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Effects of socioeconomic factors on cardiovascular-related symptoms among residents in Fukushima after the Great East Japan Earthquake: a cross-sectional study using data from the Fukushima Health Management Survey

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ABSTRACT

Objective To investigate the association between socioeconomic factors and the exacerbation of cardiovascular symptoms among evacuees after the Great East Japan Earthquake.

Methods A sample of 73 433 individuals was included in the Fukushima Health Management Survey. Self-report questionnaires were used to determine the influence of socioeconomic factors including living arrangements, loss of employment and decreased income on the exacerbation of headache, dizziness, palpitations and shortness of breath. Odds ratios (ORs) and 95% CIs of the effect of socioeconomic factors were estimated for each symptom using multiple logistic regression analyses.

Results Exacerbation of headaches was reported by 1893 individuals, dizziness by 1229, palpitations by 1085 and shortness of breath by 626 individuals. Evacuation accommodation was associated with all of these symptoms. Compared with participants living in their own home (OR=1.00), individuals living in relatives' homes had increased probability of experiencing exacerbation of headache (1.58; 95% CI 1.19 to 2.09) and dizziness (1.42; 95% CI 1.02 to 1.98); those living in rental housing or apartments experienced exacerbation of headache (1.54; 95% CI 1.32 to 1.80), dizziness (1.45; 95% CI 1.20 to 1.75), palpitations (1.25; 95% CI 1.03 to 1.51) and shortness of breath (1.76; 95% CI 1.35 to 2.28); participants living in evacuation shelters experienced exacerbation of headache (1.80; 95% CI 1.09 to 2.96); and refugees living in temporary housing also experienced exacerbation of headache (1.42; 95% CI 1.15 to 1.72), dizziness (1.40; 95% CI 1.09 to 1.79) and shortness of breath (1.49; 95% CI 1.07 to 2.08). Compared with the evacuees who retained their jobs, unemployed individuals showed increased probability of exacerbation of headache (1.28, 95% CI 1.12 to 1.46), dizziness (1.26, 95% CI 1.07 to 1.48) and palpitations (1.21, 95% CI 1.01 to 1.45). Decreased income was associated with exacerbation of headache (1.39, 95% CI 1.22 to 1.60).

Conclusion After the earthquake, living in non-home conditions was more likely to result in exacerbated cardiovascular symptoms among evacuees. Loss of employment was another risk factor related to exacerbated headache and dizziness.

Strengths and limitations of this study

- Our study is the first to identify an inverse relationship between low socioeconomic status and exacerbated cardiovascular-related symptoms after the Great East Japan earthquake using a sample of 73 433 evacuees.
- The present study was based on a subjective self-response survey. Moreover, the exacerbated symptoms are not necessarily logical predictors of cardiovascular diseases.
- Overall, the response rate to questionnaires was low (40.7%) and potential sampling skews may have biased the data.
- A further limitation of the present study was that information regarding changes in family relationships (eg, death and physical separation) among the evacuees after the disaster was not captured.
- Additionally, most questionnaires were collected over a short time period (from January to March 2012).

INTRODUCTION

The Great East Japan Earthquake and the subsequent Fukushima Daiichi nuclear disaster, which occurred in March 2011, were together the most destructive catastrophe in Japan to date. Due to concerns regarding

released radiation, most residents in nearby towns were forced to evacuate and consequently suffered long-lasting anxiety. Shortly after the disaster, a Fukushima Health Management Survey was conducted to investigate the effects of long-term low-dose radiation exposure caused by the accident and to assess the physical and mental well-being of evacuees. This study included a basic survey which estimated each resident's radiation exposure and four detailed surveys: a Comprehensive Health Check, thyroid ultrasonography, a Mental Health and Lifestyle Survey and a survey of pregnant women and nursing mothers.[1] The Mental Health and Lifestyle Survey used self-report questionnaires to investigate the health status and lifestyle of refugees by querying information regarding nutrition and diet, perceived symptoms of illness, disaster-related experience and socioeconomic factors.

Several previous studies have identified changes in the incidence of cardiovascular events following disasters, but the results are conflicting.[2–14] A recent study reported a heterogeneous occurrence of cardiovascular events after the Great East Japan Earthquake,[2] while another study reported a significant increase in the incidence of cardioembolic stroke after the earthquake.[10] However, neither study examined the incidence of perceived cardiovascular disease symptoms after a disaster, nor did they focus on the effect of refugee socioeconomic status on health problems during the evacuation period. Yet these aspects should be considered because they are relevant for reviewing refugee health status, assessing the incidence of various diseases and providing health guidelines for refugees.

