福島県立医科大学 学術機関リポジトリ

Title	Dietary pattern changes in Fukushima residents after the Great East Japan Earthquake: the Fukushima Health Management Survey 2011-2013
Author(s)	Ma, Enbo; Ohira, Tetsuya; Nakano, Hironori; Maeda, Masaharu; Yabe, Hirooki; Sakai, Akira; Yasumura, Seiji; Kamiya, Kenji
Citation	Public health nutrition. 24(8): 2195-2204
Issue Date	2021-06
URL	http://ir.fmu.ac.jp/dspace/handle/123456789/1580
Rights	This article has been published in a revised form in "Public Health Nutrition" https://doi.org/10.1017/s1368980020000300. This version is free to view and download for private research and study only. Not for re-distribution or re-use. © The Authors 2020.
DOI	10.1017/S1368980020000300
Text Version	author

This document is downloaded at: 2021-11-05T05:10:59Z

Fukushima Medical University

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

Enbo Ma[1-3,*], Tetsuya Ohira[1-3], Hironori Nakano[2,3], Masaharu Maeda[3,4], Hirooki Yabe[3,5], Akira Sakai[3,6], Seiji Yasumura[3,7], and Kenji Kamiya[3]

[1] Health Promotion Center, Fukushima Medical University, Fukushima, Japan.
[2] Department of Epidemiology, Fukushima Medical University School of Medicine, Fukushima, Japan.
[3] Radiation Medical Science Center for Fukushima Health Management Survey, Fukushima Medical University, Fukushima, Japan.
[4] Department of Disaster Psychiatry, Fukushima Medical University School of Medicine, Fukushima, Japan.
[5] Department of Neuropsychiatry, Fukushima Medical University School of Medicine, Japan.
[6] Department of Radiation Life Sciences, Fukushima Medical University School of Medicine, Japan.
[7] Department of Public Health, Fukushima Medical University School of Medicine, Fukushima, Japan.

***Corresponding Author**: Dr. Enbo Ma, Associate Professor, Health Promotion Center, Fukushima Medical University, 1 Hikariga-oka, Fukushima City, 960-1295 Japan. Tel: +81-24-547-1788. Fax: +81-24-547-1789. E-mail address: mae@fmu.ac.jp.

Running title: Dietary patterns in Fukushima after disaster

Key words: Dietary pattern: Food frequency questionnaire: Fukushima Health Management Survey: Evacuee: Principal component analysis

Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Committee for Ethics at Fukushima Medical University (application No. 1316 and 1319). Written informed consent was obtained from all subjects.

Author contributions: E.M. developed the hypothesis and drafted the manuscript; E.M., T.O., and H.N. analyzed the data; T.O., S.Y., H.Y., M.M., A.S., and K.K. collected and provided the data; T.O., S.Y., M.M., and K.K. revised the manuscript.

Financial Support: This survey was supported by the National Health Fund for Children and Adults Affected by the Nuclear Incident for design and conduction of the study. The findings and conclusions of this article are solely the responsibility of the authors and do not represent the official views of the Fukushima Prefecture government.

Conflict of Interest: E. Ma, T. Ohira, H. Nakano, M. Maeda, H. Yabe, A. Sakai, S. Yasumura, and K. Kamiya, declared no conflicts of interest.

Acknowledgments: The authors would like to thank Enago (www.enago.com) for the English language review.

Abstract

OBJECTIVE: Dietary patterns more closely resemble actual eating behaviors 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 and 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 nonevacuees. The means of typical pattern scores in evacuees and it of juice pattern scores in nonevacuees 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.

Key words**:** Dietary pattern: Food frequency questionnaire: Fukushima Health Management Survey: Evacuee: Principal component analysis

Introduction

The Great East Japan Earthquake occurred on March 11, 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 cardiovascular disease, 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 patterns, however, more closely resemble actual eating behaviors 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 principle component analysis (PCA) 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 March 11 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 Fukushima Health Management Survey, 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 nonevacuees [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 food frequency questionnaire (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 19 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-hour recall records; for example, the Spearmen correlation coefficient of fruit, milk, miso soup, beef/pork, rice and bread was between 0.14 and 0.34 [(6)]. The 19 food items were divided into 6 food groups: non-juice fruits/vegetables (fruit, green vegetables, red and orange vegetables, and light-colored vegetables); fruit/vegetable juices; meat (chicken, beef, pork, ham, and sausages); soybean products (fermented soybeans, soy 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 6 response choices: none, <1 time/wk, 1–2 times/wk, 3–4 times/wk, 5–6 times/wk, or every day.

