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## Associations of socioeconomic factors after a disaster with cardiovascular related symptoms: the Fukushima Health Management Survey

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Keywords:	Great East Japan Earthquake, socioeconomic factors, cardiovascular related symptoms

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1 **Associations of socioeconomic factors**  
2 **after a disaster with cardiovascular**  
3 **related symptoms: the Fukushima**  
4 **Health Management Survey**

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49 **Abstract**

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

53 **Methods:** A total of 73,433 subjects were included in the Fukushima Health  
54 Management survey. Exacerbation of headache, dizziness, palpitations, and shortness  
55 of breath were determined from self-report questionnaires. Socioeconomic factors  
56 included living arrangement, loss of employment and decreased income. Odds ratios  
57 (OR) and 95% confidence intervals (CI) of socioeconomic factors were estimated for  
58 each symptom using multiple logistic regression analyses.

59 **Results:** A total of 1,375 individuals reported exacerbation of headache, 881 of  
60 dizziness, 768 of palpitations, and 434 of shortness of breath. Evacuation  
61 accommodation was associated with all the above symptoms. Compared to participants  
62 living in their own home (OR=1.00), subjects living in relatives' homes had increased  
63 odds of experiencing exacerbation of headache (1.58; 95% CI 1.20–2.09) and dizziness  
64 (1.43; 95% CI 1.02–1.98); subjects living in temporary housing or apartments showed  
65 exacerbation of headache (1.55; 95% CI 1.32–1.81), dizziness (1.45; 95% CI 1.20–  
66 1.76), palpitations (1.25; 95% CI 1.03–1.51), and shortness of breath (1.75; 95% CI  
67 1.35–2.27); subjects living in evacuation shelters showed exacerbation of headache  
68 (1.80; 95% CI 1.10–2.97); and refugees living in temporary housing showed  
69 exacerbated headache (1.42; 95% CI 1.15–1.75), dizziness (1.39; 95% CI 1.08–1.78),  
70 and shortness of breath (1.50; 95% CI 1.07–2.09). Compared to the evacuees that  
71 retained their jobs, unemployed subjects showed increased odds for exacerbation of  
72 headache (1.28, 95% CI 1.12–1.46), dizziness (1.26, 95% CI 1.07–1.48), and

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6 73 palpitations (1.22, 95% CI 1.02–1.46). Decreased income was associated with  
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8 74 exacerbation of headache (1.39, 95% CI 1.21–1.60).

9  
10 75 **Conclusion:** After the earthquake, living in non-home conditions was more likely to  
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12 76 exacerbate cardiovascular symptoms among evacuees. Loss of employment was  
13  
14 77 another risk factor for exacerbated headache and dizziness.  
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21 80 **Keywords:** Great East Japan Earthquake, socioeconomic factors, cardiovascular related

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6 97 **Strengths and limitations of this study**  
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- 8 ● We examined the associations of socioeconomic factors after a disaster with  
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10 cardiovascular related symptoms among evacuees of the number of 73,433  
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12 subjects after the Great East Japan earthquake.  
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14 ● Our study is the first to identify an inverse relationship between low socioeconomic  
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16 status and exacerbated cardiovascular symptoms from an evacuee self-report after  
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18 a disaster.  
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20 ● A limitation of the present study was an overall response rate was low (40.7%) and  
21  
22 data may have contained sampling biases.  
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24 ● Another limitation of the present study should be that the information of changes in  
25  
26 family relationships (e.g., death, physical separation) among the evacuees after the  
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28 disaster has not been captured.  
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30 ● In addition, most questionnaires were collected in the same period (from Jan 2012  
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32 to Mar 2012).  
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6 121 **Introduction**

7 122 The Great East Japan Earthquake and the subsequent Fukushima Daiichi nuclear  
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9 123 disaster, which occurred in March 2011, was the most destructive catastrophe in Japan  
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11 124 to date. Due to concerns over released radiation, most of the residents in nearby towns  
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13 125 were forced to evacuate and consequently suffered long-lasting anxiety. Shortly after  
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15 126 the disaster, a Fukushima Health Management Survey was conducted to investigate the  
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17 127 effects of long-term low-dose radiation exposure caused by the accident and to assess  
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19 128 the physical and mental wellbeing of evacuees. This survey included a basic survey,  
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21 129 which estimated individual radiation exposure of each resident, and four detailed  
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23 130 surveys comprising of a Comprehensive Health Check and thyroid ultrasonography, a  
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25 131 mental health and lifestyle survey, and a survey of pregnant women and nursing  
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27 132 mothers (1). The Mental Health and Lifestyle Survey used self-report questionnaires to  
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29 133 investigate health status and lifestyle of the refugees, including nutrition and diet,  
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31 134 perceived symptoms of illness, disaster-related experience, and socioeconomic  
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33 135 determinants.

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38 136 Several previous studies have shown changes in the incidence of cardiovascular  
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40 137 events following disasters; however, results are conflicting (2-11). A recent study  
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42 138 reported a heterogeneous occurrence of cardiovascular events after the Great East  
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44 139 Japan Earthquake (2), while another study reported a significant increase in the  
45  
46 140 incidence of cardioembolic stroke after the earthquake (11). However, neither study  
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48 141 examined the incidence of perceived cardiovascular disease symptoms after a disaster,  
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50 142 nor did they focus on the effect of refugee socioeconomic status on health problems  
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52 143 during their evacuation term. However, considering these aspects is relevant for  
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6 144 reviewing refugee health status, accessing the incidence of various diseases, and  
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8 145 providing health guidelines for refugees.  
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10 146 Consequently, we conducted the present study to investigate the risk factors of  
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12 147 perceived cardiovascular symptoms following a major disaster. We hypothesized that a  
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14 148 decrease in socioeconomic status due to the earthquake would be associated with  
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16 149 exacerbated cardiovascular symptoms among evacuees.  
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## 21 151 **Methods**

### 22 152 **Participants**

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25 153 The primary purpose of the Fukushima Health Management Survey was to monitor  
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27 154 the long-term health and lifestyle of Fukushima residents and to provide them with  
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29 155 appropriate care (12). The Fukushima Health Management Survey consists of a basic  
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31 156 survey and four detailed surveys, namely, the thyroid ultrasound examination,  
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33 157 comprehensive health check, mental health and lifestyle survey, and pregnancy and  
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35 158 birth survey (for details of these surveys see (1)). The subjects of mental health and  
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37 159 lifestyle survey was included in the present study. Briefly, the target population, consists  
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39 160 of 210,189 officially registered victims of the Great East Japan Earthquake from the  
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41 161 evacuation zones Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village,  
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43 162 Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City,  
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45 163 Yamakiya District of Kawamata Town, and Iitate Village. In 2012, 180,604  
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47 164 questionnaires were sent out with 73,569 questionnaires returned with responses, i.e. a  
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49 165 response rate of 40.7%. Among the responders, 136 were excluded due to blank or  
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51 166 duplicated questionnaires and 9,245 for questionnaires filled in by a proxy. After  
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6 167 exclusion, the data of 73,433 subjects (32,301 men and 41,132 women) were used in  
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8 168 our analyses.

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10 169 The study protocol was approved by the Ethics Committee of Fukushima Medical  
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12 170 University. Participants who returned the self-administered questionnaires were  
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14 171 considered to have consented to participate.  
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### 18 173 **Data collection and measurement**

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20 174 A questionnaire was used to broadly investigate the health status and lifestyle of  
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22 175 the refugees. The exacerbation of headache, dizziness, palpitations, and shortness of  
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24 176 breath was determined based on self-reports in the questionnaire. All subjects were  
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26 177 asked to answer the question 'Do you have the following perceived symptoms after the  
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28 178 earthquake?' and could choose between the replies 'No', 'Yes', and 'Exacerbation'. In  
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30 179 the present study we focused on reports of 'exacerbation'.  
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34 180 To evaluate Posttraumatic Stress Disorder (PTSD) symptoms we used the  
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36 181 non-military version of the Posttraumatic Stress Disorder Checklist (PCL-S) (12). This is  
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38 182 a 17-item self-report checklist based on the Diagnostic and Statistical Manual of Mental  
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40 183 Disorders (4th edition, DSM-IV) criteria (13), with each item rated using a Likert-type  
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42 184 scale from one ('not at all') to five ('extremely'). Respondents were requested to  
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44 185 respond to questions about each PTSD symptom separately and report whether they  
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46 186 had experienced a given symptom during the past month. Based on summing the  
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48 187 scores from each of the 17 items, a total PCL-S score can range from 17 to 85 (12).  
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51 188 In addition to the PCL-S checklist, the following items were included in the  
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53 189 self-assessment and self-report questionnaires:

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56 190 1. Demographic characteristics  
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6 191 Demographic subject characteristics include gender, age group, mental health  
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8 192 status, history of mental illness, incidence of PTSD symptoms, smoking and drinking  
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10 193 habits, and current physical activity levels. Age groups were divided into childbearing  
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12 194 age (20–49 years), middle age (50–64 years), and old age (65 years and above).

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14 195 Mental health status, and specifically incidence and severity of depression, was  
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16 196 measured by the Japanese version of the K6 Kessler Psychological Distress Scale,  
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18 197 which has been validated by previous studies (14, 15). In the K6 assessment,  
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20 198 participants were asked if they had experienced any of the following six symptoms  
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22 199 during the past 30 days: feeling so depressed that nothing could cheer them up, feeling  
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24 200 that everything was an effort, or feeling nervous, hopeless, restless, fidgety, or  
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26 201 worthless. Each question was rated on a 5-point Likert-type scale from zero (none of the  
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28 202 time) to four (all of the time), with higher scores signifying worse mental health status  
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30 203 (total range: 0–24) (12). In addition, we assessed participant's history of mental illness  
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32 204 by self-report as 'yes' or 'no'.  
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36 205 We obtained data on smoking and drinking habits using the following metrics,  
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38 206 respectively: 'non-smoker', 'ex-smoker', or 'current smoker'; and 'once or more per  
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40 207 month', 'less than once per month', or 'ex- drinker'. Participants had four options to  
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42 208 assess current physical activity level: 'every day', '2-4 times/week', 'once a week', or  
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44 209 'nearly none'.  
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## 46 210 2. Socioeconomic variables

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49 211 Participants were required to select from six options regarding their living  
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51 212 arrangements: evacuation shelter, temporary housing, rental housing or apartment, a  
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53 213 relative's home, their own home, and other. For analysis, evacuation shelters and  
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6 214 temporary housing were combined due to their similarity, and the last option was  
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8 215 considered non-informative due to its ambiguity and thus excluded from analysis.  
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10 216 Other socioeconomic variables included change in employment status and change in  
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12 217 income. By answering 'Yes' to either question, the participant indicated he/she became  
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14 218 unemployed or experienced decreased income since the disaster.

### 16 219 3. Disaster-related variables

18 220 Disaster-related variables included experience of the tsunami (yes or no), experience  
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20 221 of the nuclear power plant accident (defined as hearing the explosion; yes or no), losing  
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22 222 someone close because of the disaster (yes or no), and damage to accommodation (no,  
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24 223 partial damage, half of accommodation destroyed, more than a half destroyed, total  
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26 224 destruction).

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### 31 226 **Statistical analysis**

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34 227 The incidence of exacerbation of headache, dizziness, palpitations, and shortness of  
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36 228 breath was compared between subjects with different demographic, socioeconomic,  
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38 229 and disaster-related characteristics using chi-square tests. For the analyses  
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40 230 investigating PTSD incidence, a PCL-S cut-off score of 50 was used, according to  
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42 231 Weathers et al (16). Subjects who received a PCL-S of 50 or greater were allocated to  
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44 232 the 'high-scoring group' and compared to the low-scoring (PCL-S < 50) group using  
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46 233 chi-square tests.

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49 234 Odds ratios (ORs) and 95% confidence intervals (CIs) of each socioeconomic  
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51 235 determinant (living arrangement, unemployment, and decreased income) were  
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53 236 estimated by applying multiple logistic regression models. Adjustment variables  
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55 237 consisted of sex (male, female), age (20–49, 50–64, ≥65 years), drinking status (once or  
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6 238 more per month, ex-drinker, less than once per month), smoking status  
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8 239 (non-smoker, ex-smoker, current smoker), mental health distress (K6<3, K6>=13),  
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10 240 hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or  
11  
12 241 no), physical activities (>= once per day, 2–4 times per week, once per week, never),  
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14 242 tsunami experience (yes or no), radiation experience (yes or no), damage of  
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16 243 accommodation (no, partial, half, more than a half, total), loss of family member (yes or  
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18 244 no).

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21 245 We conducted the above analyses both for separate and combined sexes. All  
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23 246 analyses were conducted using SAS software version 9.4 (SAS Institute Inc., Cary, NC,  
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25 247 USA).

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## 28 29 249 **Results**

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32 250 As shown in the tables, 1,893 individuals reported exacerbation of headaches, 1,229  
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34 251 of dizziness, 626 of palpitations, and 434 exacerbation of shortness of breath.

## 35 36 252 **Demographic characteristics**

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38 253 Table 1 summarizes the demographic characteristics of the subjects. Exacerbation of  
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40 254 the above cardiovascular symptoms was significantly more likely to happen in women  
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42 255 than in men (3.5% vs. 1.4% for headaches; 2.2% vs. 1.1% for dizziness; 2.0% vs. 0.9%  
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44 256 for palpitations; 0.9% vs. 0.8% for shortness of breath). Subjects experiencing  
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46 257 exacerbation of headaches, dizziness, or palpitations were more likely to be young (20–  
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48 258 49 years), while those experiencing exacerbation of shortness of breath were more  
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50 259 likely to be old (>=65 years). Subjects experiencing exacerbation of cardiovascular  
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52 260 symptoms were also more likely to suffer from depression (K6>=13) and Posttraumatic  
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54 261 Stress Disorder (PCL>=50), and to commonly have a history of hypertension, stroke, or

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6 262 heart disease. Non-smokers and non-drinkers were no less likely than (ex-) smokers or  
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8 263 (ex-) drinkers to experience exacerbation of cardiovascular symptoms. However,  
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10 264 symptom exacerbation was most pronounced in subjects who were physically active  
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12 265 less than once a day.

### 14 266 **Socioeconomic variables**

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17 267 Table 1 also shows refugees living in their own or a relative's home are less likely to  
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19 268 experience exacerbated cardiovascular symptoms. Of the refugees living in their own  
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21 269 home, 1.4% reported exacerbation of headache, 0.9% of dizziness, 1.6% of palpitations  
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23 270 and 1.0% of shortness of breath. The corresponding statistics for refugees living in  
24  
25 271 temporary housing and rental houses/apartments were 2.8%, 1.9%, 1.3%, and 1.2%  
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27 272 and 3.5%, 2.1%, 1.8%, and 1.0%, respectively.

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30 273 In the group that became unemployed due to the disaster, 4.2% subjects reported  
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32 274 the exacerbation of headache, 2.5% of dizziness, 2.1% of palpitations and 1.1% of  
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34 275 shortness of breath, while the corresponding statistics for the group that did not lose  
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36 276 their jobs after the disaster were 2.2%, 1.5%, 1.3%, and 0.8%. In addition, exacerbation  
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38 277 of most cardiovascular symptoms was higher in subjects whose income decreased due  
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40 278 to the disaster compared to those who maintained income levels (3.6% vs. 2.4% for  
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42 279 exacerbation of headache, 2.0% vs. 1.6% for exacerbation of dizziness, and 1.7% vs.  
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44 280 1.4% for exacerbation of palpitation).

### 47 281 **Disaster-related variables**

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50 282 Subjects that directly experienced the tsunami and the nuclear power plant accident  
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52 283 were more likely to experience exacerbated cardiovascular symptoms. Among those  
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54 284 experiencing the tsunami, 3.2% reported exacerbation of headache, 2.2% of dizziness,  
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56 285 1.7% of palpitations, and 1.7% of shortness of breath, compared to 2.4%, 1.6%, 1.5%,  
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6 286 and 0.8%, respectively, of subjects with no experience of the tsunami. The  
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8 287 corresponding statistics for subjects that had heard the nuclear power plant accident  
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10 288 were 3.1%, 2.1%, 1.9%, and 1.1% compared to 2.1%, 1.2%, 1.0%, and 0.6%, that had  
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12 289 not.

### 290 **Multiple Logistic Regression analyses**

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17 291 Table 3 summarizes the odds ratios (ORs) and 95% CIs of each socioeconomic  
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19 292 determinant for exacerbation of headache, dizziness, palpitations, and shortness of  
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21 293 breath. Living arrangement emerged as a risk factor for exacerbated cardiovascular  
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23 294 symptoms from our models, which were adjusted for multiple demographic-, health-,  
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25 295 and disaster-related variables. Compared to participants living in their own home (OR =  
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27 296 1), those living in relatives' homes had higher odds to experience exacerbation of  
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29 297 headache (1.58; 95% CI 1.20–2.09) and dizziness (1.43; 95% CI 1.02–1.98). Similarly,  
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31 298 subjects living in temporary housing or apartments had higher odds of exacerbated  
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33 299 headache (1.55; 95% CI 1.32–1.81), dizziness (1.45; 95% CI 1.20–1.76), palpitations  
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35 300 (1.25; 95% CI 1.03–1.51), and shortness of breath (1.75; 95% CI 1.35–2.27).  
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37 301 Participants living in evacuation shelters had increased odds of exacerbation of  
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39 302 headache (1.80; 95% CI 1.10–2.97) and refugees living in temporary housing similarly  
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41 303 had increased odds of exacerbation of headache (1.42; 95% CI 1.15–1.75), dizziness  
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43 304 (1.39; 95% CI 1.08–1.78), and shortness of breath (1.50; 95% CI 1.07–2.09).