We therefore conducted the present study to investigate the risk factors of perceived cardiovascular symptoms following a major disaster. In the present study the socioeconomic factors included: the number of years of education, living arrangements, change of employment and income. Due to the particular post-disaster situation, change of employment and income due to the disaster were captured instead of job and income level. Thus, in the present study, fewer years of education, living in non-home conditions and unemployment or decreased income due to the disaster represented decreased socioeconomic status. We hypothesised that a decrease in socioeconomic status due to the earthquake would be associated with exacerbated cardiovascular symptoms among evacuees.

METHODS

Participants

The primary purpose of the Fukushima Health Management Survey was to monitor the long-term health and lifestyle of Fukushima residents and to provide them with appropriate care.[15] The Fukushima Health Management Survey consisted of a basic survey and four detailed surveys, namely: a thyroid ultrasound examination, Comprehensive Health Check, Mental Health and Lifestyle Survey and pregnancy and birth survey (for details of these surveys see Yasamura *et al*[1]). Individuals participating in the Mental Health and Lifestyle Survey were included in the present study. Briefly, the target population consisted of 210 189 officially registered victims of the Great East Japan Earthquake. They were evacuated from the following zones: Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City, Yamakiya District of Kawamata Town and Iitate Village. In 2012, 180 604 questionnaires were sent out, of which 73 569 were returned with responses (40.7% response rate). Of the returned questionnaires, 136 were excluded because they were blank or duplicated and 9245 because they were filled in by a proxy. After these exclusions, data from 73 433 individuals (32 301 men and 41 132 women) were used for our analyses.

The study protocol was approved by the Ethics Committee of Fukushima Medical University. Participants who returned self-administered questionnaires were considered to have consented to participation in the study.

Data collection and measurement

To investigate the health status and lifestyle of the refugees, the exacerbation of headache, dizziness, palpitations and shortness of breath was determined using a self-report questionnaire. All participants were asked to answer the question 'Do you have the following perceived symptoms after the earthquake?' and could choose between the replies 'No', 'Yes' and 'Exacerbation'. In the present study we focused on reports of 'Exacerbation'.

To evaluate symptoms of post-traumatic stress disorder (PTSD) we used the non-military version of the Post-traumatic Stress Disorder Checklist (PCL-S),[15] a checklist of 17 self-reported items. The list is based on the Diagnostic and Statistical Manual of Mental Disorders (fourth edition, DSM-IV) criteria,[16] and each item is rated using a Likert-type scale from 1 ('not at all') to 5 ('extremely'). Participants were requested to respond to the questions about each PTSD symptom separately and to indicate whether they had experienced a given symptom during the past month. Based on the sum of the scores of all 17 items, a total PCL-S score could range from 17 to 85.[15]

In addition to the PCL-S checklist, the following items were included in the self-assessment and self-report questionnaires:

Demographic characteristics

The demographic characteristics that were surveyed included individuals' gender, age group, mental health status, history of mental illness, incidence of PTSD symptoms, smoking and drinking habits and current physical activity levels. Age groups were divided into childbearing age (20–49 years), middle age (50–64 years) and old age (65 years and older).

Mental health status, and specifically incidence and severity of depression, was measured using the Japanese version of the K6 Kessler Psychological Distress Scale,

which has been validated by previous studies.[17 18] For the K6 assessment, participants were asked if they had experienced any of the following symptoms during the past 30 days: feeling so depressed that nothing could cheer them up; feeling that everything was an effort; or feeling nervous, hopeless, restless, fidgety or worthless. Each question was rated on a 5-point Likert-type scale from 0 (never experienced) to 4 (experienced all of the time), with higher scores signifying worse mental health status (the range of the scores was 0–24).[15] Additionally, we assessed participants' history of mental illness via a 'yes' or 'no' question.

We obtained data on smoking and alcohol consumption habits using the following categories: 'non-smoker', 'ex-smoker' or 'current smoker'; and alcohol consumption 'once or more per month', 'less than once per month' or 'ex-drinker'. Participants had four options to assess current physical activity level: 'daily', '2–4 times/week', 'weekly' or 'nearly none'.

Socioeconomic variables

Participants were required to select a description of their living arrangements from six options: evacuation shelter, temporary housing, rental housing or apartment, a relative's home, their own home, and other. The last option was considered non-informative due to its ambiguity and was thus excluded from analysis.

Other socioeconomic variables included number of years of education (<12 years, ≥12 years), change in employment status and change in income level. By answering 'Yes' to a change in employment status or income, the participant indicated s/he had become unemployed or experienced decreased income since the disaster.