Statistical analysis

We excluded participants who had more than 3 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 (Supplementary Figure 1**)**. 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; e.g., 3–4 times per week was assessed as 0.5 times per day [(7)].

All the data were analyzed using the SAS statistical software package ver. 9.4 for Windows (SAS Institute, Cary, NC, USA). Dietary patterns were derived from a year- and sex-specific factor analysis of 19 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 labeled 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 standardized values for food items and standardized 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 exam the difference of means of three dietary patterns' scores, respectively, between evacuees and nonevacuees. 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 times/d, 1 time/d, or none), history of diagnosed chronic disease (at least one [hypertension, hyperlipidemia, 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 nonevacuees 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 <.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 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 soy 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 (Supplementary Table 1).

The factor loadings of food items were similar both in men and over 3 years (Figure 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, soy milk, boiled beans, fruit, and milk; and the meat pattern included beef/pork, chicken, and ham/sausage. Supplementary Table 2 shows the factor loadings for the identified dietary patterns.

Dietary scores were highly correlated for 3 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 nonevacuees; 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 nonevacuees 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; and the typical pattern scores were lower but the juice pattern scores were higher than in nonevacuees. The higher education level, the higher 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 3 consecutive surveys (data not shown).

Adjusted means of dietary pattern scores in evacuees and non-evacuees were plotted along survey years in Figure 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 nonevacuees than in evacuees (P<0.001 in each year), while those of juice pattern were lower in nonevacuees 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 nonevacuees (2013 vs. 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 vs. 2011: both P<0.001 in men and women). The juice pattern scores significantly decreased in nonevacuees (2013 vs. 2011: P<0.001 both in men and women), but not in evacuees (2013 vs. 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 (Figure 2 (b)). However, evacuees had the significant decline of typical pattern scores (2013 vs. 2011: P<0.001 in men and P<0.001 in women), while nonevacuees had the significant decline of juice pattern scores (2013 vs. 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 nonevacuees (2013 vs. 2011: P=0.846 in men and P=0.833) and of juice pattern score in evacuees (2013 vs. 2011: P=0.883 in men and P=0.894 in women).

Discussion

We identified 3 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 comparisons could not be made across publications, the 3 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; 15; 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 neighboring 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 9 Japanese Diet Index Scores by a FFQ with 39 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 3 rounds of surveys, showing similar results. The original FFQ was moderately correlated with the 24-hour 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. (1998) had reported that the stability in dietary score after 4 years was moderate (correlations of 0.61), but stability varied according to lifestyle behavior [19]. It is important to include repeated measures of dietary assessment over time to incorporate individual changes in complex dietary behavior [18]. In general, we observed that dietary pattern scores were lower in the evacuees than in the nonevacuees. The FMHS has reported that living in nonhome conditions has been associated with a poor dietary intake of fruits and vegetables, meat, soybean products, and

dairy products [7]. Our analysis showed similar but more comprehensive results; e.g., higher intakes of the juice pattern in evacuees than in nonevacuees. 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]. Nonevacuees 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 3 dishes of vegetables, including soup, and 14.5% of shelters had 3 dishes of meat and fish, 13.0% shelters had 2 dishes of fruits, meat, and fish, and only 15.9% of shelters had milk and dairy products once a day [22]. The Fukushima neighboring 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 sociodemographic factors, the higher the education levels, the higher the typical pattern scores; smokers had negative typical pattern scores, and their scores were lower than nonsmokers. 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 emphasized 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 generalizable 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 19 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 3 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.