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45 305 Loss of employment also emerged as a risk factor for increased odds of  
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47 306 cardiovascular symptoms. Compared to the evacuees that remained employed (OR =  
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49 307 1), subjects that had become unemployed were at higher risk of experiencing  
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51 308 exacerbation of headache (1.28; 95% CI 1.12–1.46), dizziness (1.26; 95% CI 1.07–  
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53 309 1.48), and palpitation (1.22; 95% 1.02–1.46). In an unadjusted model, we found a  
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6 310 significant positive association between unemployment and exacerbation of  
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8 311 palpitations; however, after adjusting for multiple relevant variables, this association  
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10 312 became non-significant.

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12 313 There was no association between decreased income and exacerbated  
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14 314 cardiovascular symptoms, except for headache. Here, adjusting for multiple variables  
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16 315 resulted in an increased odds ratio for exacerbation of headaches both in an analysis  
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18 316 combining both sexes (1.39, 95% CI 1.21–1.60) and in separate analyses of men and  
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21 317 women.

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## 24 25 319 **Discussion**

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27 320 We have demonstrated a decrease in socioeconomic status due to the earthquake  
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29 321 was associated with exacerbated cardiovascular symptoms among evacuees of the  
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31 322 Great East Japan Earthquake. Compared with participants living in their own home,  
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33 323 people of both genders living in relatives' homes, evacuation shelters, temporary  
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35 324 housing, or rental houses or apartments were more likely to experience exacerbated  
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37 325 headache, dizziness, palpitations, or shortness of breath. Similarly, loss of employment  
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39 326 and reduced income due to the disaster increased the risk of exacerbated symptoms.

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42 327 The following three points should be considered in the context of our results. Firstly,  
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44 328 earthquakes are definitely associated with increased cardiovascular disease, including  
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46 329 sudden cardiac death and acute myocardial infarction (2-11), which provides some  
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48 330 support for the present study. The Athens earthquake, the Newcastle earthquake of  
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50 331 Australia, and the Northridge Earthquake (NEQ) of Los Angeles were all associated with  
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52 332 increased deaths due to cardiovascular disease (4), though this increase was limited to  
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54 333 only a few days post-disaster (4). Increased cardiovascular disease subsequent to the  
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6 334 Hanshin-Awaji earthquake persisted for more than a month. In addition, an increase in  
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8 335 the number of subjects with acute myocardial infarction, especially in women, was  
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10 336 particularly evident during the first 4 weeks post-disaster (10). After the Great East  
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12 337 Japan Earthquake, the incidence of reported cardioembolic stroke increased in the first  
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14 338 3–9 months following the disaster (11), as did the incidence of heart failure and other  
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16 339 cardiovascular diseases (6). Our study contributes to the reported incidences of  
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18 340 cardiovascular disease by demonstrating exacerbated cardiovascular symptoms among  
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20 341 evacuees after a disaster from self-report questionnaires rather than from death  
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22 342 certificates.

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25 343 Secondly, increases in cardiovascular events and exacerbated cardiovascular  
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27 344 symptoms can be attributed to post-disaster distress or mental problems. A review  
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29 345 suggests that extremely stressful experiences, such as earthquakes, can trigger  
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31 346 cardiovascular events (17-19). Acute major stress and chronic stress, i.e. the  
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33 347 cumulative load of minor daily stress, can have both long-term consequences, which  
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35 348 can be perceived as stressful and a potential threat to one's environment, subsequently  
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37 349 inducing a variety of negative emotional responses, such as fear, anxiety, sadness,  
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39 350 anger, hostility, and depression (5,20) leading to hypertension or cardiovascular events  
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41 351 (17-19). In the current study, all subjects exhibiting exacerbated cardiovascular  
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43 352 symptoms were more likely to have depression ( $K6 \geq 13$ ) or Posttraumatic Stress  
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45 353 Disorder ( $PCL \geq 50$ ). Logistic regression analyses also showed that depression and  
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47 354 Posttraumatic Stress Disorder were both independently associated with exacerbated  
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49 355 cardiovascular symptoms (data not shown).

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53 356 Thirdly, although post-disaster increases in cardiovascular events were widely  
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55 357 reported in previous studies, the investigation of socioeconomic determinants of these

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6 358 events during the evacuation term of refugees was very limited. Previous studies  
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8 359 reported that one year after the Wenchuan Earthquake in China, depression severity  
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10 360 among refugees varied with income, housing status, and social support (21), indicating  
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12 361 that earthquake impact on income was indirectly associated with life satisfaction and  
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14 362 depression via its effect on financial status (22). Another study showed that six months  
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16 363 after the 2011 Christchurch earthquake in New Zealand, on average lower income per  
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18 364 home contributed unequivocally to earthquake-related distress and dysfunction (23).

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21 365 In the present study, not living in the own home but living in evacuation shelters or  
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23 366 temporary housing, was associated with exacerbation of all examined cardiovascular  
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25 367 symptoms, which was more robust in women than in men. Evacuation shelters and  
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27 368 temporary housing were less spacious, damper, and less comfortable than the refugees'  
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29 369 homes. Due to insufficient access to supermarkets or shortages of cooking equipment  
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31 370 and utilities, such as gas, evacuees living in shelters would struggle to access balanced  
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33 371 meals. A recent cross-sectional study showed a well-balanced diet was associated with  
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35 372 better living conditions among refugees after the Great East Japan Earthquake,  
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37 373 whereas imbalanced diets, particularly with regard to meat content, were not (24). In  
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39 374 addition, having to take refuge in accommodation other than the own home meant that  
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41 375 the own neighborhood had been damaged by the disaster, which may lead to shortness  
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43 376 of social support. In addition, among the refugees. All of the above factors can be  
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45 377 considered predictors of stress among refugees, where women may be more likely to  
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47 378 be influenced than men.

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51 379 Unemployment and decreased income due to the disaster were also associated with  
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53 380 exacerbation of some cardiovascular symptoms. These results were expected as poor  
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55 381 economic circumstances are expected to exacerbate depression. Low income may be  
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6 382 considered a chronic stressor, increasing psychological distress as a result of limited  
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8 383 resource access and opportunities for resource accumulation (23). Previous studies  
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10 384 also showed that, following an earthquake, living in a low-income area may contribute to  
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12 385 greater psychological distress due to lack of occupational, social, and financial  
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14 386 resources. A community study showed that, after the Christchurch earthquake, low  
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16 387 household income contributed strongly to earthquake-related distress (23). In the  
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18 388 present study, we found a significant association between disaster-related  
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20 389 unemployment and exacerbation of some cardiovascular symptoms, but the  
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22 390 subsistence allowance provided to refugees by the Japanese government may have  
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24 391 reduced effect size by reducing the impact of lowered economic circumstances on  
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26 392 refugees.

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29 393 Our understanding of disaster-related stress on cardiovascular disease remains  
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31 394 incomplete. A clinical study on the 1995 Hanshin-Awaji earthquake comparing pre- and  
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33 395 post- BP levels in well-controlled hypertension patients showed an increase of 18mmHg  
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35 396 in diastolic blood pressure two weeks after the earthquake (25). Although white-coat  
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37 397 hypertension contributed partly to the results, whereby patients exhibit increased blood  
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39 398 pressure in clinical settings, some patients developed sustained hypertension that  
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41 399 persisted for one year after the earthquake (25). One study found increased levels of  
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43 400 cholesterol and triglycerides a few weeks after an earthquake (3), whereas other studies  
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45 401 failed to show significantly higher total cholesterol or HDL-cholesterol during the first two  
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47 402 weeks after the Hanshin-Awaji earthquake (7). Therefore, the extent to which changes  
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49 403 in blood lipid profile contributes to exacerbated cardiovascular symptoms several  
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51 404 months after the Great East Japan Earthquake remains undetermined. Chronic  
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53 405 psychological stress is also associated with increased insulin resistance (5). A recent  
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6 406 study after the Great East Japan Earthquake found the negative effects of the disaster  
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8 407 on metabolic factors were greater among evacuees than non-evacuees (26), which may  
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10 408 contribute to exacerbated cardiovascular symptoms among evacuees.

11  
12 409 The large scale of assessment and assessment under post-disaster  
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14 410 conditions provide considerable authority for the present study. In addition, our study is  
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16 411 the first to identify an inverse relationship between low socioeconomic status  
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18 412 and exacerbated cardiovascular symptoms from an evacuee self-report after a disaster;  
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20 413 our results will be useful for generating guidelines for evacuee health. However, the  
21  
22 414 following study limitations should be considered: Firstly, the overall response rate was  
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24 415 low (40.7%) and data may have contained sampling biases. Secondly, under the  
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26 416 extraordinary and unusual social circumstances that follow a major disaster, health  
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28 417 symptoms perceived by evacuees may be strongly influenced by changes in family  
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30 418 relationships (e.g., death, physical separation) among the evacuees. However, the  
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32 419 present study did not capture this information. The potential associations observed in  
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34 420 this study will be investigated over an extended period. Thirdly, although most  
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36 421 questionnaires were collected in the same period (from Jan 2012 to Mar 2012), it is  
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38 422 possible the timing of the survey affected the perceived cardiovascular symptoms.  
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423 In conclusion, the present study was the first to identify a relationship between lower  
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45 424 socioeconomic status due to the earthquake with exacerbated cardiovascular  
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47 425 symptoms among evacuees after the Great East Japan Earthquake. Our findings will  
48  
49 426 inform future periodic health examinations and health guidelines for evacuees.  
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56 429 **Acknowledgements**

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7  
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9  
10 432 Nuclear Incident.'

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14 434 **Contributors**

15  
16 435 WZ and TO designed the study. TO, SY, MM, MH, NH, YS, HY, MH, HT and AO were  
17  
18 436 responsible for the data collection and overseeing study procedures. The analyses was  
19  
20 437 conducted by WZ and TO. The manuscript was made by WZ. All the authors did contribution  
21  
22 438 to the revision of the manuscript. All the authors read and approved the final version of the  
23  
24 439 manuscript.

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29 441 **Declaration of interests**

30  
31 442 We declare that we have no competing interests.

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36 444 **Patient consent**

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38 445 Obtained.

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43 447 **Data sharing statement**

44  
45 448 No additional data are available.

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55 453 **References**

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541 Table 1. Characteristics of survey participants and correlated incidence of exacerbation of  
542 the Post Traumatic Stress Disorder syndromes headache (first table), dizziness (second  
543 table), palpitations (third table), and shortness of breath (fourth table). P values indicate  
544 outcomes of Chi-square tests of participants with PCL-S  $\geq 50$ .

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	No	Yes	Exacerbation of headache	P
<b>Sex</b>	No. (%)	No. (%)	No. (%)	
Men	28,553 (88.4)	3,282 (10.2)	466 (1.4)	<0.001
Women	31,408 (76.4)	8,297 (20.2)	1,427 (3.5)	
<b>Age</b>				
15-49	18,998 (75.9)	5,063 (20.2)	966 (3.9)	<0.001
50-64	17,470 (81.9)	3,356 (15.7)	514 (2.4)	
>=65	23,493 (86.8)	3,160 (11.7)	413 (1.5)	
<b>Mental Health Status</b>				
K6<13	53,897 (85.1)	8,370 (13.2)	1,092 (1.7)	<0.001
K6>=13	6,064 (60.2)	3,209 (31.9)	801 (8.9)	
<b>Post Traumatic Stress Disorder</b>				
No	53,560 (85.0)	8,374 (13.3)	1,062 (1.7)	<0.001
Yes	6,401 (61.3)	3,205 (30.7)	831 (8.0)	
<b>Smoking Status</b>				
Never-smoker	32,452 (80.4)	6,819 (16.9)	1,104 (2.7)	<0.001
Ex-smoker	13,541 (85.6)	1,948 (12.3)	338 (2.1)	
Current smoker	11,826 (80.8)	2,414 (16.5)	403 (2.8)	
<b>Drinking Status</b>				
Never-drinker	29,746 (79.8)	6,473(17.4)	1,067 (2.9)	<0.001
Ex-drinker	2,259 (83.1)	381 (14.0)	80 (2.9)	
Current drinker	26,366 (83.6)	4,451 (14.1)	715 (2.3)	
<b>Physical activity</b>				
>= once per day	9,266 (87.6)	1,136 (10.7)	179 (1.7)	<0.001
2-4 times per week	12,085 (83.9)	2,008 (13.9)	309 (2.2)	
Once per week	8,159 (82.4)	1,512 (15.3)	234 (2.4)	
Never	28,452 (78.5)	6,633 (18.3)	1144 (3.2)	
<b>Hypertension History</b>				
No	34,634 (80.8)	7,002 (16.3)	1,216 (2.8)	<0.001
Yes	25,327 (82.8)	4,577 (15.0)	677 (2.2)	
<b>Stroke History</b>				
No	56,835 (81.7)	10,945 (15.7)	1,799 (2.6)	0.580
Yes	3,126 (81.1)	634 (14.5)	94 (2.4)	
<b>Heart Disease History</b>				
No	54,199 (81.9)	10,268 (15.5)	1,691 (2.6)	<0.001

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5	Yes	5,762 (79.2)	1,311 (18.0)	202 (10.7)	
6	<b>Unemployment</b>				
7					
8	No	49,300 (83.3)	8,599 (14.5)	1,293 (2.2)	<0.001
9					
10	Yes	10,661 (74.9)	2,980 (20.9)	600 (4.2)	Exacerbation of P
11	No		Yes		dizziness
12	<b>Decreased income</b>				
13	<b>Sex</b>				
14	No	49,841 (82.4)	9,208 (15.2)	1,432 (2.9)	<0.001
15	Yes	10,120 (78.1)	2,371 (18.3)	461 (3.6)	
16	<b>Living arrangement</b>				
17	Evacuation Shelter	610 (83.1)	106 (14.4)	213 (2.5)	<0.001
18	Temporary housing	5,674 (81.3)	1,107 (15.9)	195 (2.8)	
19	Rental house, apartment	18,133 (78.6)	4,153 (18.0)	796 (3.5)	
20	Relatives' home	2,252 (81.8)	423 (15.4)	78 (2.8)	
21	Own home	18,649 (86.3)	2,669 (12.4)	292 (1.4)	
22	<b>Tsunami experience</b>				
23	No	48,194 (82.1)	9,058 (15.4)	1,424 (2.4)	<0.001
24	Yes	11,767 (79.7)	2,521 (17.1)	469 (3.2)	
25	<b>Experience of the nuclear</b>				
26	<b>power plant accident</b>				
27	No	29,347 (83.8)	4,977 (14.2)	717 (2.1)	<0.001
28	Yes	30,614 (79.7)	6,602 (17.2)	1,176 (3.1)	
29	<b>Damage of house</b>				
30	No	15,295 (82.5)	2,843 (15.3)	413 (2.2)	<0.001
31	A part of	31,661 (83.3)	5,913 (15.4)	911 (2.4)	
32	Half	4,125 (79.0)	916 (17.5)	184 (3.5)	
33	More than a half	1,538 (78.4)	358 (18.2)	67 (3.4)	
34	Totally	3,086 (80.5)	620 (16.2)	126 (3.3)	
35	<b>Loss of family member</b>				
36	No	10,802 (76.7)	2,737 (19.4)	552 (3.9)	<0.001
37	Yes	46,887 (82.7)	8,492 (15.0)	1,291 (2.3)	

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Men	29,793 (92.2)	2,167 (6.7)	341 (1.1)	<0.001
Women	35,306 (85.8)	4,938 (12.0)	888 (2.2)	
<b>Age</b>				
20-49	22,160 (88.5)	2,360 (9.4)	507 (2.0)	0.905
50-64	19,103 (89.5)	1,935 (9.1)	302 (1.4)	
>=65	23,836 (88.1)	2,810 (10.4)	420 (1.6)	
<b>Mental Health Status</b>				
<b>K6&lt;13</b>	57,801 (91.2)	4,863 (7.7)	695 (1.1)	<0.001
K6>=13	7,298 (72.4)	2,242(22.3)	534 (5.3)	
<b>Post Traumatic Stress Disorder</b>				
No	57,505 (91.3)	4,838 (7.7)	653 (1.0)	<0.001
Yes	7,594 (72.8)	2,267 (21.7)	576 (5.5)	
<b>Smoking Status</b>				
Never-smoker	35,541 (88.0)	4,119 (10.2)	715 (1.8)	<0.001
Ex-smoker	14,228 (89.9)	1,373 (8.7)	226 (1.4)	
Current smoker	13,083 (89.4)	1,302 (8.9)	258 (1.8)	
<b>Drinking Status</b>				
Never-drinker	32,656 (87.6)	3,956 (10.6)	674 (1.8)	<0.001
Ex-drinker	2,310 (84.9)	347 (12.8)	63 (2.3)	
Current drinker	28,498 (90.4)	2,571 (8.2)	463 (1.5)	
<b>Physical activity</b>				
>= once per day	9,654(91.2)	796 (7.5)	131 (1.2)	<0.001
2-4 times per week	12,830 (89.1)	1,327 (9.2)	245 (1.7)	
Once per week	8,845 (89.3)	917 (9.3)	143 (1.4)	
Never	31,731(87.6)	3,811 (10.5)	687 (1.9)	
<b>Hypertension History</b>				
No	38,476 (89.8)	3,709 (8.7)	667 (1.6)	<0.001
Yes	26,623 (87.1)	3,396 (11.1)	562 (1.8)	
<b>Stroke History</b>				
No	61,895 (89.0)	6,538 (9.4)	1,146 (1.7)	<0.001
Yes	3,204 (83.1)	567 (14.7)	83 (2.2)	
<b>Heart Disease History</b>				
No	59,187 (89.5)	5,946 (9.0)	1,025 (1.6)	<0.001
Yes	5,912 (81.3)	1,159 (15.9)	204 (2.8)	
<b>Unemployment</b>				