Disaster-related variables

Disaster-related variables included experience of the tsunami (yes or no), experience of the nuclear power plant accident (defined as hearing the explosion; yes or no), losing someone close as a result of the disaster (yes or no) and damage to accommodation (none, partial damage, half destroyed, more than half destroyed, total destruction).

Statistical analyses

The incidence of exacerbation of headache, dizziness, palpitations and shortness of breath was compared between individuals with different demographic, socioeconomic and disaster-related characteristics using chi-square tests. For the analyses of PTSD incidence, a PCL-S score of 50 was used as a cut-off.[19] Individuals with a PCL-S of ≥50 were apportioned to the 'high-scoring group' and compared with the 'low-scoring group' (PCL-S <50) using chi-square tests.

Odds ratios (ORs) and 95% CIs for each socioeconomic characteristic (living arrangement, employment status, income level and number of years of education) were calculated using multiple logistic regression models. Adjustment variables included sex (male, female), age (20–49, 50–64, ≥65 years), alcohol consumption (once or more per month, ex-drinker, less than once per month), smoking status (non-smoker, ex-smoker, current smoker), mental health distress (K6 <3, K6 ≥13), hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or no), physical activity (≥ daily, 2–4 times per week, weekly, never), tsunami experience (yes or no), radiation experience (yes or no), damage to accommodation (none, partial, half, more than half, total) and loss of family member (yes or no).

We conducted the above analyses separately based on sex as well as with both sexes combined. All analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, North Carolina, USA).

RESULTS

From the sample of 73 433 individuals, 1893 (2.6%) reported exacerbation of headaches, 1229 (1.7%) exacerbation of dizziness, 1085(0.9%) exacerbation of palpitations and 626 (0.6%) exacerbation of shortness of breath (table 1).

Demographic characteristics

The demographic characteristics of the population are summarised in table 1. Exacerbation of cardiovascular symptoms was significantly higher in women than in men (3.5% vs 1.4% for headaches; 2.2% vs 1.1% for dizziness; 2.0% vs 0.9% for palpitations; and 0.9% vs 0.8% for shortness of breath). Young (20–49 years) individuals were more likely to experience exacerbation of headaches, dizziness or palpitations, while the 50–64 years age group more frequently experienced exacerbation of shortness of breath. Individuals experiencing exacerbation of cardiovascular symptoms were also more likely to suffer from depression (K6 ≥13) and PTSD (PCL ≥50), and commonly had a history of hypertension, stroke or heart disease. Neither smoking nor alcohol consumption increased the occurrence of exacerbated cardiovascular symptoms. Notably, symptom exacerbation was most pronounced in individuals who were not physically active daily.

Socioeconomic variables

Refugees living in their own or a relative's home were less likely to experience exacerbated cardiovascular symptoms (table 1). Of the refugees living in their own home, 1.4% reported exacerbation of headache, 0.9% of dizziness, 1.6% of palpitations, and 1.0% of shortness of breath. The corresponding statistics for refugees living in temporary housing and rental houses or apartments were 2.8%, 1.9%, 1.3% and 1.2% and 3.5%, 2.1%, 1.8% and 1.0%, respectively.

In the group that were unemployed due to the disaster, 4.2% of the individuals reported exacerbation of headache, 2.5% of dizziness, 2.1% of palpitations and 1.1% shortness of breath, while the corresponding statistics for the group that did not lose their jobs after the disaster

Table 1 Characteristics of survey participants and correlated incidence of exacerbation of cardiovascular-related symptoms