References

1. Yasumura S, Abe M (2017) Fukushima Health Management Survey and Related Issues. *Asia Pac J Public Health* **29**, 29S-35S.
2. Ohira T, Nakano H, Nagai M *et al.* (2017) Changes in Cardiovascular Risk Factors After the Great East Japan Earthquake. *Asia Pac J Public Health* **29**, 47S-55S.
3. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* **13**, 3-9.
4. Northstone K, Emmett PM (2008) A comparison of methods to assess changes in dietary patterns from pregnancy to 4 years post-partum obtained using principal components analysis. *Br J Nutr* **99**, 1099-1106.
5. Yasumura S, Hosoya M, Yamashita S *et al.* (2012) Study protocol for the Fukushima Health Management Survey. *J Epidemiol* **22**, 375-383.
6. Sauvaget C, Allen N, Hayashi M *et al.* (2002) Validation of a food frequency questionnaire in the Hiroshima/Nagasaki Life Span Study. *J Epidemiol* **12**, 394-401.
7. Zhang W, Ohira T, Abe M *et al.* (2017) Evacuation after the Great East Japan Earthquake was associated with poor dietary intake: The Fukushima Health Management Survey. *J Epidemiol* **27**, 14-23.
8. Luger E, Aspalter R, Luger M *et al.* (2016) Changes of dietary patterns during participation in a web-based weight-reduction programme. *Public Health Nutr* **19**, 1211-1221.
9. Nagai M, Ohira T, Zhang W *et al.* (2017) Lifestyle-related factors that explain disaster-induced changes in socioeconomic status and poor subjective health: a cross-sectional study from the Fukushima health management survey. *BMC Public Health* **17**, 340.
10. Suzuki N, Goto Y, Ota H *et al.* (2018) Characteristics of the Japanese Diet Described in Epidemiologic Publications: A Qualitative Systematic Review. *J Nutr Sci Vitaminol (Tokyo)* **64**, 129-137.
11. Crozier SR, Robinson SM, Godfrey KM *et al.* (2009) Women's dietary patterns change little from before to during pregnancy. *J Nutr* **139**, 1956-1963.
12. Tomata Y WT, Sugawara Y, Chou WT, Kakizaki M, Tsuji I. (2014) Dietary patterns and incident functional disability in elderly Japanese: the Ohsaki Cohort 2006 study. *J Gerontol A Biol Sci Med Sci* **69**, 8.
13. Htun NC, Suga H, Imai S *et al.* (2018) Dietary pattern and its association with blood pressure and blood lipid profiles among Japanese adults in the 2012 Japan National Health and Nutrition Survey. *Asia Pac J Clin Nutr* **27**, 1048-1061.
14. Nanri H, Hara M, Nishida Y *et al.* (2015) Dietary patterns and serum gamma-glutamyl transferase in Japanese men and women. *J Epidemiol* **25**, 378-386.
15. Okubo H, Murakami K, Sasaki S *et al.* (2010) Relative validity of dietary patterns derived from a self-administered diet history questionnaire using factor analysis among Japanese adults. *Public Health Nutr* **13**, 1080-1089.
16. Ito T, Kawakami R, Tanisawa K *et al.* (2019) Dietary patterns and abdominal obesity in middle-aged and elderly Japanese adults: Waseda Alumni's Sports, Exercise, Daily Activity, Sedentariness and Health Study (WASEDA'S Health Study). *Nutrition* **58**, 149-155.
17. Nishi N, Yoshimura E, Ishikawa-Takata K *et al.* (2013) Relationship of living conditions with dietary patterns among survivors of the great East Japan earthquake. *J Epidemiol* **23**, 376-381.
18. Mishra GD, McNaughton SA, Bramwell GD *et al.* (2006) Longitudinal changes in dietary patterns during adult life. *Br J Nutr* **96**, 735-744.
19. Mulder M, Ranchor AV, Sanderman R *et al.* (1998) The stability of lifestyle behaviour. *Int J Epidemiol* **27**, 199-207.

20. Mejean C, Deschamps V, Bellin-Lestienne C *et al.* (2010) Associations of socioeconomic factors with inadequate dietary intake in food aid users in France (The ABENA study 2004-2005). *Eur J Clin Nutr* **64**, 374-382.
21. Caspi CE, Kawachi I, Subramanian SV *et al.* (2012) The relationship between diet and perceived and objective access to supermarkets among low-income housing residents. *Soc Sci Med* **75**, 1254-1262.
22. Tsuboyama-Kasaoka N, Hoshi Y, Onodera K *et al.* (2014) What factors were important for dietary improvement in emergency shelters after the Great East Japan Earthquake? *Asia Pac J Clin Nutr* **23**, 159-166.
23. Sadakane A, Tsutsumi A, Gotoh T *et al.* (2008) Dietary patterns and levels of blood pressure and serum lipids in a Japanese population. *J Epidemiol* **18**, 58-67.
24. Olinto MT, Willett WC, Gigante DP *et al.* (2011) Sociodemographic and lifestyle characteristics in relation to dietary patterns among young Brazilian adults. *Public Health Nutr* **14**, 150-159.
25. Yanagihara H, Hatakeyama Y, Iwasaki T (2012) Coordination by registered dieticians for nutritional and dietary support in disaster in Japan. *Western Pac Surveill Response J* **3**, 46-51.
26. Tsuboyama-Kasaoka N, Purba MB (2014) Nutrition and earthquakes: experience and recommendations. *Asia Pac J Clin Nutr* **23**, 505-513.
27. McCann SE, Marshall JR, Brasure JR *et al.* (2001) Analysis of patterns of food intake in nutritional epidemiology: food classification in principal components analysis and the subsequent impact on estimates for endometrial cancer. *Public Health Nutr* **4**, 989-997.