No	52,942 (89.4)	5,376 (9.1)	874 (1.5)	<0.001
Yes	12,157 (85.4)	1,729 (12.1)	355 (2.5)	
<b>Decreased income</b>				
No	53,767 (88.9)	5,746 (9.5)	908 (1.6)	<0.001
Yes	11,332 (87.5)	1,359 (10.5)	264 (2.0)	
<b>Living arrangement</b>				
Evacuation Shelter	3,254 (89.3)	1,750 (15.6)	227 (1.6)	<0.001
Temporary housing	3,306 (85.7)	3,444 (8.1)	404 (2.0)	
Rental house, apartment	20,217 (87.6)	2,376 (10.3)	489 (2.1)	<0.001
Relatives' home	2,436 (88.5)	264 (9.6)	53 (1.9)	
Own home	19,794 (91.6)	1,617 (7.5)	199 (0.9)	
<b>Tsunami experience</b>				
No	52,378 (89.3)	5,390 (9.2)	908 (1.6)	<0.001
Yes	12,721 (86.2)	1,715 (11.6)	321 (2.2)	
<b>Experience of the nuclear power plant accident</b>				
No	31,801 (90.8)	2,814 (8.0)	426 (1.2)	<0.001
Yes	33,298 (86.7)	4,291 (11.2)	803 (2.1)	
<b>Damage of house</b>				
No	16,762 (90.4)	1,531 (8.3)	258 (1.4)	<0.001
A part of	34,218 (88.9)	3,667 (9.5)	600 (1.6)	
Half	4,480 (85.7)	616 (11.8)	129 (2.5)	
More than a half	1,668 (85.0)	247 (12.6)	48 (2.5)	
Totally	3,308 (86.3)	438 (11.4)	86 (2.2)	
<b>Loss of family member</b>				
No	11,885 (84.3)	1,843 (13.1)	363 (2.6)	<0.001
Yes	50,854 (89.7)	4,991 (8.8)	825 (1.5)	

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<b>Age</b>					
20-49	23,317 (93.2)	1,303 (5.2)	407 (1.6)	<0.001	
50-64	19,478 (91.3)	1,539 (7.2)	323 (1.5)		
>=65	24,339 (89.9)	2,372 (8.8)	355 (1.3)		
<b>Mental Health Status</b>					
K6<13	59,443 (93.8)	3,354 (5.3)	562 (0.9)	<0.001	
K6>=13	7,691 (76.4)	1,860 (18.5)	523 (5.2)		
<b>Post Traumatic Stress</b>					
<b>Disorder</b>					
No	59,105 (93.8)	3,349 (5.3)	542 (0.9)	<0.001	
Yes	8,029 (76.9)	1,865 (17.9)	543 (5.2)		
<b>Smoking Status</b>					
Never-smoker	36,836 (91.2)	2,886 (7.2)	653 (1.6)	<0.001	
Ex-smoker	14,449 (91.3)	1,164 (7.4)	214 (1.4)		
Current smoker	13,503 (92.2)	944 (6.5)	196 (1.3)		
<b>Drinking Status</b>					
Never-drinker	33,888 (90.9)	2,801 (7.5)	597 (1.6)	<0.001	
Ex-drinker	2,406 (88.5)	253 (9.3)	61 (2.2)		
Current drinker	29,119 (92.4)	2,006 (6.4)	407 (1.3)		
<b>Physical activity</b>					
>= once per day	9,916 (93.7)	569 (5.4)	96 (0.9)	<0.001	
2-4 times per week	13,210 (91.7)	997 (6.9)	195 (1.4)		
Once per week	9,090 (91.8)	676 (6.8)	139 (1.4)		
Never	32,790 (90.5)	2,802 (7.7)	637 (1.8)		
<b>Hypertension History</b>					
No	39,969 (93.3)	2,299 (5.4)	584 (1.4)	<0.001	
Yes	27,165 (88.8)	2,915 (9.5)	501 (1.6)		
<b>Stroke History</b>					
No	63,799 (91.7)	4,757 (6.8)	1,799 (1.5)	<0.001	
Yes	3,335 (86.5)	457 (11.9)	94 (1.6)		
<b>Heart Disease History</b>					
No	61,793 (93.3)	10,268 (15.5)	1,691 (2.6)	<0.001	
Yes	5,441 (74.8)	1,311 (21.3)	202 (4.0)		
<b>Unemployment</b>					
No	54,410 (91.9)	3,992 (6.7)	790 (1.4)	<0.001	
Yes	12,724 (89.4)	1,222 (8.6)	295 (2.1)		

<b>Decreased income</b>				
No	55,339 (91.5)	4,272 (7.1)	870 (1.4)	0.052
Yes	11,795 (91.1)	942 (7.3)	215 (1.7)	
<b>Living arrangement</b>				
Evacuation Shelter	No 672 (91.6)	Yes 57 (7.8)	Exacerbation of shortness of breath	P
Temporary housing	6,339 (90.9)	548 (7.9)	No. 89 (1.3)	
Rental house, apartment	20,762 (90.8)	2,809 (7.4)	2574 (11.8)	<0.001038
Relative's home	3490 (92.6)	2,667 (8.5)	3692 (9.0)	
Own home	20,178 (93.4)	1,223 (5.7)	45 (1.6)	
<b>Age</b>				
<b>Tsunami experience</b>				
20-49	24,022 (96.0)	858 (3.4)	147 (0.6)	<0.001
No	53,935 (91.9)	3,911 (6.7)	830 (1.4)	<0.001
Yes	13,199 (89.4)	1,303 (8.8)	255 (1.7)	
<b>Experience of the nuclear power plant accident</b>				
No	32,691 (93.3)	1,992 (5.7)	358 (1.0)	<0.001
Yes	34,443 (89.7)	3,222 (8.4)	727 (1.9)	
<b>Damage of house</b>				
No	17,284 (93.2)	1,034 (5.6)	233 (1.3)	<0.001
A part of	35,128 (91.3)	2,798 (7.3)	559 (1.5)	
Half	4,684 (89.7)	458 (8.8)	83 (1.6)	
More than a half	1,738 (88.5)	187 (9.5)	38 (1.9)	
Totally	3,473 (90.6)	293 (7.7)	66 (1.7)	
<b>Loss of family member</b>				
No	12,434 (88.2)	1,361 (9.7)	296 (2.1)	<0.001
Yes	52,250 (92.2)	3,661 (6.5)	759 (1.3)	

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50-64	19,821 (92.9)	1,360 (6.4)	159 (0.8)	
>=65	23,993 (88.7)	2,753 (10.2)	320 (0.4)	
<b>Mental Health Status</b>				
<b>K6&lt;13</b>	59,686 (94.2)	3,318 (5.2)	355 (0.6)	<0.001
K6>=13	8,150 (80.9)	1,653 (16.4)	271 (2.7)	
<b>Post Traumatic Stress Disorder</b>				
No	59,449 (94.4)	3,224 (5.1)	323 (0.5)	<0.001
Yes	8,387 (80.4)	1,747 (16.7)	303 (2.9)	
<b>Smoking Status</b>				
Never-smoker	37,690 (93.4)	2,367 (5.9)	318 (0.8)	<0.001
Ex-smoker	14,298 (90.3)	1,358 (8.6)	171 (1.1)	
Current smoker	13,522 (92.3)	998 (6.8)	123 (0.8)	
<b>Drinking Status</b>				
Never-drinker	34,447 (92.4)	2,516 (6.8)	323 (0.9)	0.001
Ex-drinker	2,341 (86.1)	338 (12.4)	41 (1.5)	
Current drinker	29,364 (93.1)	1,920 (6.1)	248 (0.8)	
<b>Physical activity</b>				
>= once per day	9,934 (93.9)	578 (5.5)	69 (0.7)	<0.001
2-4 times per week	13,278 (92.2)	1,001 (7.0)	123 (0.9)	
Once per week	9,136 (92.2)	672 (6.8)	97 (1.0)	
Never	33,405 (92.2)	2,499 (6.9)	325 (0.9)	
<b>Hypertension History</b>				
No	40,466 (94.9)	1,912 (4.5)	276 (0.6)	<0.001
Yes	27,172 (88.9)	3,059 (10.0)	350 (1.1)	
<b>Stroke History</b>				
No	64,581 (92.8)	4,422 (6.4)	576 (0.8)	<0.001
Yes	3,255 (84.5)	549 (14.2)	50 (1.3)	
<b>Heart Disease History</b>				
No	62,270 (94.1)	3,456 (5.2)	432 (0.7)	<0.001
Yes	5,566 (76.5)	1,515 (20.8)	194 (2.7)	
<b>Unemployment</b>				
No	54,833 (92.6)	3,889 (6.6)	470 (0.8)	<0.001
Yes	13,003 (91.3)	1,082 (7.6)	156 (1.1)	
<b>Decreased income</b>				
No	55,879 (92.4)	4,096 (6.8)	506 (0.8)	0.584

5	Yes	11,957 (92.3)	875 (6.8)	120 (0.9)	
6	<b>Living arrangement</b>				
8	Evacuation Shelter	666 (90.7)	63 (8.6)	5 (0.7)	
9	Temporary housing	6,283 (90.1)	612 (8.8)	81 (1.2)	
10	Rental house, apartment	21,419 (92.8)	1,439 (6.2)	224 (1.0)	<0.001
11	Relatives' home	2,449 (90.8)	231 (8.4)	108 (0.5)	
12	Own home	20,247 (93.7)	1,255 (5.8)	29 (1.0)	
13	<b>Tsunami experience</b>				
14	No	54,566 (93.0)	3,652 (6.2)	458 (0.8)	<0.001
15	Yes	13,270 (89.9)	1,319 (8.9)	168 (1.1)	
16	<b>Experience of the nuclear</b>				
17	<b>power plant accident</b>				
18	No	33,023 (94.2)	1,817 (5.2)	201 (0.6)	<0.001
19	Yes	34,813 (90.7)	3,154 (8.2)	425 (1.1)	
20	<b>Damage of house</b>				
21	No	17,545 (94.6)	903 (4.9)	103 (0.6)	<0.001
22	A part of	35,368 (91.9)	2,770 (7.2)	347 (0.9)	
23	Half	4,735 (90.6)	435 (8.3)	55 (1.1)	
24	More than a half	1,760 (89.7)	180 (9.2)	23 (1.2)	
25	Totally	3,510 (91.6)	279 (7.3)	43 (1.1)	
26	<b>Loss of family member</b>				
27	No	12,589 (89.3)	1,303 (9.3)	199 (1.4)	0.096
28	Yes	52,823 (93.2)	3,443 (6.1)	404 (0.7)	

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Table 2. Odds ratios (OR) and 95% CIs for Post Traumatic Stress Disorder on multiple logistic regression analyses

		Exacerbation of Headache			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> or women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	2.03 (1.58-2.62)	1.58 (1.20-2.09)	1.97 (1.12-3.47)	1.46 (1.06-2.01)
	Rental house, apartment	2.21 (1.93-2.54)	1.55 (1.32-1.81)	1.85 (1.34-2.54)	1.46 (1.22-1.75)
	Evacuation Shelter	2.01 (1.24-3.25)	1.80 (1.10-2.97)	2.24 (0.99-5.07)	1.61 (0.85-3.03)
	Temporary housing	2.13 (1.77-2.56)	1.42 (1.15-1.75)	1.67 (1.10-2.54)	1.36 (1.06-1.73)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.70 (1.53-1.88)	1.28 (1.12-1.46)	1.35 (1.04-1.77)	1.26 (1.08-1.47)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.56 (1.40-1.74)	1.39 (1.21-1.60)	1.38 (1.08-1.77)	1.39 (1.17-1.63)
		Exacerbation of Dizziness			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> or women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.98 (1.46-2.69)	1.43 (1.02-1.98)	0.97 (0.49-1.92)	1.64 (1.13-2.43)
	Rental house, apartment	2.27 (1.91-2.69)	1.45 (1.20-1.76)	1.28 (0.92-1.79)	1.55 (1.23-1.96)
	Evacuation Shelter	1.84 (1.02-3.32)	1.37 (0.73-2.65)	0.85 (0.26-2.76)	1.79 (0.85-3.77)
	Temporary housing	2.09 (1.68-2.61)	1.39 (1.08-1.78)	1.50 (1.00-2.27)	1.34 (0.99-1.83)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.65 (1.45-1.87)	1.26 (1.07-1.48)	1.12 (0.83-1.50)	1.23 (0.99-1.52)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.37 (1.19-1.57)	1.18 (0.99-1.41)	1.00 (0.74-1.36)	1.12 (0.91-1.40)

		Exacerbation of Palpitation			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.70 (1.23-2.34)	1.24 (0.87-1.75)	1.25 (0.57-2.72)	1.21 (0.82-1.79)
	Rental house, apartment	1.90 (1.60-2.25)	1.25 (1.03-1.51)	1.73 (1.17-2.54)	1.11 (0.89-1.39)
	Evacuation Shelter	0.74 (0.30-1.80)	0.51 (0.19-1.38)	0.92 (0.22-3.90)	0.35 (0.09-1.43)
	Temporary housing	1.32 (1.03-1.69)	0.82 (0.61-1.09)	1.18 (0.68-2.02)	0.72 (0.51-1.01)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.46 (1.27-1.68)	1.22 (1.02-1.46)	1.46 (1.05-2.02)	1.01 (0.79-1.28)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.07-1.44)	1.14 (0.94-1.38)	0.84 (0.58-1.19)	1.06 (0.84-1.33)

		Exacerbation of Shortness of Breath			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.60 (1.02-2.52)	1.15 (0.70-1.89)	0.95 (0.42-2.14)	1.33 (0.71-2.49)
	Rental house, apartment	2.34 (1.85-2.96)	1.75 (1.35-2.27)	1.48 (1.00-2.20)	1.98 (1.39-2.81)
	Evacuation Shelter	1.33 (0.54-3.27)	1.21 (0.48-3.01)	1.73 (0.61-4.97)	0.52 (0.07-3.81)
	Temporary housing	2.29 (1.72-3.06)	1.50 (1.07-2.09)	1.27 (0.76-2.13)	1.73 (1.11-2.69)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.55 (1.29-1.87)	1.13 (0.89-1.47)	1.19 (0.83-1.69)	1.10 (0.77-1.57)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.01-1.52)	1.14 (0.89-1.47)	1.14 (0.80-1.62)	0.91 (0.65-1.28)

a. Adjusted for age and sex.

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3 b. 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,  
4 K6>=13), hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or no), physical activities (>= once per day, 2-4 times per week, once per week, never),  
5 tsunami experience (yes or no), radiation experience (yes or no), damage of house (no, a part of, half, more than a half, totally), loss of family member (yes or no).  
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For peer review only

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract (P1-4)</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction (P6-7)</b>		
Background/rationale (P6)	2	Explain the scientific background and rationale for the investigation being reported
Objectives (P7)	3	State specific objectives, including any prespecified hypotheses
<b>Methods (P7-11)</b>		
Study design (P7)	4	Present key elements of study design early in the paper
Setting (P7)	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants (P7)	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables (P8-P10)	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement (P8-P10)	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias (None)	9	Describe any efforts to address potential sources of bias
Study size (P7-8)	10	Explain how the study size was arrived at
Quantitative variables (P8-10)	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods (P10-11)	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

**Results (P11-14)**

Participants (P11-12)	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data (P11-13)	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data (P11)	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results (P13-14)	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses None	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion (P14-18)**

Key results (P14-18)	18	Summarise key results with reference to study objectives
Limitations (P18)	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation (P14-18)	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability None	21	Discuss the generalisability (external validity) of the study results

**Other information (P19)**

Funding (P19)	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Associations of socioeconomic factors after a disaster with cardiovascular related symptoms among evacuees after the Great East Japan Earthquake in a cross-sectional study: the Fukushima Health Management Survey



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Secondary Subject Heading:	Epidemiology, Sociology



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Keywords:	Great East Japan Earthquake, socioeconomic factors, cardiovascular related symptoms

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1 **Associations of socioeconomic factors after a disaster with**  
2 **cardiovascular related symptoms among evacuees after the**  
3 **Great East Japan Earthquake in a cross-sectional study: the**  
4 **Fukushima Health Management Survey**

5  
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49 **Abstract**

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

53 **Methods:** A total of 73,433 subjects were included in the Fukushima Health  
54 Management survey. Exacerbation of headache, dizziness, palpitations, and shortness  
55 of breath were determined from self-report questionnaires. Socioeconomic factors  
56 included living arrangement, loss of employment, decreased income and educational  
57 years. Odds ratios (OR) and 95% confidence intervals (CI) of socioeconomic factors  
58 were estimated for each symptom using multiple logistic regression analyses.