	Exacerbation of headache	Exacerbation of dizziness	Exacerbation of palpitations	Exacerbation of shortness of breath
	N (%)	N (%)	N (%)	N (%)
Sex				
Men	466 (1.4)	341 (1.1)	277 (0.9)	257 (0.8)
Women	1427 (3.5)	888 (2.2)	808 (2.0)	369 (0.9)
Age				
20–49	966 (3.9)	507 (2.0)	407 (1.6)	147 (0.6)
50–64	514 (2.4)	302 (1.4)	323 (1.5)	159 (0.8)
≧65	413 (1.4)	420 (1.6)	355 (1.3)	320 (0.4)
Mental health status				
K6 <13	1092 (1.7)	695 (1.1)	562 (0.9)	355 (0.6)
K6 ≧13	801 (8.9)	534 (5.3)	523 (5.2)	271 (2.7)
Post-traumatic stress disorder				
No	1062 (1.7)	653 (1.0)	542 (0.9)	323 (0.5)
Yes	831 (8.0)	576 (5.5)	543 (5.2)	303 (2.9)
Smoking status				
Non-smoker	1104 (2.7)	715 (1.8)	653 (1.6)	318 (0.8)
Ex-smoker	338 (2.1)	226 (1.4)	214 (1,4)	171 (1.1)
Current smoker	403 (2.8)	258 (1.8)	196 (1.3)	123 (0.8)
Alcohol consumption				
Less than once a month	1067 (2.9)	674 (1.8)	597 (1.6)	323 (0.9)
Ex-drinker	80 (2.9)	63 (2.3)	61 (2.2)	41 (1.5)
One or more per month	715 (2.3)	463 (1.5)	407 (1.3)	248 (0.8)
Physical activity				
≥ daily	179 (1.7)	131 (1.2)	96 (0.9)	69 (0.7)
2–4 times per week	309 (2.2)	245 (1.7)	195 (1.4)	123 (0.9)
Weekly	234 (2.4)	143 (1.4)	139 (1.4)	97 (1.0)
Never	1144 (3.2)	687 (1.9)	637 (1.8)	325 (0.9)
Hypertension history				
No	1216 (2.8)	667 (1.6)	584 (1.4)	276 (0.6)
Yes	677 (2.2)	562 (1.8)	501 (1.6)	350 (1.1)
Stroke history				
No	1799 (2.6)	1146 (1.7)	1799 (1.5)	576 (0.8)
Yes	94 (2.4)	83 (2.2)	94 (1.6)	50 (1.3)
Heart disease history				
No	1691 (2.6)	1025 (1.6)	1691 (2.6)	432 (0.7)
Yes	202 (10.7)	204 (2.8)	202 (4.0)	194 (2.7)
Unemployment				
No	1293 (2.2)	874 (1.5)	790 (1.4)	470 (0.8)
Yes	600 (4.2)	355 (2.5)	295 (2.1)	156 (1.1)
Income decrease				
No	1432 (2.4)	968 (1.6)	870 (1.4)	506 (0.8)
Yes	461 (3.6)	261 (2.0)	215 (1.7)	120 (0.9)
Living arrangement				
Evacuation shelter	213 (2.5)	12 (1.6)	5 (0.7)	5 (0.7)

Continued

Table 1 Continued

	Exacerbation of headache	Exacerbation of dizziness	Exacerbation of palpitations	Exacerbation of shortness of breath
	N (%)	N (%)	N (%)	N (%)
Temporary housing	195 (2.8)	134 (1.9)	89 (1.3)	81 (1.2)
Rental house or apartment	796 (3.5)	489 (2.1)	421 (1.8)	224 (1.0)
Relatives' home	78 (2.8)	53 (1.9)	209 (1.0)	108 (0.5)
Own home	292 (1.4)	199 (0.9)	45 (1.6)	29 (1.0)
Tsunami experience				
No	1424 (2.4)	908 (1.6)	830 (1.4)	458 (0.8)
Yes	469 (3.2)	321 (2.2)	255 (1.7)	168 (1.1)
Radiation experience				
No	717 (2.1)	426 (1.2)	358 (1.0)	201 (0.6)
Yes	1176 (3.1)	803 (2.1)	727 (1.9)	425 (1.1)
Damage to house				
None	413 (2.2)	258 (1.4)	233 (1.3)	103 (0.6)
Partial	911 (2.4)	600 (1.6)	559 (1.5)	347 (0.9)
Half	184 (3.5)	129 (2.5)	83 (1.6)	55 (1.1)
More than half	67 (3.4)	48 (2.5)	38 (1.9)	23 (1.2)
Total	126 (3.3)	86 (2.2)	66 (1.7)	43 (1.1)
Loss of family member				
No	552 (3.9)	363 (2.6)	296 (2.1)	199 (1.4)
Yes	1291 (2.3)	825 (1.5)	759 (1.3)	404 (0.7)
Number of years of education				
<12 years (reference)	352 (1.9)	265 (1.4)	223 (1.2)	202 (1.1)
≧12 years	1471 (2.9)	916 (1.8)	822 (1.6)	397 (0.8)

were 2.2%, 1.5%, 1.4% and 0.8%. Exacerbation of most cardiovascular symptoms was higher in subjects whose income decreased due to the disaster compared with those who maintained income levels (3.6% vs 2.4% for exacerbation of headache, 2.0% vs 1.6% for exacerbation of dizziness and 1.7% vs 1.4% for exacerbation of palpitation).

Additionally, exacerbation of most cardiovascular symptoms was higher among individuals who were educated for 12 years or more compared with those who were less educated (2.9% vs 1.9% for exacerbation of headache, 1.8% vs 1.4% for exacerbation of dizziness and 1.6% vs 1.2% for exacerbation of palpitation).

