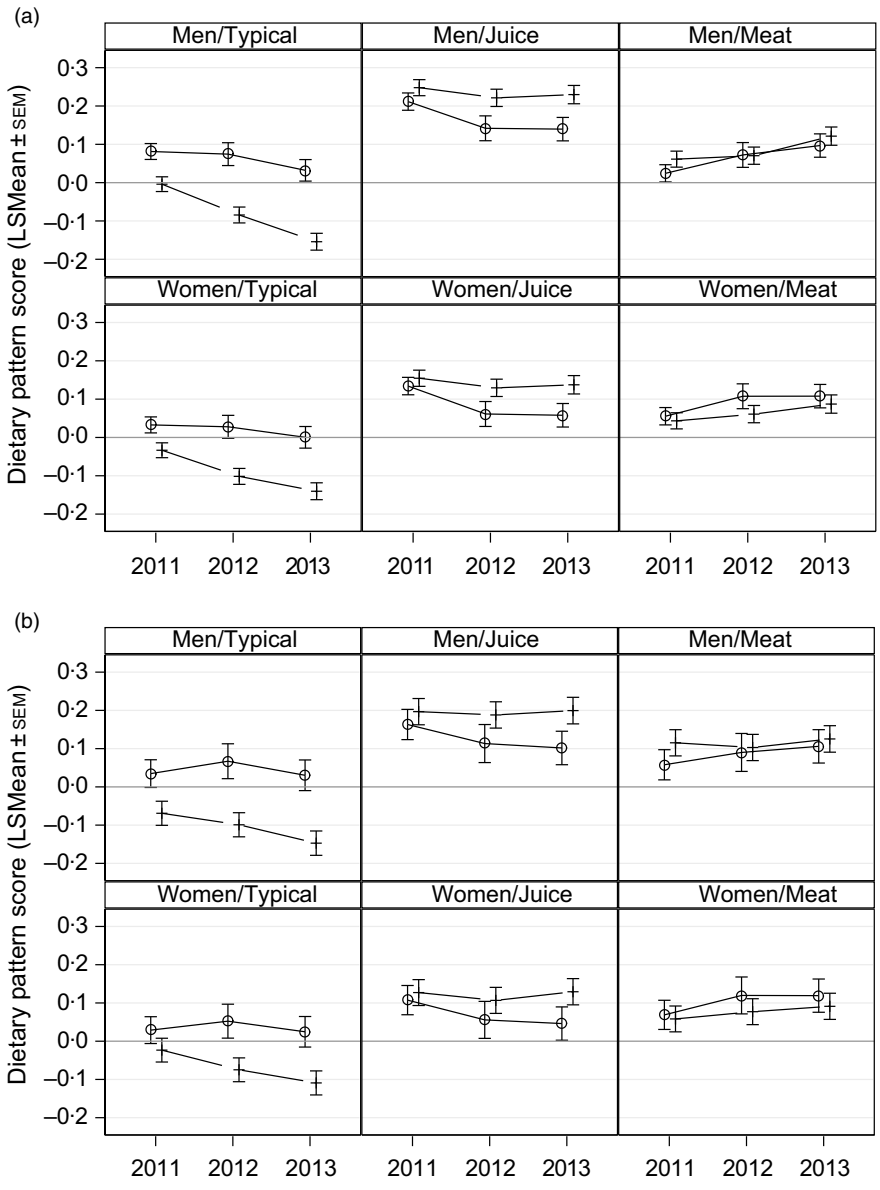

Fig. 2 Least square means of dietary pattern scores in evacuees and non-evacuees among survey years in total men and women (a) and those who had all three dietary assessments (b), adjusted for education level, smoking status, alcohol drinking, daily physical activity, self-reported health condition, history of diagnosed chronic disease, depression level and employment status. ○, Non-evacuee; +, evacuee; ——, non-evacuee; — ·, evacuee

study also indicated that individuals living in difficult conditions had lower 'prudent dietary pattern' scores than those living in acceptable conditions[17]. Those who did not live at home, with limited room space and simpler kitchen equipment, had difficulty eating balanced daily meals[7,17,22].

Similar to the other studies[17,23] regarding other socio-demographic factors, the higher the education levels, the higher the typical pattern scores; smokers had negative typical pattern scores, and their scores were lower than non-smokers. Importantly, women had lower scores in the typical and juice patterns than men, while the vegetable pattern was more likely to be followed by women[24]. Residents who reported being in poor health condition had negative and lower scores in the typical and meat patterns than those reporting good health conditions. This emphasised that to adopt better dietary habits, food availability, supply and continuous nutritional support by dieticians are necessary for helping those living in difficult conditions, especially for vulnerable populations[17,25].

The study had some limitations. First, the FHMS response rates remained at approximately 27 %[1], whereas the FFQ response rates decreased from 2011 to 2013. Thus, the representativeness of this study on dietary patterns might not be generalisable to the whole prefecture or to the country's general population. Second, the validity and reproducibility of this modified FFQ had not been

verified. We could not compute the food intake amount and therefore could not compute nutrients and conduct energy-adjusted analysis; we only used food frequencies for deriving dietary patterns in this study. Without the estimated intake of nutrients, the nutritional status and needs would be difficult to evaluate, particularly in vulnerable evacuees after the disaster[26]. Also, food consumption was self-reported, and dietary reporting is generally underreported. These findings could lead to nonrandom misclassifications[8]. Meanwhile, a total of nineteen food items might not sufficiently indicate changes in the intake of specific foods/food groups, given the identified patterns only explained 7·5–8·0 % of the variations at each year. The FFQ in our study had the same food groups as other studies but might not cover more detailed food items to be incorporated in this analysis[12,27]. Third, although our results showed significant correlations among dietary scores, the short term of three consecutive years and no previous survey results as controls might not encompass the long-term effect in Fukushima residents.

In summary, changes in dietary patterns in both men and women have been observed between 2011 and 2013, with typical and juice pattern scores in particular. Careful investigation of those who have insufficient intake of typical pattern foods and promotion of them, particularly for evacuees, are needed.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020000300

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