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)	
Age, mean (SD)	54.8	(18.1)	57.7	(17.1)	59.3	(16.6)	55	(18.9)	56.9	(18.3)	58	(17.8)
Evacuation, n (%)												
No	13,163	(44.9)	5,838	(27.6)	6,167	(34.4)	17,087	(44.9)	7,180	(26.4)	7,597	(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, n (%)												
Elementary/junior high school	7,192	(24.5)	5,111	(24.1)	4,109	(22.9)	8,740	(23.0)	6,100	(22.4)	4,721	(20.7)
High school	14,462	(49.3)	10,209	(48.2)	8,675	(48.4)	17,887	(47.1)	12,575	(46.2)	10,547	(46.2)
Vocational college	3,096	(10.6)	2,253	(10.6)	1,922	(10.7)	7,889	(20.8)	5,814	(21.4)	5,029	(22.0)
Undergraduate/graduate	3,588	(12.2)	2,793	(13.2)	2,583	(14.4)	1,957	(5.1)	1,545	(5.7)	1,469	(6.4)
Health condition, n (%)												
Very good	1,481	(5.0)	902	(4.3)	652	(3.6)	1,296	(3.4)	849	(3.1)	699	(3.1)
Good	4,698	(16.0)	3,731	(17.6)	3,201	(17.9)	4,292	(11.3)	3,621	(13.3)	3,197	(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	4,604	(15.7)	3,319	(15.7)	3,022	(16.9)	6,712	(17.7)	4,563	(16.8)	3,789	(16.6)
Very poor	613	(2.1)	382	(1.8)	329	(1.8)	808	(2.1)	505	(1.9)	439	(1.9)
Smoke, n (%)												
No	8,083	(27.5)	5,388	(25.4)	4,909	(27.4)	29,547	(77.7)	18,190	(66.9)	16,409	(71.9)
Former	11,052	(37.7)	7,394	(34.9)	6,966	(38.8)	3,243	(8.5)	2,041	(7.5)	1,781	(7.8)
Current	9,928	(33.8)	6,312	(29.8)	5,180	(28.9)	3,969	(10.4)	2,353	(8.7)	1,857	(8.1)
Alcohol drink, n (%)												
No	8,849	(30.2)	6,258	(29.5)	5,177	(28.9)	26,061	(68.6)	17,953	(66.0)	15,137	(66.4)
Former	1,643	(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)	6,835	(25.1)	6,036	(26.5)
Physical activity, n (%)												
everyday	4,887	(16.7)	3,391	(16.0)	3,066	(17.1)	4,461	(11.7)	3,042	(11.2)	2,555	(11.2)
2-4 times/d	5,601	(19.1)	4,291	(20.3)	3,689	(20.6)	7,373	(19.4)	5,706	(21)	5,045	(22.1)
1 time/d	4,252	(14.5)	3,265	(15.4)	2,785	(15.5)	4,886	(12.9)	4,248	(15.6)	3,509	(15.4)
No	14,130	(48.2)	9,894	(46.7)	8,295	(46.3)	20,562	(54.1)	13,811	(50.8)	11,521	(50.5)
History of chronic disease, n (%)												
no	11,694	(39.9)	7,251	(34.2)	6,139	(34.2)	18,264	(48.0)	11,650	(42.8)	9,917	(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, n (%)												
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)	3,481	(11.9)	2,057	(9.7)	1,494	(8.3)	6,217	(16.4)	3,545	(13.0)	2,467	(10.8)
Employment, n (%)												
No change	12,541	(42.7)	9,327	(44)	8,213	(45.8)	16,810	(44.2)	12,196	(44.8)	10,554	(46.3)
Unemployment	10,504	(35.8)	5,710	(27.0)	4,850	(27.0)	10,190	(26.8)	5,022	(18.5)	4,429	(19.4)
Change a job	5,117	(17.4)	4,179	(19.7)	3,437	(19.2)	8,297	(21.8)	6,306	(23.2)	4,981	(21.8)

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

Table 2. Spearman 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

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* value	Mean	95% CI	*P* value	Mean	95% CI	*P* value
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	4,998	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	2,149	-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	3,794	-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

95% CI, 95% confidence interval

* Adjusted for age (continuous) at survey year and all covariates above in the regression model as the main effect.