Disaster-related variables

The group that experienced the tsunami and the nuclear power plant accident were more likely to experience exacerbated cardiovascular symptoms. Among those who had experienced the tsunami, 3.2% reported exacerbation of headache, 2.2% of dizziness, 1.7% of palpitations and 1.1% of shortness of breath compared with 2.4%, 1.6%, 1.5% and 0.8%, respectively, among those with no experience of the tsunami. The corresponding statistics for individuals that had heard the nuclear power plant accident were 3.1%, 2.1%, 1.9% and 1.1% compared with 2.1%, 1.2%, 1.0% and 0.6% for those that had not.

Multiple logistic regression analyses

Table 2 summarises the ORs and 95% CIs of each socioeconomic characteristic for exacerbation of headache, dizziness, palpitations and shortness of breath. Living arrangement emerged as a risk factor for exacerbated cardiovascular symptoms from our models, which were adjusted for multiple demographic-, health- and disaster-related variables. Compared with participants living in their own home (OR=1), those living in relatives' homes had a greater probability of experiencing exacerbation of headache (1.58; 95% CI 1.19 to 2.09) and dizziness (1.42; 95% CI 1.02 to 1.98). Similarly, those living in rental houses or apartments had a greater chance of experiencing exacerbatation of headache (1.54; 95% CI 1.32 to 1.80), dizziness (1.45; 95% CI 1.20 to 1.75), palpitations (1.25; 95% CI 1.03 to 1.51) and shortness of breath (1.76; 95% CI 1.35 to 2.28). Participants living in evacuation shelters had an increased probability of experiencing exacerbation of headache (1.80; 95% CI 1.09 to 2.96) and refugees living in temporary housing similarly had an increased likelihood of experiencing exacerbation

Table 2 Odds ratios (PR) and 95% CIs for cardiovascular-related symptoms obtained from multiple logistic regression analyses

		Exacerbation of headache			
		OR (95% CI)*	**OR (95% CI)†**	**OR (95% CI) for men†**	**OR (95% CI) for women†**
Living arrangement	**Own home (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Relatives home	2.03 (1.58 to 2.62)	1.58 (1.19 to 2.09)	1.95 (1.11 to 2.57)	1.46 (1.06 to 2.02)
	Rental house or apartment	–2.21 (1.93 to 2.54)	1.54 (1.32 to 1.80)	1.83 (1.34 to 2.53)	1.46 (1.22 to 1.75)
	Evacuation shelter	2.01 (1.24 to 3.25)	1.80 (1.09 to 2.96)	2.24 (0.99 to 5.16)	1.61 (0.85 to 3.03)
	Temporary housing	2.13 (1.77 to 2.56)	1.42 (1.15 to 1.72)	1.69 (1.11 to 3.43)	1.36 (1.06 to 1.73)
Unemployment	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.70 (1.53 to 1.88)	1.28 (1.12 to 1.46)	1.36 (1.04 to 1.78)	1.26 (1.09 to 1.47)
Income decrease	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.56 (1.40 to 1.74)	1.39 (1.22 to 1.60)	1.39 (1.08 to 1.78)	1.39 (1.17 to 1.63)
Number of years of education	**<12 years (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	≧12 years	1.02 (0.89 to 1.16)	1.04 (0.81 to 1.63)	1.25 (0.91 to 1.73)	0.97 (0.80 to 1.17)
		Exacerbation of dizziness			
		OR (95% CI)*	**OR (95% CI)†**	**OR (95% CI) for men†**	**OR (95% CI) for women†**
Living arrangement	**Own home (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Relatives' home	1.98 (1.46 to 2.69)	1.42 (1.02 to 1.98)	0.96 (0.49 to 1.91)	1.66 (1.13 to 2.43)
	Rental house or apartment	2.27 (1.91 to 2.69)	1.45 (1.20 to 1.75)	1.28 (0.92 to 1.79)	1.55 (1.23 to 1.96)
	Evacuation shelter	1.84 (1.02 to 3.32)	1.39 (0.74 to 2.59)	0.85 (0.26 to 2.77	1.83 (0.87 to 3.84)
	Temporary housing	2.09 (1.68 to 2.61)	1.40 (1.09 to 1.79)	1.51 (1.00 to 2.28)	1.36 (1.00 to 1.85)
Unemployment	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.65 (1.45 to 1.87)	1.26 (1.07 to 1.48)	1.27 (0.94 to 1.73)	1.20 (0.98 to 1.45)
Income decrease	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.37 (1.19 to 1.57)	1.18 (0.99 to 1.40)	1.12 (0.83 to 1.51)	1.22(0.98 to 1.51)
Number of years of education	**<12 years (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	≧12 years	1.17 (1.01 to 1.37)	1.13 (0.94 to 1.36)	1.08 (0.08 to 1.47)	1.14 (0.90 to 1.44)