59 **Results:** A total of 1,893 (2.6%) individuals reported exacerbation of headache, 1,229  
60 (1.7%) of dizziness, 1,085 (1.5%) of palpitations, and 626 (0.9%) of shortness of breath.  
61 Evacuation accommodation was associated with all the above symptoms. Compared to  
62 participants living in their own home (OR=1.00), subjects living in relatives' homes had  
63 increased odds of experiencing exacerbation of headache (1.58; 95% CI 1.19–2.09)  
64 and dizziness (1.42; 95% CI 1.02–1.98); subjects living in rental houses or apartments  
65 showed exacerbation of headache (1.54; 95% CI 1.32–1.80), dizziness (1.45; 95% CI  
66 1.20–1.75), palpitations (1.25; 95% CI 1.03–1.51), and shortness of breath (1.76; 95%  
67 CI 1.35–2.28); subjects living in evacuation shelters showed exacerbation of headache  
68 (1.80; 95% CI 1.09–2.96); and refugees living in temporary housing showed  
69 exacerbated headache (1.42; 95% CI 1.15–1.75), dizziness (1.40; 95% CI 1.09–1.79),  
70 and shortness of breath (1.49; 95% CI 1.07–2.08). Compared to the evacuees that  
71 retained their jobs, unemployed subjects showed increased odds for exacerbation of  
72 headache (1.28, 95% CI 1.12–1.46), dizziness (1.26, 95% CI 1.07–1.48), and

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6 73 palpitations (1.21, 95% CI 1.01–1.45). Decreased income was associated with  
7  
8 74 exacerbation of headache (1.39, 95% CI 1.22–1.60).

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10 75 **Conclusion:** After the earthquake, living in non-home conditions was more likely to  
11  
12 76 exacerbate cardiovascular symptoms among evacuees. Loss of employment was  
13  
14 77 another risk factor for exacerbated headache and dizziness.

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21 80 **Keywords:** Great East Japan Earthquake, socioeconomic factors, cardiovascular  
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23 81 related symptoms

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6 97 **Strengths and limitations of this study**  
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- 8 ● We examined the associations of socioeconomic factors after a disaster with  
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10 cardiovascular related symptoms among evacuees of the number of 73,433  
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12 subjects after the Great East Japan earthquake.  
13  
14 ● Our study is the first to identify an inverse relationship between low socioeconomic  
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16 status and exacerbated cardiovascular symptoms from an evacuee self-report after  
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18 a disaster.  
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20 ● A limitation of the present study was an overall response rate was low (40.7%) and  
21  
22 data may have contained sampling biases.  
23  
24 ● Another limitation of the present study should be that the information of changes in  
25  
26 family relationships (e.g., death, physical separation) among the evacuees after the  
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28 disaster has not been captured.  
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30 ● In addition, most questionnaires were collected in the same period (from Jan 2012  
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32 to Mar 2012).  
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6 121 **Introduction**

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8 122 The Great East Japan Earthquake and the subsequent Fukushima Daiichi nuclear  
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10 123 disaster, which occurred in March 2011, was the most destructive catastrophe in Japan  
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12 124 to date. Due to concerns over released radiation, most of the residents in nearby towns  
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14 125 were forced to evacuate and consequently suffered long-lasting anxiety. Shortly after  
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16 126 the disaster, a Fukushima Health Management Survey was conducted to investigate the  
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18 127 effects of long-term low-dose radiation exposure caused by the accident and to assess  
19  
20 128 the physical and mental wellbeing of evacuees. This survey included a basic survey,  
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22 129 which estimated individual radiation exposure of each resident, and four detailed  
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24 130 surveys comprising of a Comprehensive Health Check and thyroid ultrasonography, a  
25  
26 131 mental health and lifestyle survey, and a survey of pregnant women and nursing  
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28 132 mothers (1). The Mental Health and Lifestyle Survey used self-report questionnaires to  
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30 133 investigate health status and lifestyle of the refugees, including nutrition and diet,  
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32 134 perceived symptoms of illness, disaster-related experience, and socioeconomic  
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34 135 determinants.

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38 136 Several previous studies have shown changes in the incidence of cardiovascular  
39  
40 137 events following disasters; however, results are conflicting (2-14). A recent study  
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42 138 reported a heterogeneous occurrence of cardiovascular events after the Great East  
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44 139 Japan Earthquake (2), while another study reported a significant increase in the  
45  
46 140 incidence of cardioembolic stroke after the earthquake (10). However, neither study  
47  
48 141 examined the incidence of perceived cardiovascular disease symptoms after a disaster,  
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50 142 nor did they focus on the effect of refugee socioeconomic status on health problems  
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52 143 during their evacuation term. However, considering these aspects is relevant for  
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6 144 reviewing refugee health status, accessing the incidence of various diseases, and  
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8 145 providing health guidelines for refugees.  
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10 146 Consequently, we conducted the present study to investigate the risk factors of  
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12 147 perceived cardiovascular symptoms following a major disaster. In the present study,  
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14 148 socioeconomic determinants included educational years, living arrangement, change of  
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16 149 employment and income. Due to the special post-disaster situation, change of  
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18 150 employment and income due to the disaster, instead of job and income level were  
19  
20 151 captured. Thus in the present study, a decrease or low socioeconomic status was  
21  
22 152 considered as less educational years, living in non-home conditions, unemployment or  
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24 153 decreased income due to the disaster. We hypothesized that a decrease in  
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26 154 socioeconomic status due to the earthquake would be associated with exacerbated  
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28 155 cardiovascular symptoms among evacuees.  
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## 33 34 157 **Methods**

### 35 36 158 **Participants**

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38 159 The primary purpose of the Fukushima Health Management Survey was to monitor  
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40 160 the long-term health and lifestyle of Fukushima residents and to provide them with  
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42 161 appropriate care (15). The Fukushima Health Management Survey consists of a basic  
43  
44 162 survey and four detailed surveys, namely, the thyroid ultrasound examination,  
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46 163 comprehensive health check, mental health and lifestyle survey, and pregnancy and  
47  
48 164 birth survey (for details of these surveys see (1)). The subjects of mental health and  
49  
50 165 lifestyle survey was included in the present study. Briefly, the target population, consists  
51  
52 166 of 210,189 officially registered victims of the Great East Japan Earthquake from the  
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54 167 evacuation zones Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village,  
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6 168 Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City,  
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8 169 Yamakiya District of Kawamata Town, and Iitate Village. In 2012, 180,604  
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10 170 questionnaires were sent out with 73,569 questionnaires returned with responses, i.e. a  
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12 171 response rate of 40.7%. Among the responders, 136 were excluded due to blank or  
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14 172 duplicated questionnaires and 9,245 for questionnaires filled in by a proxy. After  
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16 173 exclusion, the data of 73,433 subjects (32,301 men and 41,132 women) were used in  
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18 174 our analyses.

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21 175 The study protocol was approved by the Ethics Committee of Fukushima Medical  
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23 176 University. Participants who returned the self-administered questionnaires were  
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25 177 considered to have consented to participate.  
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#### 29 179 **Data collection and measurement**

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32 180 A questionnaire was used to broadly investigate the health status and lifestyle of  
33  
34 181 the refugees. The exacerbation of headache, dizziness, palpitations, and shortness of  
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36 182 breath was determined based on self-reports in the questionnaire. All subjects were  
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38 183 asked to answer the question 'Do you have the following perceived symptoms after the  
39  
40 184 earthquake?' and could choose between the replies 'No', 'Yes', and 'Exacerbation'. In  
41  
42 185 the present study we focused on reports of 'exacerbation'.  
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45 186 To evaluate Posttraumatic Stress Disorder (PTSD) symptoms we used the  
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47 187 non-military version of the Posttraumatic Stress Disorder Checklist (PCL-S) (15). This is  
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49 188 a 17-item self-report checklist based on the Diagnostic and Statistical Manual of Mental  
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51 189 Disorders (4th edition, DSM-IV) criteria (16), with each item rated using a Likert-type  
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53 190 scale from one ('not at all') to five ('extremely'). Respondents were requested to  
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56 191 respond to questions about each PTSD symptom separately and report whether they  
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6 192 had experienced a given symptom during the past month. Based on summing the  
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8 193 scores from each of the 17 items, a total PCL-S score can range from 17 to 85 (15).  
9

10 194 In addition to the PCL-S checklist, the following items were included in the  
11  
12 195 self-assessment and self-report questionnaires:  
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14 196 1. Demographic characteristics  
15

16 197 Demographic subject characteristics include gender, age group, mental health  
17  
18 198 status, history of mental illness, incidence of PTSD symptoms, smoking and drinking  
19  
20 199 habits, and current physical activity levels. Age groups were divided into childbearing  
21  
22 200 age (20–49 years), middle age (50–64 years), and old age (65 years and above).  
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24

25 201 Mental health status, and specifically incidence and severity of depression, was  
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27 202 measured by the Japanese version of the K6 Kessler Psychological Distress Scale,  
28  
29 203 which has been validated by previous studies (17, 18). In the K6 assessment,  
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31 204 participants were asked if they had experienced any of the following six symptoms  
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33 205 during the past 30 days: feeling so depressed that nothing could cheer them up, feeling  
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35 206 that everything was an effort, or feeling nervous, hopeless, restless, fidgety, or  
36  
37 207 worthless. Each question was rated on a 5-point Likert-type scale from zero (none of the  
38  
39 208 time) to four (all of the time), with higher scores signifying worse mental health status  
40  
41 209 (total range: 0–24) (15). In addition, we assessed participant's history of mental illness  
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43 210 by self-report as 'yes' or 'no'.  
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46 211 We obtained data on smoking and drinking habits using the following metrics,  
47  
48 212 respectively: 'non-smoker', 'ex-smoker', or 'current smoker'; and 'once or more per  
49  
50 213 month', 'less than once per month', or 'ex- drinker'. Participants had four options to  
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52 214 assess current physical activity level: 'every day', '2-4 times/week', 'once a week', or  
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54 215 'nearly none'.  
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6 216 2. Socioeconomic variables

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8 217 Participants were required to select from six options regarding their living  
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10 218 arrangements: evacuation shelter, temporary housing, rental housing or apartment, a  
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12 219 relative's home, their own home, and other. The last option was considered  
13  
14 220 non-informative due to its ambiguity and thus excluded from analysis.  
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16  
17 221 Other socioeconomic variables included educational years (< 12 years, >=12 years),  
18  
19 222 change in employment status and change in income. By answering 'Yes' to either  
20  
21 223 question, the participant indicated he/she became unemployed or experienced  
22  
23 224 decreased income since the disaster.

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25 225 3. Disaster-related variables

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27 226 Disaster-related variables included experience of the tsunami (yes or no), experience  
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29 227 of the nuclear power plant accident (defined as hearing the explosion; yes or no), losing  
30  
31 228 someone close because of the disaster (yes or no), and damage to accommodation (no,  
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33 229 partial damage, half of accommodation destroyed, more than a half destroyed, total  
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35 230 destruction).  
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40 232 **Statistical analysis**

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42 233 The incidence of exacerbation of headache, dizziness, palpitations, and shortness of  
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44 234 breath was compared between subjects with different demographic, socioeconomic,  
45  
46 235 and disaster-related characteristics using chi-square tests. For the analyses  
47  
48 236 investigating PTSD incidence, a PCL-S cut-off score of 50 was used, according to  
49  
50 237 Weathers et al (19). Subjects who received a PCL-S of 50 or greater were allocated to  
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52 238 the 'high-scoring group' and compared to the low-scoring (PCL-S < 50) group using  
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54 239 chi-square tests.  
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6 240 Odds ratios (ORs) and 95% confidence intervals (CIs) of each socioeconomic  
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8 241 determinant (living arrangement, unemployment, decreased income and educational  
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10 242 years were estimated by applying multiple logistic regression models. Adjustment  
11  
12 243 variables consisted of sex (male, female), age (20–49, 50–64, ≥65 years), drinking  
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14 244 status (once or more per month, ex-drinker, less than once per month), smoking status  
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16 245 (non-smoker, ex-smoker, current smoker), mental health distress (K6<3, K6≥13),  
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18 246 hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or  
19  
20 247 no), physical activities (≥ once per day, 2–4 times per week, once per week, never),  
21  
22 248 tsunami experience (yes or no), radiation experience (yes or no), damage of  
23  
24 249 accommodation (no, partial, half, more than a half, total), loss of family member (yes or  
25  
26 250 no).

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29 251 We conducted the above analyses both for separate and combined sexes. All  
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31 252 analyses were conducted using SAS software version 9.4 (SAS Institute Inc., Cary, NC,  
32  
33 253 USA).

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## 37 38 255 **Results**

39  
40 256 As shown in the tables, 1,893 (2.6%) individuals reported exacerbation of headaches,  
41  
42 257 1,229 (1.7%) of dizziness, 1,085 (1.5%) of palpitations, and 626 (0.9%) exacerbation of  
43  
44 258 shortness of breath.

## 45 46 47 259 **Demographic characteristics**

48  
49 260 Table 1 summarizes the demographic characteristics of the subjects. Exacerbation of  
50  
51 261 the above cardiovascular symptoms was significantly more likely to happen in women  
52  
53 262 than in men (3.5% vs. 1.4% for headaches; 2.2% vs. 1.1% for dizziness; 2.0% vs. 0.9%  
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55 263 for palpitations; 0.9% vs. 0.8% for shortness of breath). Subjects experiencing  
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6 264 exacerbation of headaches, dizziness, or palpitations were more likely to be young (20–  
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8 265 49 years), while those experiencing exacerbation of shortness of breath were more  
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10 266 likely to be 50-64 years. Subjects experiencing exacerbation of cardiovascular  
11  
12 267 symptoms were also more likely to suffer from depression ( $K6 \geq 13$ ) and Posttraumatic  
13  
14 268 Stress Disorder ( $PCL \geq 50$ ), and to commonly have a history of hypertension, stroke, or  
15  
16 269 heart disease. Non-smokers and non-drinkers were no less likely than (ex-) smokers or  
17  
18 270 (ex-) drinkers to experience exacerbation of cardiovascular symptoms. However,  
19  
20 271 symptom exacerbation was most pronounced in subjects who were physically active  
21  
22 272 less than once a day.

### 273 **Socioeconomic variables**

274 Table 1 also shows refugees living in their own or a relative's home are less likely to  
275 experience exacerbated cardiovascular symptoms. Of the refugees living in their own  
276 home, 1.4% reported exacerbation of headache, 0.9% of dizziness, 1.6% of palpitations  
277 and 1.0% of shortness of breath. The corresponding statistics for refugees living in  
278 temporary housing and rental houses/apartments were 2.8%, 1.9%, 1.3%, and 1.2%  
279 and 3.5%, 2.1%, 1.8%, and 1.0%, respectively.

280 In the group that became unemployed due to the disaster, 4.2% subjects reported  
281 the exacerbation of headache, 2.5% of dizziness, 2.1% of palpitations and 1.1% of  
282 shortness of breath, while the corresponding statistics for the group that did not lose  
283 their jobs after the disaster were 2.2%, 1.5%, 1.4%, and 0.8%. Exacerbation of most  
284 cardiovascular symptoms was higher in subjects whose income decreased due to the  
285 disaster compared to those who maintained income levels (3.6% vs. 2.4% for  
286 exacerbation of headache, 2.0% vs. 1.6% for exacerbation of dizziness, and 1.7% vs.  
287 1.4% for exacerbation of palpitation).