† Diagnosis of hypertension, hyperlipidemia, cancer, stroke, heart disease, diabetes, or chronic hepatitis.

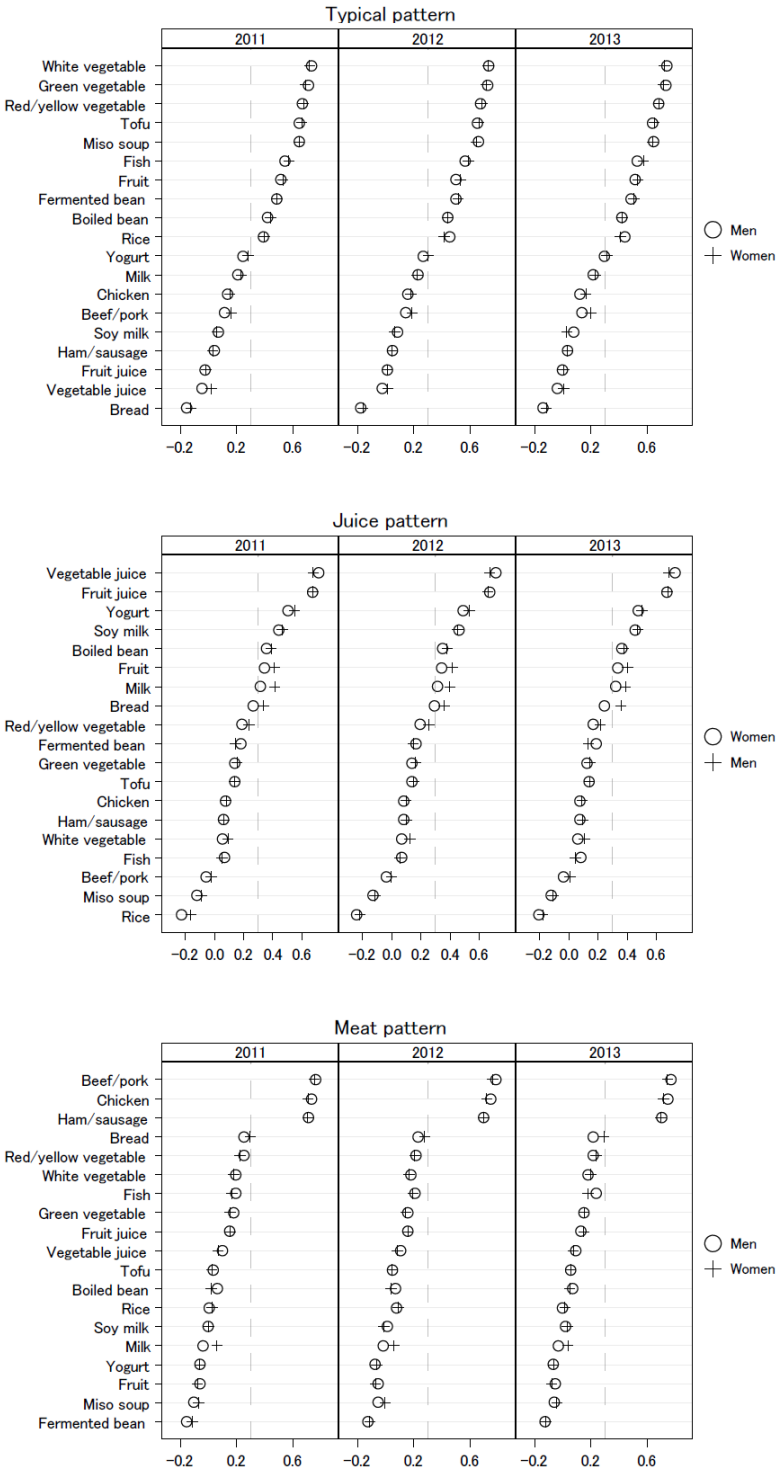

Figure 1. Factor loadings of food items by sex and survey years.