Continued

Table 2 Continued

		Exacerbation of palpitation			
		OR (95% CI)*	**OR (95% CI)†**	**OR (95% CI) for men†**	**OR (95% CI) for women†**
Living arrangement	**Own home (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Relatives' home	1.70 (1.23 to 2.34)	1.23 (0.87 to 1.74)	1.25 (0.57 to 2.71)	1.21 (0.82 to 1.78)
	Rental house or apartment	1.90 (1.60 to 2.25)	1.25 (1.03 to 1.51)	1.73 (1.17 to 2.53)	1.11 (0.89 to 1.39)
	Evacuation shelter	0.74 (0.30 to 1.80)	0.51 (0.19 to 1.39)	0.93 (0.22 to 3.92)	0.35 (0.09 to 1.45)
	Temporary housing	1.32 (1.03 to 1.69)	0.82 (0.62 to 1.10)	1.19 (0.69 to 2.04)	0.72 (0.51 to 1.01)
Unemployment	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.46 (1.27 to 1.68)	1.21 (1.01 to 1.45)	1.29 (0.91 to 1.83)	1.20 (0.97 to 1.48)
Income decrease	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.24 (1.07 to 1.44)	1.14 (0.94 to 1.38)	1.46 (1.05 to 2.03)	1.00 (0.80 to 1.28)
Number of years of education	**<12 years (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	≧12 years	1.28 (1.09 to 1.50)	1.14 (0.93 to 1.39)	1.15 (0.79 to 1.67)	1.00 (0.81 to 1.23)
		Exacerbation of shorness of breath			
		OR (95% CI)*	**OR (95% CI)†**	**OR (95% CI) for men†**	**OR (95% CI) for women†**
Living arrangement	**Own home (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Relatives' home	1.60 (1.02 to 2.52)	1.16 (0.71 to 1.90)	0.95 (0.42 to 2.16)	1.33 (0.72 to 2.63)
	Rental house or apartment	2.34 (1.85 to 2.96)	1.76 (1.35 to 2.28)	1.50 (1.01 to 2.22)	1.98 (1.39 to 2.81)
	Evacuation shelter	1.33 (0.54 to 3.27)	1.20 (0.48 to 3.00)	1.73 (0.60 to 4.95)	0.52 (0.07 to 3.79)
	Temporary housing	2.29 (1.72 to 3.06)	1.49 (1.07 to 2.08)	1.25 (0.75 to 2.09)	1.72 (1.10 to 2.68)
Unemployment	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.55 (1.29 to 1.87)	1.13 (0.89 to 1.44)	1.06 (0.73 to 1.55)	1.17 (0.85 to 1.60)
Income decrease	**No (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	Yes	1.24 (1.01 to 1.52)	1.14 (0.89 to 1.47)	1.18 (0.83 to 1.69)	1.10 (0.77 to 1.57)
Number of years of education	**<12 years (reference)**	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
	≧12 years	0.94 (0.78 to 1.13)	0.84 (0.67 to 1.06)	0.76 (0.54 to 1.07)	0.90 (0.66 to 1.23)

*Adjusted for age and sex.
†Further adjusted for drinking status (once or more per month, ex-drinker, less than once per month), smoking status (non-smoker, ex-smoker, current smoker), mental health distress (K6 <3, K6>=13), hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or no), physical activities (≧ daily, 2–4 times per week, weekly, never), tsunami experience (yes or no), radiation experience (yes or no), damage to house (none, partial, half, more than half, total), loss of family member (yes or no).

of headache (1.42; 95% CI 1.15 to 1.72), dizziness (1.40; 95% CI 1.09 to 1.79) and shortness of breath (1.49; 95% CI 1.07 to 2.08).

Loss of employment also emerged as a risk factor that increased the probability of cardiovascular symptom exacerbation. Compared with evacuees who remained employed (OR=1), those who lost their employment were at higher risk of experiencing exacerbation of headache (1.28; 95% CI 1.12 to 1.46), dizziness (1.26; 95% CI 1.07 to 1.48) and palpitations (1.21; 95% CI 1.01 to 1.45). In an unadjusted model, we found a significant positive association between unemployment and exacerbation of palpitations; however, after adjusting for multiple relevant variables, this association was not significant.

There was no association between decreased income and exacerbated cardiovascular symptoms, except for headaches. In this case, adjusting for multiple variables resulted in an increased OR for exacerbation of headaches both in an analysis combining the sexes (1.39, 95% CI 1.22 to 1.60) and in separate analyses of men and women. Number of years of education was also not associated with exacerbated cardiovascular symptoms in multiple-adjusted models in the present study.