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6 288 In addition, exacerbation of most cardiovascular symptoms was higher in subjects  
7  
8 289 who had 12 years education or more compared to those who had less education (2.9%  
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10 290 vs. 1.9% for exacerbation of headache, 1.8% vs. 1.4% for exacerbation of dizziness,  
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12 291 and 1.6% vs. 1.2% for exacerbation of palpitation).  
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### 17 293 **Disaster-related variables**

18  
19 294 Subjects that directly experienced the tsunami and the nuclear power plant accident  
20  
21 295 were more likely to experience exacerbated cardiovascular symptoms. Among those  
22  
23 296 experiencing the tsunami, 3.2% reported exacerbation of headache, 2.2% of dizziness,  
24  
25 297 1.7% of palpitations, and 1.7% of shortness of breath, compared to 2.4%, 1.6%, 1.5%,  
26  
27 298 and 0.8%, respectively, of subjects with no experience of the tsunami. The  
28  
29 299 corresponding statistics for subjects that had heard the nuclear power plant accident  
30  
31 300 were 3.1%, 2.1%, 1.9%, and 1.1% compared to 2.1%, 1.2%, 1.0%, and 0.6%, that had  
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33 301 not.  
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### 36 302 **Multiple Logistic Regression analyses**

37  
38 303 Table 2 summarizes the odds ratios (ORs) and 95% CIs of each socioeconomic  
39  
40 304 determinant for exacerbation of headache, dizziness, palpitations, and shortness of  
41  
42 305 breath. Living arrangement emerged as a risk factor for exacerbated cardiovascular  
43  
44 306 symptoms from our models, which were adjusted for multiple demographic-, health-,  
45  
46 307 and disaster-related variables. Compared to participants living in their own home (OR =  
47  
48 308 1), those living in relatives' homes had higher odds to experience exacerbation of  
49  
50 309 headache (1.58; 95% CI 1.19–2.09) and dizziness (1.42; 95% CI 1.02–1.98). Similarly,  
51  
52 310 subjects living in rental houses or apartments had higher odds of exacerbated  
53  
54 311 headache (1.54; 95% CI 1.32–1.80), dizziness (1.45; 95% CI 1.20–1.75), palpitations  
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6 312 (1.25; 95% CI 1.03–1.51), and shortness of breath (1.76; 95% CI 1.35–2.28).  
7  
8 313 Participants living in evacuation shelters had increased odds of exacerbation of  
9  
10 314 headache (1.80; 95% CI 1.09–2.96) and refugees living in temporary housing similarly  
11  
12 315 had increased odds of exacerbation of headache (1.42; 95% CI 1.15–1.72), dizziness  
13  
14 316 (1.40; 95% CI 1.09–1.79), and shortness of breath (1.49; 95% CI 1.07–2.08).

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16  
17 317 Loss of employment also emerged as a risk factor for increased odds of  
18  
19 318 cardiovascular symptoms. Compared to the evacuees that remained employed (OR =  
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21 319 1), subjects that had become unemployed were at higher risk of experiencing  
22  
23 320 exacerbation of headache (1.28; 95% CI 1.12–1.46), dizziness (1.26; 95% CI 1.07–  
24  
25 321 1.48), and palpitation (1.21; 95% 1.01–1.45). In an unadjusted model, we found a  
26  
27 322 significant positive association between unemployment and exacerbation of  
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29 323 palpitations; however, after adjusting for multiple relevant variables, this association  
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31 324 became non-significant.

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33  
34 325 There was no association between decreased income and exacerbated  
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36 326 cardiovascular symptoms, except for headache. Here, adjusting for multiple variables  
37  
38 327 resulted in an increased odds ratio for exacerbation of headaches both in an analysis  
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40 328 combining both sexes (1.39, 95% CI 1.22–1.60) and in separate analyses of men and  
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42 329 women.

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45 330 Educational years was not associated with and exacerbated cardiovascular  
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47 331 symptoms in multiple-adjusted models in the present study.

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## 50 51 333 **Discussion**

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53 334 We have demonstrated a decrease in socioeconomic status due to the earthquake  
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55 335 was associated with exacerbated cardiovascular symptoms among evacuees of the  
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6 336 Great East Japan Earthquake. Compared with participants living in their own home,  
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8 337 people of both genders living in relatives' homes, evacuation shelters, temporary  
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10 338 housing, or rental houses or apartments were more likely to experience exacerbated  
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12 339 headache, dizziness, palpitations, or shortness of breath. Similarly, loss of employment  
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14 340 and reduced income due to the disaster increased the risk of exacerbated symptoms.

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17 341 The following three points should be considered in the context of our results. Firstly,  
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19 342 earthquakes are definitely associated with increased cardiovascular disease, including  
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21 343 sudden cardiac death and acute myocardial infarction (2-14), which provides some  
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23 344 support for the present study. The Hanshin-Awaji earthquake was associated with an  
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25 345 increased cardiovascular disease and the increase persisted for more than a month. In  
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27 346 addition, an increase in the number of subjects with acute myocardial infarction,  
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29 347 especially in women, was particularly evident during the first 4 weeks post-disaster (9).  
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31 348 After the Great East Japan Earthquake, the incidence of reported cardioembolic stroke  
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33 349 increased in the first 3–9 months following the disaster (10), as did the incidence of  
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35 350 other cardiovascular diseases (11-14). Our study contributes to the reported incidences  
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37 351 of cardiovascular disease by demonstrating exacerbated cardiovascular symptoms  
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39 352 among evacuees after a disaster from self-report questionnaires rather than from death  
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41 353 certificates.

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44 354 Secondly, increases in cardiovascular events and exacerbated cardiovascular  
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46 355 symptoms can be attributed to post-disaster distress or mental problems. A review  
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48 356 suggests that extremely stressful experiences, such as earthquakes, can trigger  
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50 357 cardiovascular events (20-22). Acute major stress and chronic stress, i.e. the  
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52 358 cumulative load of minor daily stress, can have both long-term consequences, which  
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55 359 can be perceived as stressful and a potential threat to one's environment, subsequently



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6 360 inducing a variety of negative emotional responses, such as fear, anxiety, sadness,  
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8 361 anger, hostility, and depression (4,23) leading to hypertension or cardiovascular events  
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10 362 (20-22). In the current study, all subjects exhibiting exacerbated cardiovascular  
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12 363 symptoms were more likely to have depression ( $K6 \geq 13$ ) or Posttraumatic Stress  
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14 364 Disorder ( $PCL \geq 50$ ). Logistic regression analyses also showed that depression and  
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16 365 Posttraumatic Stress Disorder were both independently associated with exacerbated  
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18 366 cardiovascular symptoms (data not shown).

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21 367 Thirdly, although post-disaster increases in cardiovascular events were widely  
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23 368 reported in previous studies, the investigation of socioeconomic determinants of these  
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25 369 events during the evacuation term of refugees was very limited. Previous studies  
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27 370 reported that one year after the Wenchuan Earthquake in China, depression severity  
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29 371 among refugees varied with income, housing status, and social support (24), indicating  
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31 372 that earthquake impact on income was indirectly associated with life satisfaction and  
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33 373 depression via its effect on financial status (25). Another study showed that six months  
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35 374 after the 2011 Christchurch earthquake in New Zealand, on average lower income per  
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37 375 home contributed unequivocally to earthquake-related distress and dysfunction (26).

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40 376 In the present study, not living in the own home but living in evacuation shelters or  
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42 377 temporary housing, was associated with exacerbation of all examined cardiovascular  
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44 378 symptoms, which was more robust in women than in men. Evacuation shelters and  
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46 379 temporary housing were less spacious, damper, and less comfortable than the refugees'  
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48 380 homes. Due to insufficient access to supermarkets or shortages of cooking equipment  
49  
50 381 and utilities, such as gas, evacuees living in shelters would struggle to access balanced  
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52 382 meals. A recent cross-sectional study showed a well-balanced diet was associated with  
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54 383 better living conditions among refugees after the Great East Japan Earthquake,  
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6 384 whereas imbalanced diets, particularly with regard to meat content, were not (27). In  
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8 385 addition, having to take refuge in accommodation other than the own home meant that  
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10 386 the own neighborhood had been damaged by the disaster, which may lead to shortness  
11  
12 387 of social support. In addition, among the refugees. All of the above factors can be  
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14 388 considered predictors of stress among refugees, where women may be more likely to  
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16 389 be influenced than men.

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19 390 Unemployment and decreased income due to the disaster were also associated with  
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21 391 exacerbation of some cardiovascular symptoms. These results were expected as poor  
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23 392 economic circumstances are expected to exacerbate depression. Low income may be  
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25 393 considered a chronic stressor, increasing psychological distress as a result of limited  
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27 394 resource access and opportunities for resource accumulation (26). Previous studies  
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29 395 also showed that, following an earthquake, living in a low-income area may contribute to  
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31 396 greater psychological distress due to lack of occupational, social, and financial  
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33 397 resources. A community study showed that, after the Christchurch earthquake, low  
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35 398 household income contributed strongly to earthquake-related distress (26). In the  
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37 399 present study, we found a significant association between disaster-related  
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39 400 unemployment and exacerbation of some cardiovascular symptoms, but the  
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41 401 subsistence allowance provided to refugees by the Japanese government may have  
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43 402 reduced effect size by reducing the impact of lowered economic circumstances on  
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45 403 refugees.

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49 404 Educational level was inversely associated with cardiovascular disease risk in present  
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51 405 studies (27, 28). However, in present study, educational years was not associated with  
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53 406 exacerbated cardiovascular symptoms. It may due to the post-disaster conditions. In the  
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55 407 present study, both earthquake, tsunami and nuclear accident related factors and  
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6 408 unemployment or decreased income due to the disasters had a large influence on the  
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8 409 exacerbated cardiovascular symptoms of the subjects, which may weaken the impact  
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10 410 from the educational levels.

11 Our understanding of disaster-related stress on cardiovascular disease remains  
12 incomplete. A clinical study on the 1995 Hanshin-Awaji earthquake comparing pre- and  
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14 412 post- BP levels in well-controlled hypertension patients showed an increase of 18mmHg  
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16 413 in diastolic blood pressure two weeks after the earthquake (29). Although white-coat  
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18 414 hypertension contributed partly to the results, whereby patients exhibit increased blood  
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20 415 pressure in clinical settings, some patients developed sustained hypertension that  
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22 416 persisted for one year after the earthquake (29). One study found increased levels of  
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24 417 cholesterol and triglycerides a few weeks after an earthquake (3), whereas other studies  
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26 418 failed to show significantly higher total cholesterol or HDL-cholesterol during the first two  
27  
28 419 weeks after the Hanshin-Awaji earthquake (6). Therefore, the extent to which changes  
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30 420 in blood lipid profile contributes to exacerbated cardiovascular symptoms several  
31  
32 421 months after the Great East Japan Earthquake remains undetermined. Chronic  
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34 422 psychological stress is also associated with increased insulin resistance (4). A recent  
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36 423 study after the Great East Japan Earthquake found the negative effects of the disaster  
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38 424 on metabolic factors were greater among evacuees than non-evacuees (30), which may  
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40 425 contribute to exacerbated cardiovascular symptoms among evacuees.  
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47 The large scale of assessment and assessment under post-disaster  
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49 428 conditions provide considerable authority for the present study. In addition, our study is  
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51 429 the first to identify an inverse relationship between low socioeconomic status  
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53 430 and exacerbated cardiovascular symptoms from an evacuee self-report after a disaster;  
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55 431 our results will be useful for generating guidelines for evacuee health. However, the  
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6 432 following study limitations should be considered: Firstly, The study was based on a  
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8 433 subjectivity of self-response survey. Further information, such as the incidence of  
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10 434 cardiovascular disease should be captured. However, though the above-mentioned  
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12 435 symptoms would not be logical predict cardiovascular diseases, several previous  
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14 436 studies showed headache was suggestive of an incremental risk for stroke (31, 32), and  
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16 437 other studies also showed that vertigo or dizziness, chest pain was associated with  
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18 438 cardiovascular problems (33, 34). Therefore, our study of the 4 symptoms may be  
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20 439 helpful for improvement of evacuees' health to some extent. Secondly, not only the  
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22 440 Great East Japan Earthquake but also the accompanied nuclear accident had a large  
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24 441 psychological impact on the evacuees, thus the present study may cannot be  
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26 442 unconditionally compared with other studies due to the special situation. Thirdly, the  
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28 443 overall response rate was low (40.7%) and data may have contained sampling biases.  
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30 444 Thirdly, under the extraordinary and unusual social circumstances that follow a major  
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32 445 disaster, health symptoms perceived by evacuees may be strongly influenced by  
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34 446 changes in family relationships (e.g., death, physical separation) among the evacuees.  
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36 447 However, the present study did not capture these information. Moreover, other  
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38 448 socioeconomic determinants, such as household income, and other cardiovascular risk  
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40 449 factors, such as blood pressure, cholesterol levels, were not captured in the present  
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42 450 study either. In addition, although most questionnaires were collected in the same  
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44 451 period (from Jan 2012 to Mar 2012), it is possible the timing of the survey affected the  
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46 452 perceived cardiovascular symptoms. Finally, other environmental factors, such as  
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48 453 temperature, food supplies, medical facilities may also affect cardiovascular problems  
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50 454 (35, 36). These information were not collected in the present study. The potential  
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52 455 associations observed in this study will be investigated over an extended period.  
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6 456 In conclusion, the present study was the first to identify a relationship between lower  
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8 457 socioeconomic status due to the earthquake with exacerbated cardiovascular  
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10 458 symptoms among evacuees after the Great East Japan Earthquake. Our findings will  
11  
12 459 inform future periodic health examinations and health guidelines for evacuees.  
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18  
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20  
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22  
23 464 Nuclear Incident.'  
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25 465

#### 27 466 **Contributors**

28  
29 467 WZ and TO designed the study. TO, SY, MM, MH, NH, YS, HY, MH, HT and AO were  
30  
31 468 responsible for the data collection and overseeing study procedures. The analyses was  
32  
33 469 conducted by WZ and TO. The manuscript was made by WZ. All the authors did contribution  
34  
35 470 to the revision of the manuscript. All the authors read and approved the final version of the  
36  
37 471 manuscript.  
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40 472

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43  
44 474 This survey was conducted as part of Fukushima Prefecture's post-disaster recovery plans  
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46 475 and was supported by the national 'Health Fund for Children and Adults Affected by the  
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48 476 Nuclear Incident'.  
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#### 52 478 **Declaration of interests**

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55 479 We declare that we have no competing interests.  
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8 481 **Patient consent**

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10 482 Obtained.

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14 484 **Data sharing statement**

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16 485 No additional data are available.

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50 502 **References**

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

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	Exacerbation of headache	Exacerbation of dizziness	Exacerbation of palpitation	Exacerbation of shortness of breath
	No. (%)	No. (%)	No. (%)	No. (%)
<b>Sex</b>				
Men	466 (1.4)	341 (1.1)	277 (0.9)	257 (0.8)
Women	1,427 (3.5)	888 (2.2)	808 (2.0)	369 (0.9)
<b>Age</b>				
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)
<b>Mental Health Status</b>				
K6<13	1,092 (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)
<b>Post Traumatic Stress Disorder</b>				
No	1,062 (1.7)	653 (1.0)	542 (0.9)	323 (0.5)
Yes	831 (8.0)	576 (5.5)	543 (5.2)	303 (2.9)
<b>Smoking Status</b>				
Never-smoker	1,104 (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)
<b>Drinking Status</b>				
Never-drinker	1,067 (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)
Current drinker	715 (2.3)	463 (1.5)	407 (1.3)	248 (0.8)
<b>Physical activity</b>				
>= once per day	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)
Once per week	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)
<b>Hypertension History</b>				
No	1,216 (2.8)	667 (1.6)	584 (1.4)	276 (0.6)
Yes	677 (2.2)	562 (1.8)	501 (1.6)	350 (1.1)
<b>Stroke History</b>				
No	1,799 (2.6)	1,146 (1.7)	1,799 (1.5)	576 (0.8)
Yes	94 (2.4)	83 (2.2)	94 (1.6)	50 (1.3)
<b>Heart Disease History</b>				
No	1,691 (2.6)	1,025 (1.6)	1,691 (2.6)	432 (0.7)
Yes	202 (10.7)	204 (2.8)	202 (4.0)	194 (2.7)
<b>Unemployment</b>				
No	1,293 (2.2)	874 (1.5)	790 (1.4)	470 (0.8)
Yes	600 (4.2)	355 (2.5)	295 (2.1)	156 (1.1)
<b>Decreased income</b>				

No	1,432 (2.4)	968 (1.6)	870 (1.4)	506 (0.8)
Yes	461 (3.6)	261 (2.0)	215 (1.7)	120 (0.9)
<b>Living arrangement</b>				
Evacuation Shelter Temporary housing	213 (2.5)	12 (1.6)	5 (0.7)	5 (0.7)
Rental house, apartment	195 (2.8)	134 (1.9)	89 (1.3)	81 (1.2)
Relatives' home	796 (3.5)	489 (2.1)	421 (1.8)	224 (1.0)
Own home	78 (2.8)	53 (1.9)	209 (1.0)	108 (0.5)
	292 (1.4)	199 (0.9)	45 (1.6)	29 (1.0)
<b>Tsunami experience</b>				
No	1,424 (2.4)	908 (1.6)	830 (1.4)	458 (0.8)
Yes	469 (3.2)	321 (2.2)	255 (1.7)	168 (1.1)
<b>Experience of the nuclear power plant accident</b>				
No	717 (2.1)	426 (1.2)	358 (1.0)	201 (0.6)
Yes	1,176 (3.1)	803 (2.1)	727 (1.9)	425 (1.1)
<b>Damage of house</b>				
No	413 (2.2)	258 (1.4)	233 (1.3)	103 (0.6)
A part of	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 a half	67 (3.4)	48 (2.5)	38 (1.9)	23 (1.2)
Totally	126 (3.3)	86 (2.2)	66 (1.7)	43 (1.1)
<b>Loss of family member</b>				
No	552 (3.9)	363 (2.6)	296 (2.1)	199 (1.4)