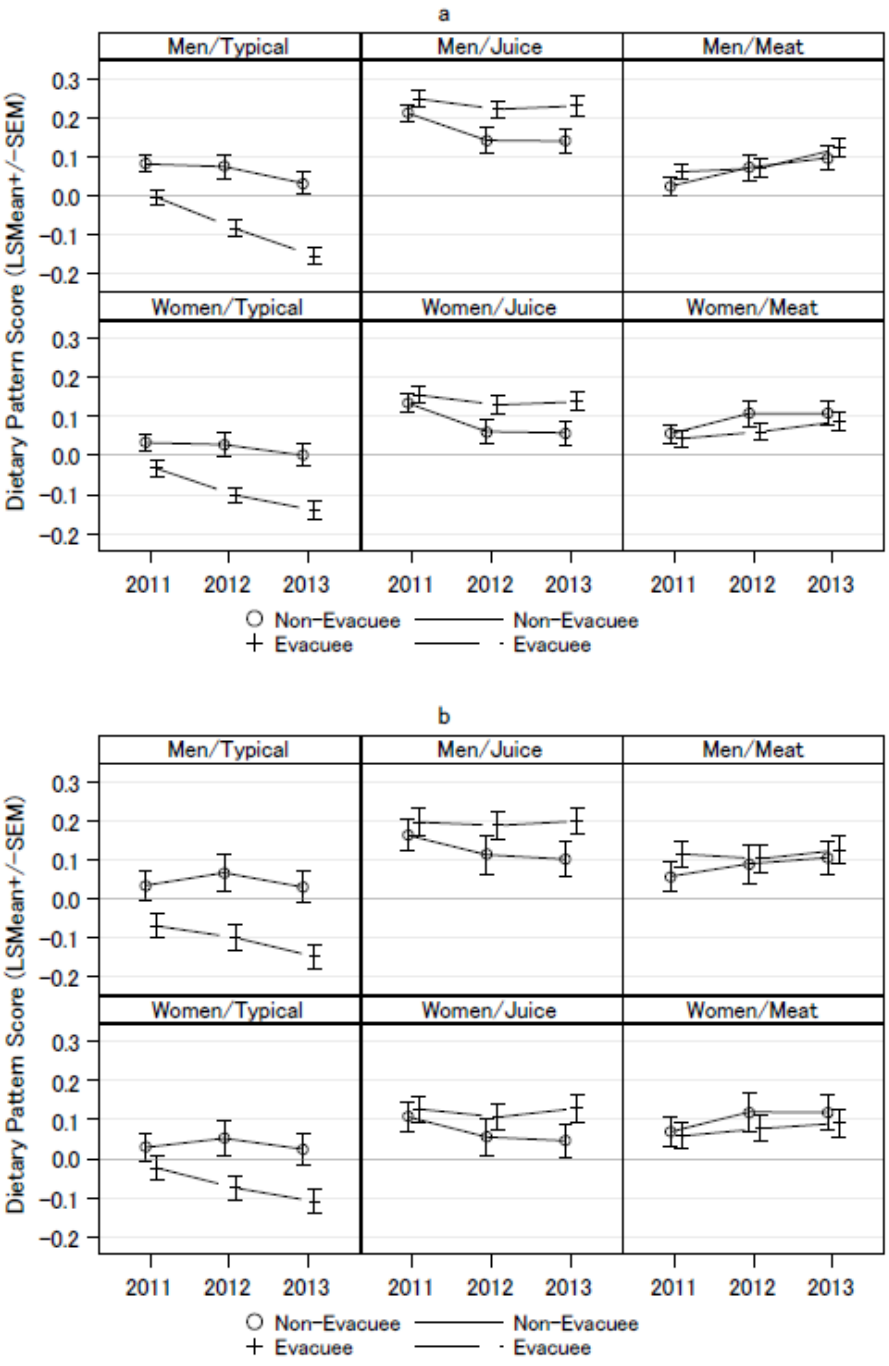

Figure 2. Least square means of dietary pattern scores in evacuees and nonevacuees among survey years in total men and women (a) and those who had all three dietary assessments (b), adjusted for education level, smoking status, alcohol drinking, daily physical activity, self-reported health condition,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