DISCUSSION

We demonstrated that a decrease in socioeconomic status due to the Great East Japan Earthquake was associated with exacerbated cardiovascular symptoms among evacuees. Compared with participants living in their own home, people of both genders living in relatives' homes, evacuation shelters, temporary housing, or rental houses or apartments were more likely to experience exacerbation of headache, dizziness, palpitations or shortness of breath. Similarly, loss of employment and reduced income due to the disaster increased the risk of experiencing exacerbated symptoms.

The following three points should be considered in the context of our results. First, earthquakes are definitely associated with increased cardiovascular disease, including sudden cardiac death and acute myocardial infarction,[2–14] and our results are consistent with these earlier findings. The Hanshin-Awaji earthquake was associated with increased cardiovascular disease that persisted for longer than a month. Further, an increase in the number of individuals with acute myocardial infarction, especially women, was particularly evident during the 4 weeks immediately following the disaster.[9] After the Great East Japan Earthquake, the incidence of reported cardioembolic stroke increased in the 3–9 months following the disaster,[10] as did the incidence of other cardiovascular diseases.[11–14] Our study contributes to the reported incidence of cardiovascular disease using self-report questionnaires rather than death certificates and by demonstrating that exacerbated cardiovascular symptoms occurred among evacuees after the disaster.

Second, increases in cardiovascular events and exacerbated cardiovascular symptoms can be attributed to post-disaster distress or mental problems. Studies have suggested that extremely stressful experiences, such as earthquakes, can trigger cardiovascular events.[20–22] Acute major stress and chronic stress (ie, the cumulative load of minor daily stress) can have long-term consequences, which can be perceived as stressful themselves and a potential threat to one's environment, thereby inducing a variety of negative emotional responses such as fear, anxiety, sadness, anger, hostility and depression.[4 23] In turn, these emotional responses may lead to hypertension or cardiovascular events.[20–22] A recent study suggests that PTSD was frequently noted in patients with cardiovascular disease 6 months after the Great East Japan Earthquake. The patients with PTSD were more likely to experience a combination of acute myocardial infarction, stroke, heart disease and death.[24] In the current study, all individuals exhibiting exacerbated cardiovascular symptoms were more likely to have depression (K6 ≥13) or PTSD (PCL ≥50). Logistic regression analyses also showed that depression and PTSD were both independently associated with exacerbated cardiovascular symptoms (data not shown).

Third, although post-disaster increases in cardiovascular events were widely reported in previous studies, investigation of socioeconomic factors that influenced these events during the evacuation term of refugees was limited. Previous studies reported that 1 year after the Wenchuan Earthquake in China, depression severity among refugees varied with income, housing status and social support.[25] This indicated that, through its impact on income, the earthquake was indirectly associated with life satisfaction and depression.[26] Another study showed that 6 months after the 2011 Christchurch earthquake in New Zealand, on average lower income per home contributed unequivocally to earthquake-related distress and dysfunction.[27] A recent study also showed that 6 months after the Great East Japan Earthquake tsunami experience, property loss and poverty were associated with PTSD in patients with cardiovascular disease and had an adverse prognostic impact.[24]

This study showed that living in evacuation shelters or temporary housing, rather than one's own home, was associated with exacerbation of all the examined cardiovascular symptoms, and the statistical results were more robust in women than in men. Evacuation shelters and temporary housing were less spacious, damper and less comfortable than refugees' homes.

Due to insufficient access to supermarkets or shortages of cooking equipment and utilities such as gas, evacuees living in shelters may not have access to balanced meals. A recent cross-sectional study showed a well-balanced diet was associated with better living conditions among refugees after the Great East Japan Earthquake whereas imbalanced diets were not.[28 29] Furthermore, the simple fact of being unable to stay in one's own home and requiring refuge accommodation meant that one's neighbourhood had been damaged during the disaster, and this may have led to insufficient social support. All

of the above factors can be considered predictors of stress among refugees, and this may affect women more strongly than men.

Unemployment and decreased income due to the disaster were also associated with the exacerbation of some cardiovascular symptoms. These results were predictable as poor economic circumstances are expected to exacerbate depression. Low income may be considered a chronic stressor, increasing psychological distress as a result of limited access to resources and opportunities for accumulation of resources.[27]

Previous studies have shown that, following an earthquake, living in a low-income area may contribute to greater psychological distress due to a lack of occupational, social and financial resources. A community study revealed that, after the Christchurch earthquake, low household income contributed strongly to earthquake-related distress.[27] In the present study, we found a significant association between disaster-related unemployment and exacerbation of some cardiovascular symptoms. However, the subsistence allowance given to refugees by the Japanese government may have reduced this effect by reducing the impact of refugees' lowered economic circumstances.