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634	Yes	1,291 (2.3)	825 (1.5)	759 (1.3)	404 (0.7)
635	<b>Educational years</b>				
636	<12 years (reference)	352 (1.9)	265 (1.4)	223 (1.2)	202 (1.1)
637	>=12 years	1,471 (2.9)	916 (1.8)	822 (1.6)	397 (0.8)
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Table 2. Odds ratios (OR) and 95% CIs for cardiovascular related symptoms on multiple logistic regression analyses

		Exacerbation of Headache			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	2.03 (1.58-2.62)	1.58 (1.19-2.09)	1.95 (1.11-2.57)	1.46 (1.06-2.02)
	Rental house, apartment	2.21 (1.93-2.54)	1.54 (1.32-1.80)	1.83 (1.34-2.53)	1.46 (1.22-1.75)
	Evacuation Shelter	2.01 (1.24-3.25)	1.80 (1.09-2.96)	2.24 (0.99-5.16)	1.61 (0.85-3.03)
	Temporary housing	2.13 (1.77-2.56)	1.42 (1.15-1.72)	1.69 (1.11-3.43)	1.36 (1.06-1.73)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.70 (1.53-1.88)	1.28 (1.12-1.46)	1.36 (1.04-1.78)	1.26 (1.09-1.47)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.56 (1.40-1.74)	1.39 (1.22-1.60)	1.39 (1.08-1.78)	1.39 (1.17-1.63)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.02 (0.89-1.16)	1.04 (0.81-1.63)	1.25 (0.91-1.73)	0.97 (0.80-1.17)

## Exacerbation of Dizziness

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.98 (1.46-2.69)	1.42 (1.02-1.98)	0.96 (0.49-1.91)	1.66 (1.13-2.43)
	Rental house, apartment	2.27 (1.91-2.69)	1.45 (1.20-1.75)	1.28 (0.92-1.79)	1.55 (1.23-1.96)
	Evacuation Shelter	1.84 (1.02-3.32)	1.39 (0.74-2.59)	0.85 (0.26-2.77)	1.83 (0.87-3.84)
	Temporary housing	2.09 (1.68-2.61)	1.40 (1.09-1.79)	1.51 (1.00-2.28)	1.36 (1.00-1.85)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.65 (1.45-1.87)	1.26 (1.07-1.48)	1.27 (0.94-1.73)	1.20 (0.98-1.45)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.37 (1.19-1.57)	1.18 (0.99-1.40)	1.12 (0.83-1.51)	1.22 (0.98-1.51)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.17 (1.01-1.37)	1.13 (0.94-1.36)	1.08 (0.80-1.47)	1.14 (0.90-1.44)

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## Exacerbation of Palpitation

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.70 (1.23-2.34)	1.23 (0.87-1.74)	1.25 (0.57-2.71)	1.21 (0.82-1.78)
	Rental house, apartment	1.90 (1.60-2.25)	1.25 (1.03-1.51)	1.73 (1.17-2.53)	1.11 (0.89-1.39)
	Evacuation Shelter	0.74 (0.30-1.80)	0.51 (0.19-1.39)	0.93 (0.22-3.92)	0.35 (0.09-1.45)
	Temporary housing	1.32 (1.03-1.69)	0.82 (0.62-1.10)	1.19 (0.69-2.04)	0.72 (0.51-1.01)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.46 (1.27-1.68)	1.21 (1.01-1.45)	1.29 (0.91-1.83)	1.20 (0.97-1.48)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.07-1.44)	1.14 (0.94-1.38)	1.46 (1.05-2.03)	1.00 (0.80-1.28)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.28 (1.09-1.50)	1.14 (0.93-1.39)	1.15 (0.79-1.67)	1.00 (0.81-1.23)

## Exacerbation of Shortness of Breath

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.60 (1.02-2.52)	1.16 (0.71-1.90)	0.95 (0.42-2.16)	1.33 (0.72-2.63)
	Rental house, apartment	2.34 (1.85-2.96)	1.76 (1.35-2.28)	1.50 (1.01-2.22)	1.98 (1.39-2.81)
	Evacuation Shelter	1.33 (0.54-3.27)	1.20 (0.48-3.00)	1.73 (0.60-4.95)	0.52 (0.07-3.79)
	Temporary housing	2.29 (1.72-3.06)	1.49 (1.07-2.08)	1.25 (0.75-2.09)	1.72 (1.10-2.68)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.55 (1.29-1.87)	1.13 (0.89-1.44)	1.06 (0.73-1.55)	1.17 (0.85-1.60)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.01-1.52)	1.14 (0.89-1.47)	1.18 (0.83-1.69)	1.10 (0.77-1.57)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	0.94 (0.78-1.13)	0.84 (0.67-1.06)	0.76 (0.54-1.07)	0.90 (0.66-1.23)

a. Adjusted for age and sex.

b. 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 (>= once per day, 2-4 times per week, once per week, never), tsunami experience (yes or no), radiation experience (yes or no), damage of house (no, a part of, half, more than a half, totally), loss of family member (yes or no).

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract (P1-4)</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction (P6-7)</b>		
Background/rationale (P6)	2	Explain the scientific background and rationale for the investigation being reported
Objectives (P7)	3	State specific objectives, including any prespecified hypotheses
<b>Methods (P7-11)</b>		
Study design (P7)	4	Present key elements of study design early in the paper
Setting (P7)	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants (P7)	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables (P8-P10)	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement (P8-P10)	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias (None)	9	Describe any efforts to address potential sources of bias
Study size (P7-8)	10	Explain how the study size was arrived at
Quantitative variables (P8-10)	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods (P10-11)	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

**Results (P11-14)**

Participants (P11-12)	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data (P11-13)	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data (P11)	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results (P13-14)	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses None	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion (P14-18)**

Key results (P14-18)	18	Summarise key results with reference to study objectives
Limitations (P18)	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation (P14-18)	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability None	21	Discuss the generalisability (external validity) of the study results

**Other information (P19)**

Funding (P19)	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

## STROBE Statement—checklist of items that should be included in reports of observational studies

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Data sources/ measurement (P8-P10)	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias (None)	9	Describe any efforts to address potential sources of bias
Study size (P7-8)	10	Explain how the study size was arrived at
Quantitative variables (P8-10)	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods (P10-11)	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

**Results (P11-14)**

Participants (P11-12)	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data (P11-13)	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data (P11)	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results (P13-14)	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses None	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion (P14-20)**

Key results (P14-20)	18	Summarise key results with reference to study objectives
Limitations (P18-20)	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation (P14-18)	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability None	21	Discuss the generalisability (external validity) of the study results

**Other information (P20)**

Funding (P20)	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



# BMJ Open

## Effects of socioeconomic factors after a disaster on cardiovascular related symptoms among evacuees after the Great East Japan Earthquake in a population-based cross-sectional study: the Fukushima Health Management Survey

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Secondary Subject Heading:	Epidemiology, Sociology

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Keywords:	Great East Japan Earthquake, socioeconomic factors, cardiovascular related symptoms

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1 **Effects of socioeconomic factors after a disaster on**  
2 **cardiovascular related symptoms among evacuees after the**  
3 **Great East Japan Earthquake in a population-based**  
4 **cross-sectional study: the Fukushima Health Management**  
5 **Survey**

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50 **Abstract**

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

54 **Methods:** A total of 73,433 subjects were included in the Fukushima Health  
55 Management survey. Exacerbation of headache, dizziness, palpitations, and shortness  
56 of breath were determined from self-report questionnaires. Socioeconomic factors  
57 included living arrangement, loss of employment and decreased income. Odds ratios  
58 (OR) and 95% confidence intervals (CI) of socioeconomic factors were estimated for  
59 each symptom using multiple logistic regression analyses.

60 **Results:** A total of 1,375 individuals reported exacerbation of headache, 881 of  
61 dizziness, 768 of palpitations, and 434 of shortness of breath. Evacuation  
62 accommodation was associated with all the above symptoms. Compared to participants  
63 living in their own home (OR=1.00), subjects living in relatives' homes had increased  
64 odds of experiencing exacerbation of headache (1.58; 95% CI 1.20–2.09) and dizziness  
65 (1.43; 95% CI 1.02–1.98); subjects living in temporary housing or apartments showed  
66 exacerbation of headache (1.55; 95% CI 1.32–1.81), dizziness (1.45; 95% CI 1.20–  
67 1.76), palpitations (1.25; 95% CI 1.03–1.51), and shortness of breath (1.75; 95% CI  
68 1.35–2.27); subjects living in evacuation shelters showed exacerbation of headache  
69 (1.80; 95% CI 1.10–2.97); and refugees living in temporary housing showed  
70 exacerbated headache (1.42; 95% CI 1.15–1.75), dizziness (1.39; 95% CI 1.08–1.78),  
71 and shortness of breath (1.50; 95% CI 1.07–2.09). Compared to the evacuees that  
72 retained their jobs, unemployed subjects showed increased odds for exacerbation of  
73 headache (1.28, 95% CI 1.12–1.46), dizziness (1.26, 95% CI 1.07–1.48), and

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6 74 palpitations (1.22, 95% CI 1.02–1.46). Decreased income was associated with  
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8 75 exacerbation of headache (1.39, 95% CI 1.21–1.60).

9  
10 76 **Conclusion:** After the earthquake, living in non-home conditions was more likely to  
11  
12 77 exacerbate cardiovascular symptoms among evacuees. Loss of employment was  
13  
14 78 another risk factor for exacerbated headache and dizziness.  
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21 81 **Keywords:** Great East Japan Earthquake, socioeconomic factors, cardiovascular related

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6 98 **Strengths and limitations of this study**  
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- 8 99 ● Our study is the first to identify an inverse relationship between low socioeconomic  
10 status and exacerbated cardiovascular related symptoms among evacuees of the  
11 number of 73,433 subjects after the Great East Japan earthquake.  
12  
13  
14 102 ● A limitation of the present study was based on a subjectivity of self-response survey.  
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16 103 And the exacerbated symptoms would not be logical predict cardiovascular  
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18 104 diseases.  
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21 105 ● An overall response rate was low (40.7%) and data may have contained sampling  
22  
23 106 biases.  
24  
25 107 ● Another limitation of the present study was the information of changes in family  
26  
27 108 relationships (e.g., death, physical separation) among the evacuees after the  
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29 109 disaster has not been captured.  
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32 110 ● In addition, most questionnaires were collected in the same period (from Jan 2012  
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34 111 to Mar 2012).  
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6 122 **Introduction**

7 123 The Great East Japan Earthquake and the subsequent Fukushima Daiichi nuclear  
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9 124 disaster, which occurred in March 2011, was the most destructive catastrophe in Japan  
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11 125 to date. Due to concerns over released radiation, most of the residents in nearby towns  
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13 126 were forced to evacuate and consequently suffered long-lasting anxiety. Shortly after  
14  
15 127 the disaster, a Fukushima Health Management Survey was conducted to investigate the  
16  
17 128 effects of long-term low-dose radiation exposure caused by the accident and to assess  
18  
19 129 the physical and mental wellbeing of evacuees. This survey included a basic survey,  
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21 130 which estimated individual radiation exposure of each resident, and four detailed  
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23 131 surveys comprising of a Comprehensive Health Check and thyroid ultrasonography, a  
24  
25 132 mental health and lifestyle survey, and a survey of pregnant women and nursing  
26  
27 133 mothers (1). The Mental Health and Lifestyle Survey used self-report questionnaires to  
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29 134 investigate health status and lifestyle of the refugees, including nutrition and diet,  
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31 135 perceived symptoms of illness, disaster-related experience, and socioeconomic  
32  
33 136 determinants.

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38 137 Several previous studies have shown changes in the incidence of cardiovascular  
39  
40 138 events following disasters; however, results are conflicting (2-11). A recent study  
41  
42 139 reported a heterogeneous occurrence of cardiovascular events after the Great East  
43  
44 140 Japan Earthquake (2), while another study reported a significant increase in the  
45  
46 141 incidence of cardioembolic stroke after the earthquake (11). However, neither study  
47  
48 142 examined the incidence of perceived cardiovascular disease symptoms after a disaster,  
49  
50 143 nor did they focus on the effect of refugee socioeconomic status on health problems  
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52 144 during their evacuation term. However, considering these aspects is relevant for  
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6 145 reviewing refugee health status, accessing the incidence of various diseases, and  
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8 146 providing health guidelines for refugees.  
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10 147 Consequently, we conducted the present study to investigate the risk factors of  
11  
12 148 perceived cardiovascular symptoms following a major disaster. In the present study,  
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14 149 socioeconomic determinants included educational years, living arrangement, change of  
15  
16 150 employment and income. Due to the special post-disaster situation, change of  
17  
18 151 employment and income due to the disaster, instead of job and income level were  
19  
20 152 captured. Thus in the present study, a decrease or low socioeconomic status was  
21  
22 153 considered as less educational years, living in non-home conditions, unemployment or  
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24 154 decreased income due to the disaster. We hypothesized that a decrease in  
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26 155 socioeconomic status due to the earthquake would be associated with exacerbated  
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28 156 cardiovascular symptoms among evacuees.  
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## 33 34 158 **Methods**

### 35 36 159 **Participants**

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38 160 The primary purpose of the Fukushima Health Management Survey was to monitor  
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40 161 the long-term health and lifestyle of Fukushima residents and to provide them with  
41  
42 162 appropriate care (12). The Fukushima Health Management Survey consists of a basic  
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44 163 survey and four detailed surveys, namely, the thyroid ultrasound examination,  
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46 164 comprehensive health check, mental health and lifestyle survey, and pregnancy and  
47  
48 165 birth survey (for details of these surveys see (1)). The subjects of mental health and  
49  
50 166 lifestyle survey was included in the present study. Briefly, the target population, consists  
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52 167 of 210,189 officially registered victims of the Great East Japan Earthquake from the  
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54 168 evacuation zones Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village,  
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6 169 Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City,  
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8 170 Yamakiya District of Kawamata Town, and Iitate Village. In 2012, 180,604  
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10 171 questionnaires were sent out with 73,569 questionnaires returned with responses, i.e. a  
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12 172 response rate of 40.7%. Among the responders, 136 were excluded due to blank or  
13  
14 173 duplicated questionnaires and 9,245 for questionnaires filled in by a proxy. After  
15  
16 174 exclusion, the data of 73,433 subjects (32,301 men and 41,132 women) were used in  
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18 175 our analyses.

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21 176 The study protocol was approved by the Ethics Committee of Fukushima Medical  
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23 177 University. Participants who returned the self-administered questionnaires were  
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25 178 considered to have consented to participate.  
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### 30 180 **Data collection and measurement**

31  
32 181 A questionnaire was used to broadly investigate the health status and lifestyle of  
33  
34 182 the refugees. The exacerbation of headache, dizziness, palpitations, and shortness of  
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36 183 breath was determined based on self-reports in the questionnaire. All subjects were  
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38 184 asked to answer the question 'Do you have the following perceived symptoms after the  
39  
40 185 earthquake?' and could choose between the replies 'No', 'Yes', and 'Exacerbation'. In  
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42 186 the present study we focused on reports of 'exacerbation'.  
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45 187 To evaluate Posttraumatic Stress Disorder (PTSD) symptoms we used the  
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47 188 non-military version of the Posttraumatic Stress Disorder Checklist (PCL-S) (12). This is  
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49 189 a 17-item self-report checklist based on the Diagnostic and Statistical Manual of Mental  
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51 190 Disorders (4th edition, DSM-IV) criteria (13), with each item rated using a Likert-type  
52  
53 191 scale from one ('not at all') to five ('extremely'). Respondents were requested to  
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55 192 respond to questions about each PTSD symptom separately and report whether they  
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6 193 had experienced a given symptom during the past month. Based on summing the  
7  
8 194 scores from each of the 17 items, a total PCL-S score can range from 17 to 85 (12).  
9

10 195 In addition to the PCL-S checklist, the following items were included in the  
11  
12 196 self-assessment and self-report questionnaires:  
13

14 197 1. Demographic characteristics  
15

16 198 Demographic subject characteristics include gender, age group, mental health  
17  
18 199 status, history of mental illness, incidence of PTSD symptoms, smoking and drinking  
19  
20 200 habits, and current physical activity levels. Age groups were divided into childbearing  
21  
22 201 age (20–49 years), middle age (50–64 years), and old age (65 years and above).  
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25 202 Mental health status, and specifically incidence and severity of depression, was  
26  
27 203 measured by the Japanese version of the K6 Kessler Psychological Distress Scale,  
28  
29 204 which has been validated by previous studies (14, 15). In the K6 assessment,  
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31 205 participants were asked if they had experienced any of the following six symptoms  
32  
33 206 during the past 30 days: feeling so depressed that nothing could cheer them up, feeling  
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35 207 that everything was an effort, or feeling nervous, hopeless, restless, fidgety, or  
36  
37 208 worthless. Each question was rated on a 5-point Likert-type scale from zero (none of the  
38  
39 209 time) to four (all of the time), with higher scores signifying worse mental health status  
40  
41 210 (total range: 0–24) (12). In addition, we assessed participant's history of mental illness  
42  
43 211 by self-report as 'yes' or 'no'.  
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46 212 We obtained data on smoking and drinking habits using the following metrics,  
47  
48 213 respectively: 'non-smoker', 'ex-smoker', or 'current smoker'; and 'once or more per  
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50 214 month', 'less than once per month', or 'ex- drinker'. Participants had four options to  
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52 215 assess current physical activity level: 'every day', '2-4 times/week', 'once a week', or  
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54 216 'nearly none'.  
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6 217 2. Socioeconomic variables

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8 218 Participants were required to select from six options regarding their living  
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10 219 arrangements: evacuation shelter, temporary housing, rental housing or apartment, a  
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12 220 relative's home, their own home, and other. The last option was considered  
13  
14 221 non-informative due to its ambiguity and thus excluded from analysis.