Educational level was inversely associated with cardiovascular disease risk in previous studies.[30 31] However, in our study, the number of years that individuals had been educated was not associated with exacerbated cardiovascular symptoms. This may be due to post-disaster conditions. In the present study, factors related to the earthquake, tsunami and the nuclear accident, and unemployment or decreased income due to the disasters had a large influence on exacerbated cardiovascular symptoms. This result may have superseded any potential impact of education levels.

Our understanding of disaster-related stress on cardiovascular disease remains incomplete. A clinical study from the 1995 Hanshin-Awaji earthquake compared blood pressure levels before and after the earthquake in patients with well-controlled hypertension and showed an 18 mm Hg increase in diastolic blood pressure 2 weeks after the earthquake.[32] Although 'white-coat hypertension' (patients exhibiting increased blood pressure in clinical settings) partly contributed to the results, some patients developed sustained hypertension that persisted for 1 year after the earthquake.[32] One study found that there were increased levels of cholesterol and triglycerides in patients a few weeks after an earthquake,[3] whereas another study failed to show significantly higher total cholesterol or HDL-cholesterol during the 2 weeks following the Hanshin-Awaji earthquake.[6] Thus, the extent to which changes in the blood lipid profile contribute to exacerbated cardiovascular symptoms several months after the Great East Japan Earthquake remains unknown. Chronic psychological stress is also associated with increased insulin resistance.[4] A recent study after the Great East Japan Earthquake found that the negative effects of the disaster on metabolic factors were greater among evacuees than non-evacuees,[33] which may also contribute to the occurrence of exacerbated cardiovascular symptoms among evacuees.

Although the results of the present study are limited to residents in the Fukushima prefecture after the Great East Japan Earthquake, it could provide inspiration for future studies among evacuees after disasters. In addition, our study suggests that early improvements in the provision of living conditions for evacuees could be achieved in several ways: providing speedy restorations of the access to their own homes; providing more employment opportunity for evacuees; and providing more financial support. For future disasters, the present study provides an epidemiological basis for governments and authorities to act as soon as possible for preparation.

The large scale of the assessment and assessment under post-disaster conditions provides considerable credibility for the present study. Additionally, our study is the first to identify an inverse relationship between low socioeconomic status and exacerbated cardiovascular symptoms from an evacuee self-report questionnaire after a disaster; thus, our results will be useful for generating guidelines for evacuee health. However, the following limitations of this study should be considered. First, the study was based on a subjective self-response survey. However, it is reasonable to expect respondents to understand that the studied symptoms are related to stress and/or autonomic nervous system disorders. Further information, such as the incidence of cardiovascular disease, should be captured. Although the studied symptoms are not necessarily logical predictors of cardiovascular disease, several previous studies have shown that headaches are suggestive of an incremental risk of stroke,[34 35] and other studies have also shown that vertigo or dizziness and chest pain are associated with cardiovascular problems.[36 37] We also conducted an analysis on a subsample of individuals' self-reported information, which suggested that all of the discussed symptoms were associated with a diagnosis of hypertension in the previous year, and that exacerbation of dizziness, palpitations and shortness of breath were associated with a diagnosis of heart disease in the last year (data not shown). Therefore, our study of these four symptoms may be helpful for developing plans to improve evacuees' health to some extent.

Second, both the Great East Japan Earthquake and also the accompanying nuclear accident had a large psychological impact on the evacuees. Because of this unusual situation, the present study is not entirely comparable with other studies. Third, the overall response rate to the questionnaires was low (40.7%) and sampling skews may have resulted in biased data.

Fourth, under the unusual social circumstances that follow a major disaster, the health symptoms perceived by evacuees may be strongly influenced by changes in family relationships (eg, death and physical separation) among the evacuees. However, the present study did not capture these data. Moreover, other socioeconomic factors, such as household income, and other cardiovascular risk factors,

such as blood pressure and cholesterol levels, were also not captured in the present study. Additionally, although most questionnaires were collected in the same period (from January to March 2012), it is possible that the timing of the survey affected the perceived cardiovascular symptoms. Finally, other environmental factors such as temperature, food supplies and medical facilities may also affect cardiovascular problems.[38 39] These data were also not collected in the present study. The potential associations observed in this study will be further investigated over an extended period.

In conclusion, the present study was the first to identify a relationship between lower socioeconomic status due to the Great East Japan Earthquake and exacerbated cardiovascular symptoms among evacuees. Our findings will provide baseline information for future periodic health examinations and for the development of health guidelines for evacuees.

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