15  
16 222 Other socioeconomic variables included educational years (< 12 years, >=12 years),  
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18 223 change in employment status and change in income. By answering 'Yes' to either  
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20 224 question, the participant indicated he/she became unemployed or experienced  
21  
22 225 decreased income since the disaster.

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25 226 3. Disaster-related variables

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27 227 Disaster-related variables included experience of the tsunami (yes or no), experience  
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29 228 of the nuclear power plant accident (defined as hearing the explosion; yes or no), losing  
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31 229 someone close because of the disaster (yes or no), and damage to accommodation (no,  
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33 230 partial damage, half of accommodation destroyed, more than a half destroyed, total  
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35 231 destruction).

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40 233 **Statistical analysis**

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42 234 The incidence of exacerbation of headache, dizziness, palpitations, and shortness of  
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44 235 breath was compared between subjects with different demographic, socioeconomic,  
45  
46 236 and disaster-related characteristics using chi-square tests. For the analyses  
47  
48 237 investigating PTSD incidence, a PCL-S cut-off score of 50 was used, according to  
49  
50 238 Weathers et al (16-19). Subjects who received a PCL-S of 50 or greater were allocated  
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52 239 to the 'high-scoring group' and compared to the low-scoring (PCL-S < 50) group using  
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54 240 chi-square tests.  
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6 241 Odds ratios (ORs) and 95% confidence intervals (CIs) of each socioeconomic  
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8 242 determinant (living arrangement, unemployment, decreased income and educational  
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10 243 years were estimated by applying multiple logistic regression models. Adjustment  
11  
12 244 variables consisted of sex (male, female), age (20–49, 50–64, ≥65 years), drinking  
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14 245 status (once or more per month, ex-drinker, less than once per month), smoking status  
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16 246 (non-smoker, ex-smoker, current smoker), mental health distress (K6<3, K6≥13),  
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18 247 hypertension history (yes or no), stroke history (yes or no), heart disease history (yes or  
19  
20 248 no), physical activities (≥ once per day, 2–4 times per week, once per week, never),  
21  
22 249 tsunami experience (yes or no), radiation experience (yes or no), damage of  
23  
24 250 accommodation (no, partial, half, more than a half, total), loss of family member (yes or  
25  
26 251 no).

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29 252 We conducted the above analyses both for separate and combined sexes. All  
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31 253 analyses were conducted using SAS software version 9.4 (SAS Institute Inc., Cary, NC,  
32  
33 254 USA).

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## 37 38 256 **Results**

39  
40 257 As shown in the tables, 1,893 (2.6%) individuals reported exacerbation of headaches,  
41  
42 258 1,229 (1.7%) of dizziness, 626 (0.9%) of palpitations, and 434 (0.6%) exacerbation of  
43  
44 259 shortness of breath.

## 45 46 47 260 **Demographic characteristics**

48  
49 261 Table 1 summarizes the demographic characteristics of the subjects. Exacerbation of  
50  
51 262 the above cardiovascular symptoms was significantly more likely to happen in women  
52  
53 263 than in men (3.5% vs. 1.4% for headaches; 2.2% vs. 1.1% for dizziness; 2.0% vs. 0.9%  
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55 264 for palpitations; 0.9% vs. 0.8% for shortness of breath). Subjects experiencing  
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6 265 exacerbation of headaches, dizziness, or palpitations were more likely to be young (20–  
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8 266 49 years), while those experiencing exacerbation of shortness of breath were more  
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10 267 likely to be 50-64 years. Subjects experiencing exacerbation of cardiovascular  
11  
12 268 symptoms were also more likely to suffer from depression (K6 $\geq$ 13) and Posttraumatic  
13  
14 269 Stress Disorder (PCL $\geq$ 50), and to commonly have a history of hypertension, stroke, or  
15  
16 270 heart disease. Non-smokers and non-drinkers were no less likely than (ex-) smokers or  
17  
18 271 (ex-) drinkers to experience exacerbation of cardiovascular symptoms. However,  
19  
20 272 symptom exacerbation was most pronounced in subjects who were physically active  
21  
22 273 less than once a day.

#### 274 **Socioeconomic variables**

275 Table 1 also shows refugees living in their own or a relative's home are less likely to  
276 experience exacerbated cardiovascular symptoms. Of the refugees living in their own  
277 home, 1.4% reported exacerbation of headache, 0.9% of dizziness, 1.6% of palpitations  
278 and 1.0% of shortness of breath. The corresponding statistics for refugees living in  
279 temporary housing and rental houses/apartments were 2.8%, 1.9%, 1.3%, and 1.2%  
280 and 3.5%, 2.1%, 1.8%, and 1.0%, respectively.

281 In the group that became unemployed due to the disaster, 4.2% subjects reported  
282 the exacerbation of headache, 2.5% of dizziness, 2.1% of palpitations and 1.1% of  
283 shortness of breath, while the corresponding statistics for the group that did not lose  
284 their jobs after the disaster were 2.2%, 1.5%, 1.4%, and 0.8%. Exacerbation of most  
285 cardiovascular symptoms was higher in subjects whose income decreased due to the  
286 disaster compared to those who maintained income levels (3.6% vs. 2.4% for  
287 exacerbation of headache, 2.0% vs. 1.6% for exacerbation of dizziness, and 1.7% vs.  
288 1.4% for exacerbation of palpitation).

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6 289 In addition, exacerbation of most cardiovascular symptoms was higher in subjects  
7  
8 290 who had 12 years education or more compared to those who had less education (2.9%  
9  
10 291 vs. 1.9% for exacerbation of headache, 1.8% vs. 1.4% for exacerbation of dizziness,  
11  
12 292 and 1.6% vs. 1.2% for exacerbation of palpitation).  
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#### 16 294 **Disaster-related variables**

17  
18 295 Subjects that directly experienced the tsunami and the nuclear power plant accident  
19  
20 296 were more likely to experience exacerbated cardiovascular symptoms. Among those  
21  
22 297 experiencing the tsunami, 3.2% reported exacerbation of headache, 2.2% of dizziness,  
23  
24 298 1.7% of palpitations, and 1.7% of shortness of breath, compared to 2.4%, 1.6%, 1.5%,  
25  
26 299 and 0.8%, respectively, of subjects with no experience of the tsunami. The  
27  
28 300 corresponding statistics for subjects that had heard the nuclear power plant accident  
29  
30 301 were 3.1%, 2.1%, 1.9%, and 1.1% compared to 2.1%, 1.2%, 1.0%, and 0.6%, that had  
31  
32 302 not.  
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#### 34 303 **Multiple Logistic Regression analyses**

35  
36 304 Table 2 summarizes the odds ratios (ORs) and 95% CIs of each socioeconomic  
37  
38 305 determinant for exacerbation of headache, dizziness, palpitations, and shortness of  
39  
40 306 breath. Living arrangement emerged as a risk factor for exacerbated cardiovascular  
41  
42 307 symptoms from our models, which were adjusted for multiple demographic-, health-,  
43  
44 308 and disaster-related variables. Compared to participants living in their own home (OR =  
45  
46 309 1), those living in relatives' homes had higher odds to experience exacerbation of  
47  
48 310 headache (1.58; 95% CI 1.19–2.09) and dizziness (1.42; 95% CI 1.02–1.98). Similarly,  
49  
50 311 subjects living in rental houses or apartments had higher odds of exacerbated  
51  
52 312 headache (1.54; 95% CI 1.32–1.80), dizziness (1.45; 95% CI 1.20–1.75), palpitations  
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6 313 (1.25; 95% CI 1.03–1.51), and shortness of breath (1.76; 95% CI 1.35–2.28).  
7  
8 314 Participants living in evacuation shelters had increased odds of exacerbation of  
9  
10 315 headache (1.80; 95% CI 1.09–2.96) and refugees living in temporary housing similarly  
11  
12 316 had increased odds of exacerbation of headache (1.42; 95% CI 1.15–1.72), dizziness  
13  
14 317 (1.40; 95% CI 1.09–1.79), and shortness of breath (1.49; 95% CI 1.07–2.08).

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16  
17 318 Loss of employment also emerged as a risk factor for increased odds of  
18  
19 319 cardiovascular symptoms. Compared to the evacuees that remained employed (OR =  
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21 320 1), subjects that had become unemployed were at higher risk of experiencing  
22  
23 321 exacerbation of headache (1.28; 95% CI 1.12–1.46), dizziness (1.26; 95% CI 1.07–  
24  
25 322 1.48), and palpitation (1.21; 95% 1.01–1.45). In an unadjusted model, we found a  
26  
27 323 significant positive association between unemployment and exacerbation of  
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29 324 palpitations; however, after adjusting for multiple relevant variables, this association  
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31 325 became non-significant.

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33  
34 326 There was no association between decreased income and exacerbated  
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36 327 cardiovascular symptoms, except for headache. Here, adjusting for multiple variables  
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38 328 resulted in an increased odds ratio for exacerbation of headaches both in an analysis  
39  
40 329 combining both sexes (1.39, 95% CI 1.22–1.60) and in separate analyses of men and  
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42 330 women.

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45 331 Educational years was not associated with and exacerbated cardiovascular  
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47 332 symptoms in multiple-adjusted models in the present study.

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## 50 51 334 **Discussion**

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53 335 We have demonstrated a decrease in socioeconomic status due to the earthquake  
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55 336 was associated with exacerbated cardiovascular symptoms among evacuees of the  
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6 337 Great East Japan Earthquake. Compared with participants living in their own home,  
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8 338 people of both genders living in relatives' homes, evacuation shelters, temporary  
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10 339 housing, or rental houses or apartments were more likely to experience exacerbated  
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12 340 headache, dizziness, palpitations, or shortness of breath. Similarly, loss of employment  
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14 341 and reduced income due to the disaster increased the risk of exacerbated symptoms.

15  
16 342 The following three points should be considered in the context of our results. Firstly,  
17  
18 343 earthquakes are definitely associated with increased cardiovascular disease, including  
19  
20 344 sudden cardiac death and acute myocardial infarction (2-14), which provides some  
21  
22 345 support for the present study. The Hanshin-Awaji earthquake was associated with an  
23  
24 346 increased cardiovascular disease and the increase persisted for more than a month. In  
25  
26 347 addition, an increase in the number of subjects with acute myocardial infarction,  
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28 348 especially in women, was particularly evident during the first 4 weeks post-disaster (9).  
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30 349 After the Great East Japan Earthquake, the incidence of reported cardioembolic stroke  
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32 350 increased in the first 3–9 months following the disaster (10), as did the incidence of  
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34 351 other cardiovascular diseases (11-14). Our study contributes to the reported incidences  
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36 352 of cardiovascular disease by demonstrating exacerbated cardiovascular symptoms  
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38 353 among evacuees after a disaster from self-report questionnaires rather than from death  
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40 354 certificates.

41  
42 355 Secondly, increases in cardiovascular events and exacerbated cardiovascular  
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44 356 symptoms can be attributed to post-disaster distress or mental problems. A review  
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46 357 suggests that extremely stressful experiences, such as earthquakes, can trigger  
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48 358 cardiovascular events (20-22). Acute major stress and chronic stress, i.e. the  
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50 359 cumulative load of minor daily stress, can have both long-term consequences, which  
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52 360 can be perceived as stressful and a potential threat to one's environment, subsequently  
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6 361 inducing a variety of negative emotional responses, such as fear, anxiety, sadness,  
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8 362 anger, hostility, and depression (4,23) leading to hypertension or cardiovascular events  
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10 363 (20-22). A recent study suggest that post-traumatic stress disorder (PTSD) was  
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12 364 frequently noted in CVD patients at 6 months after the Great East Japan Earthquake.  
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14 365 The patients with PTSD were more likely to experience a composite of death, acute  
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16 366 myocardial infarction, stroke and heart disease (24). In the current study, all subjects  
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18 367 exhibiting exacerbated cardiovascular symptoms were more likely to have depression  
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20 368 (K6 $\geq$ 13) or Posttraumatic Stress Disorder (PCL $\geq$ 50). Logistic regression analyses  
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22 369 also showed that depression and Posttraumatic Stress Disorder were both  
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24  
25 370 independently associated with exacerbated cardiovascular symptoms (data not shown).  
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27  
28 371 Thirdly, although post-disaster increases in cardiovascular events were widely  
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30 372 reported in previous studies, the investigation of socioeconomic determinants of these  
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32 373 events during the evacuation term of refugees was very limited. Previous studies  
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34 374 reported that one year after the Wenchuan Earthquake in China, depression severity  
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36 375 among refugees varied with income, housing status, and social support (25), indicating  
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38 376 that earthquake impact on income was indirectly associated with life satisfaction and  
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40 377 depression via its effect on financial status (26). Another study showed that six months  
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42 378 after the 2011 Christchurch earthquake in New Zealand, on average lower income per  
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44 379 home contributed unequivocally to earthquake-related distress and dysfunction (27). A  
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47 380 recent study also showed that at 6 months after the Great East Japan Earthquake,  
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49 381 Tsunami experience, property loss and poverty were associated with PTSD in CVD  
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51 382 patients and had an had an adverse prognostic impact (24).  
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54 383 In the present study, not living in the own home but living in evacuation shelters or  
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56 384 temporary housing, was associated with exacerbation of all examined cardiovascular  
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5 385 symptoms, which was more robust in women than in men. Evacuation shelters and  
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7 386 temporary housing were less spacious, damper, and less comfortable than the refugees'  
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9 387 homes. Due to insufficient access to supermarkets or shortages of cooking equipment  
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11 388 and utilities, such as gas, evacuees living in shelters would struggle to access balanced  
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13 389 meals. A recent cross-sectional study showed a well-balanced diet was associated with  
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15 390 better living conditions among refugees after the Great East Japan Earthquake,  
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17 391 whereas imbalanced diets, were not (27,28). In addition, having to take refuge in  
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19 392 accommodation other than the own home meant that the own neighborhood had been  
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21 393 damaged by the disaster, which may lead to shortness of social support. In addition,  
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23 394 among the refugees. All of the above factors can be considered predictors of stress  
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25 395 among refugees, where women may be more likely to be influenced than men.  
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29 396 Unemployment and decreased income due to the disaster were also associated with  
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31 397 exacerbation of some cardiovascular symptoms. These results were expected as poor  
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33 398 economic circumstances are expected to exacerbate depression. Low income may be  
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35 399 considered a chronic stressor, increasing psychological distress as a result of limited  
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37 400 resource access and opportunities for resource accumulation (29). Previous studies  
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39 401 also showed that, following an earthquake, living in a low-income area may contribute to  
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41 402 greater psychological distress due to lack of occupational, social, and financial  
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43 403 resources. A community study showed that, after the Christchurch earthquake, low  
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45 404 household income contributed strongly to earthquake-related distress (29). In the  
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47 405 present study, we found a significant association between disaster-related  
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49 406 unemployment and exacerbation of some cardiovascular symptoms, but the  
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51 407 subsistence allowance provided to refugees by the Japanese government may have  
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6 408 reduced effect size by reducing the impact of lowered economic circumstances on  
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8 409 refugees.

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10 410 Educational level was inversely associated with cardiovascular disease risk in present  
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12 411 studies (30, 31). However, in present study, educational years was not associated with  
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14 412 exacerbated cardiovascular symptoms. It may due to the post-disaster conditions. In the  
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16 413 present study, both earthquake, tsunami and nuclear accident related factors and  
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18 414 unemployment or decreased income due to the disasters had a large influence on the  
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20 415 exacerbated cardiovascular symptoms of the subjects, which may weaken the impact  
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22 416 from the educational levels.

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25 417 Our understanding of disaster-related stress on cardiovascular disease remains  
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27 418 incomplete. A clinical study on the 1995 Hanshin-Awaji earthquake comparing pre- and  
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29 419 post- BP levels in well-controlled hypertension patients showed an increase of 18mmHg  
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31 420 in diastolic blood pressure two weeks after the earthquake (32). Although white-coat  
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33 421 hypertension contributed partly to the results, whereby patients exhibit increased blood  
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35 422 pressure in clinical settings, some patients developed sustained hypertension that  
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37 423 persisted for one year after the earthquake (32). One study found increased levels of  
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39 424 cholesterol and triglycerides a few weeks after an earthquake (3), whereas other studies  
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41 425 failed to show significantly higher total cholesterol or HDL-cholesterol during the first two  
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43 426 weeks after the Hanshin-Awaji earthquake (6). Therefore, the extent to which changes  
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45 427 in blood lipid profile contributes to exacerbated cardiovascular symptoms several  
46  
47 428 months after the Great East Japan Earthquake remains undetermined. Chronic  
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49 429 psychological stress is also associated with increased insulin resistance (4). A recent  
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51 430 study after the Great East Japan Earthquake found the negative effects of the disaster  
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6 431 on metabolic factors were greater among evacuees than non-evacuees (33), which may  
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8 432 contribute to exacerbated cardiovascular symptoms among evacuees.  
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10 433 The large scale of assessment and assessment under post-disaster  
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12 434 conditions provide considerable authority for the present study. In addition, our study is  
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14 435 the first to identify an inverse relationship between low socioeconomic status  
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16 436 and exacerbated cardiovascular symptoms from an evacuee self-report after a disaster;  
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18 437 our results will be useful for generating guidelines for evacuee health. However, the  
19  
20 438 following study limitations should be considered: Firstly, The study was based on a  
21  
22 439 subjectivity of self-response survey. It is reasonable to understand these symptoms as  
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24 440 those related to stress and/or autonomic nervous system disorders. Further information,  
25  
26 441 such as the incidence of cardiovascular disease should be captured. However, though  
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28 442 the above-mentioned symptoms would not be logical predict cardiovascular diseases,  
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30 443 several previous studies showed headache was suggestive of an incremental risk for  
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32 444 stroke (34, 35), and other studies also showed that vertigo or dizziness, chest pain was  
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34 445 associated with cardiovascular problems (36, 37). We also conducted a sub-analyses  
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36 446 suggest that all the above-mentioned symptoms were associated with the diagnosis of  
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38 447 hypertension in the last year by self-report and exacerbation of dizziness, palpitation  
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40 448 and shortness of breath was associated with the diagnosis of heart disease in the last  
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42 449 year by self-report among the evacuees (data not shown). Therefore, our study of the 4  
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44 450 symptoms may be helpful for improvement of evacuees' health to some extent.  
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47 451 Secondly, not only the Great East Japan Earthquake but also the accompanied nuclear  
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49 452 accident had a large psychological impact on the evacuees, thus the present study may  
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51 453 cannot be unconditionally compared with other studies due to the special situation.  
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54 454 Thirdly, the overall response rate was low (40.7%) and data may have contained  
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6 455 sampling biases. Thirdly, under the extraordinary and unusual social circumstances that  
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8 456 follow a major disaster, health symptoms perceived by evacuees may be strongly  
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10 457 influenced by changes in family relationships (e.g., death, physical separation) among  
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12 458 the evacuees. However, the present study did not capture these information. Moreover,  
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14 459 other socioeconomic determinants, such as household income, and other  
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16 460 cardiovascular risk factors, such as blood pressure, cholesterol levels, were not  
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18 461 captured in the present study either. In addition, although most questionnaires were  
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20 462 collected in the same period (from Jan 2012 to Mar 2012), it is possible the timing of the  
21  
22 463 survey affected the perceived cardiovascular symptoms. Finally, other environmental  
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24 464 factors, such as temperature, food supplies, medical facilities may also affect  
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26 465 cardiovascular problems (38, 39). These information were not collected in the present  
27  
28 466 study. The potential associations observed in this study will be investigated over an  
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30 467 extended period.  
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33  
34 468 In conclusion, the present study was the first to identify a relationship between lower  
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36 469 socioeconomic status due to the earthquake with exacerbated cardiovascular  
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38 470 symptoms among evacuees after the Great East Japan Earthquake. Our findings will  
39  
40 471 inform future periodic health examinations and health guidelines for evacuees.  
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45  
46 474 This Survey was conducted as part of Fukushima Prefecture's post-disaster recovery  
47  
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49  
50 476 Nuclear Incident.  
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#### 52 477 **Contributors**

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6 478 WZ and TO designed the study. TO, SY, MM, MH, NH, YS, HY, MH, HT and AO were  
7  
8 479 responsible for the data collection and overseeing study procedures. The analyses was  
9  
10 480 conducted by WZ and TO. The manuscript was made by WZ. All the authors did contribution  
11  
12 481 to the revision of the manuscript. All the authors read and approved the final version of the  
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14 482 manuscript.  
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17 483

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20  
21 485 This survey was conducted as part of Fukushima Prefecture's post-disaster recovery plans  
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23 486 and was supported by the national 'Health Fund for Children and Adults Affected by the  
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25 487 Nuclear Incident'.  
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#### 28 29 489 **Declaration of interests**

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32 490 We declare that we have no competing interests.  
33  
34 491

#### 35 36 492 **Patient consent**

37  
38 493 Obtained.  
39  
40 494

#### 41 42 495 **Data sharing statement**

43  
44 496 No additional data are available.  
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636 Table 1. Characteristics of survey participants and correlated incidence of exacerbation of cardiovascular related symptoms.

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	Exacerbation of headache	Exacerbation of dizziness	Exacerbation of palpitation	Exacerbation of shortness of breath
	No. (%)	No. (%)	No. (%)	No. (%)
<b>Sex</b>				
Men	466 (1.4)	341 (1.1)	277 (0.9)	257 (0.8)
Women	1,427 (3.5)	888 (2.2)	808 (2.0)	369 (0.9)
<b>Age</b>				
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)
<b>Mental Health Status</b>				
K6<13	1,092 (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)
<b>Post Traumatic Stress Disorder</b>				
No	1,062 (1.7)	653 (1.0)	542 (0.9)	323 (0.5)
Yes	831 (8.0)	576 (5.5)	543 (5.2)	303 (2.9)
<b>Smoking Status</b>				
Never-smoker	1,104 (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)

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Current smoker	403 (2.8)	258 (1.8)	196 (1.3)	123 (0.8)
<b>Drinking Status</b>				
Never-drinker	1,067 (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)
Current drinker	715 (2.3)	463 (1.5)	407 (1.3)	248 (0.8)
<b>Physical activity</b>				
>= once per day	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)
Once per week	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)
<b>Hypertension History</b>				
No	1,216 (2.8)	667 (1.6)	584 (1.4)	276 (0.6)
Yes	677 (2.2)	562 (1.8)	501 (1.6)	350 (1.1)
<b>Stroke History</b>				
No	1,799 (2.6)	1,146 (1.7)	1,799 (1.5)	576 (0.8)
Yes	94 (2.4)	83 (2.2)	94 (1.6)	50 (1.3)
<b>Heart Disease History</b>				
No	1,691 (2.6)	1,025 (1.6)	1,691 (2.6)	432 (0.7)
Yes	202 (10.7)	204 (2.8)	202 (4.0)	194 (2.7)
<b>Unemployment</b>				
No	1,293 (2.2)	874 (1.5)	790 (1.4)	470 (0.8)
Yes	600 (4.2)	355 (2.5)	295 (2.1)	156 (1.1)
<b>Decreased income</b>				



No	1,432 (2.4)	968 (1.6)	870 (1.4)	506 (0.8)
Yes	461 (3.6)	261 (2.0)	215 (1.7)	120 (0.9)
<b>Living arrangement</b>				
Evacuation Shelter Temporary housing	213 (2.5)	12 (1.6)	5 (0.7)	5 (0.7)
Rental house, apartment	195 (2.8)	134 (1.9)	89 (1.3)	81 (1.2)
Relatives' home	796 (3.5)	489 (2.1)	421 (1.8)	224 (1.0)
Own home	78 (2.8)	53 (1.9)	209 (1.0)	108 (0.5)
	292 (1.4)	199 (0.9)	45 (1.6)	29 (1.0)
<b>Tsunami experience</b>				
No	1,424 (2.4)	908 (1.6)	830 (1.4)	458 (0.8)
Yes	469 (3.2)	321 (2.2)	255 (1.7)	168 (1.1)
<b>Experience of the nuclear power plant accident</b>				
No	717 (2.1)	426 (1.2)	358 (1.0)	201 (0.6)
Yes	1,176 (3.1)	803 (2.1)	727 (1.9)	425 (1.1)
<b>Damage of house</b>				
No	413 (2.2)	258 (1.4)	233 (1.3)	103 (0.6)
A part of	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 a half	67 (3.4)	48 (2.5)	38 (1.9)	23 (1.2)
Totally	126 (3.3)	86 (2.2)	66 (1.7)	43 (1.1)
<b>Loss of family member</b>				
No	552 (3.9)	363 (2.6)	296 (2.1)	199 (1.4)

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640	Yes	1,291 (2.3)	825 (1.5)	759 (1.3)	404 (0.7)
641	<b>Educational years</b>				
642	<12 years (reference)	352 (1.9)	265 (1.4)	223 (1.2)	202 (1.1)
643	>=12 years	1,471 (2.9)	916 (1.8)	822 (1.6)	397 (0.8)

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Table 2. Odds ratios (OR) and 95% CIs for cardiovascular related symptoms on multiple logistic regression analyses

		Exacerbation of Headache			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	2.03 (1.58-2.62)	1.58 (1.19-2.09)	1.95 (1.11-2.57)	1.46 (1.06-2.02)
	Rental house, apartment	2.21 (1.93-2.54)	1.54 (1.32-1.80)	1.83 (1.34-2.53)	1.46 (1.22-1.75)
	Evacuation Shelter	2.01 (1.24-3.25)	1.80 (1.09-2.96)	2.24 (0.99-5.16)	1.61 (0.85-3.03)
	Temporary housing	2.13 (1.77-2.56)	1.42 (1.15-1.72)	1.69 (1.11-3.43)	1.36 (1.06-1.73)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.70 (1.53-1.88)	1.28 (1.12-1.46)	1.36 (1.04-1.78)	1.26 (1.09-1.47)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.56 (1.40-1.74)	1.39 (1.22-1.60)	1.39 (1.08-1.78)	1.39 (1.17-1.63)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.02 (0.89-1.16)	1.04 (0.81-1.63)	1.25 (0.91-1.73)	0.97 (0.80-1.17)

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## Exacerbation of Dizziness

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.98 (1.46-2.69)	1.42 (1.02-1.98)	0.96 (0.49-1.91)	1.66 (1.13-2.43)
	Rental house, apartment	2.27 (1.91-2.69)	1.45 (1.20-1.75)	1.28 (0.92-1.79)	1.55 (1.23-1.96)
	Evacuation Shelter	1.84 (1.02-3.32)	1.39 (0.74-2.59)	0.85 (0.26-2.77)	1.83 (0.87-3.84)
<b>Unemployment</b>	Temporary housing	2.09 (1.68-2.61)	1.40 (1.09-1.79)	1.51 (1.00-2.28)	1.36 (1.00-1.85)
	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
<b>Decreased income</b>	Yes	1.65 (1.45-1.87)	1.26 (1.07-1.48)	1.27 (0.94-1.73)	1.20 (0.98-1.45)
	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
<b>Educational years</b>	Yes	1.37 (1.19-1.57)	1.18 (0.99-1.40)	1.12 (0.83-1.51)	1.22 (0.98-1.51)
	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.17 (1.01-1.37)	1.13 (0.94-1.36)	1.08 (0.80-1.47)	1.14 (0.90-1.44)

## Exacerbation of Palpitation

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.70 (1.23-2.34)	1.23 (0.87-1.74)	1.25 (0.57-2.71)	1.21 (0.82-1.78)
	Rental house, apartment	1.90 (1.60-2.25)	1.25 (1.03-1.51)	1.73 (1.17-2.53)	1.11 (0.89-1.39)
	Evacuation Shelter	0.74 (0.30-1.80)	0.51 (0.19-1.39)	0.93 (0.22-3.92)	0.35 (0.09-1.45)
	Temporary housing	1.32 (1.03-1.69)	0.82 (0.62-1.10)	1.19 (0.69-2.04)	0.72 (0.51-1.01)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.46 (1.27-1.68)	1.21 (1.01-1.45)	1.29 (0.91-1.83)	1.20 (0.97-1.48)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.07-1.44)	1.14 (0.94-1.38)	1.46 (1.05-2.03)	1.00 (0.80-1.28)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	1.28 (1.09-1.50)	1.14 (0.93-1.39)	1.15 (0.79-1.67)	1.00 (0.81-1.23)

Exacerbation of Shortness of Breath

		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.60 (1.02-2.52)	1.16 (0.71-1.90)	0.95 (0.42-2.16)	1.33 (0.72-2.63)
	Rental house, apartment	2.34 (1.85-2.96)	1.76 (1.35-2.28)	1.50 (1.01-2.22)	1.98 (1.39-2.81)
	Evacuation Shelter	1.33 (0.54-3.27)	1.20 (0.48-3.00)	1.73 (0.60-4.95)	0.52 (0.07-3.79)
	Temporary housing	2.29 (1.72-3.06)	1.49 (1.07-2.08)	1.25 (0.75-2.09)	1.72 (1.10-2.68)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.55 (1.29-1.87)	1.13 (0.89-1.44)	1.06 (0.73-1.55)	1.17 (0.85-1.60)
<b>Decreased income</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.01-1.52)	1.14 (0.89-1.47)	1.18 (0.83-1.69)	1.10 (0.77-1.57)
<b>Educational years</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	>=12 years	0.94 (0.78-1.13)	0.84 (0.67-1.06)	0.76 (0.54-1.07)	0.90 (0.66-1.23)

a. Adjusted for age and sex.

b. 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 (>= once per day, 2-4 times per week, once per week, never), tsunami experience (yes or no), radiation experience (yes or no), damage of house (no, a part of, half, more than a half, totally), loss of family member (yes or no).

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract (P1-4)</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction (P6-7)</b>		
Background/rationale (P6)	2	Explain the scientific background and rationale for the investigation being reported
Objectives (P7)	3	State specific objectives, including any prespecified hypotheses
<b>Methods (P7-11)</b>		
Study design (P7)	4	Present key elements of study design early in the paper
Setting (P7)	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants (P7)	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables (P8-P10)	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement (P8-P10)	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias (None)	9	Describe any efforts to address potential sources of bias
Study size (P7-8)	10	Explain how the study size was arrived at
Quantitative variables (P8-10)	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods (P10-11)	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

**Results (P11-14)**

Participants (P11-12)	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data (P11-13)	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data (P11)	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results (P13-14)	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses None	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion (P14-20)**

Key results (P14-20)	18	Summarise key results with reference to study objectives
Limitations (P18-20)	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation (P14-18)	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability (P19-20)	21	Discuss the generalisability (external validity) of the study results

**Other information (P20)**

Funding (P20)	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



# BMJ Open

## 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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<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Epidemiology, Sociology

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Keywords:	Great East Japan Earthquake, socioeconomic factors, cardiovascular related symptoms

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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 were included in the Fukushima Health Management survey. Self-report questionnaires were used to determine the influence of socioeconomic factors, including living arrangement, loss of employment, and decreased income on the exacerbation of headache, dizziness, palpitations, and shortness of breath. Odds ratios (OR) and 95% confidence intervals (CIs) of the effect of socioeconomic factors were estimated for each symptom using multiple logistic regression analyses.

**Results:** Exacerbation of headaches were reported by 1,375 individuals, dizziness by 881, palpitations by 768, and shortness of breath by 434 individuals. Evacuation accommodation was associated with all of these symptoms. Compared to 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 1.20–2.09) and dizziness (1.43; 95% CI 1.02–1.98); those living in temporary housing or apartments experienced exacerbation of headache (1.55; 95% CI 1.32–1.81), dizziness (1.45; 95% CI 1.20–1.76), palpitations (1.25; 95% CI 1.03–1.51), and shortness of breath (1.75; 95% CI 1.35–2.27); participants living in evacuation shelters experienced exacerbation of headache (1.80; 95% CI 1.10–2.97); and refugees living in temporary housing also experienced exacerbation of headache (1.42; 95% CI 1.15–1.75), dizziness (1.39; 95% CI 1.08–1.78), and shortness of breath (1.50; 95% CI 1.07–2.09). Compared to the evacuees that retained their jobs, unemployed individuals showed increased probability

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6 of exacerbation of headache (1.28, 95% CI 1.12–1.46), dizziness (1.26, 95% CI 1.07–  
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8 1.48), and palpitations (1.22, 95% CI 1.02–1.46). Decreased income was associated  
9  
10 with exacerbation of headache (1.39, 95% CI 1.21–1.60).

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12 **Conclusion:** After the earthquake, living in non-home conditions was more likely to  
13  
14 result in exacerbated cardiovascular symptoms among evacuees. Loss of employment  
15  
16 was another risk factor related to exacerbated headache and dizziness.  
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21 **Keywords:** cardiovascular symptoms, Great East Japan Earthquake, socioeconomic  
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### 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 (e.g. death and physical separation) among the evacuees after the disaster was not captured.
- Additionally, most questionnaires were collected over a short time period (from Jan 2012 to Mar 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 wellbeing of evacuees. This study included a basic survey which estimated each resident's radiation exposure and four detailed surveys: a Comprehensive Health Check, a thyroid ultrasonography, a Mental Health and Lifestyle Survey, and a survey of pregnant women and nursing mothers (1). The Mental Health and Lifestyle Survey utilized 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, however, 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



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6 are relevant for reviewing refugee health status, assessing the incidence of various  
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8 diseases, and for providing health guidelines for refugees.  
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11 Consequently, we conducted the present study to investigate the risk factors of  
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13 perceived cardiovascular symptoms following a major disaster. In the present study, the  
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15 socioeconomic factors included: the number of years of education, living arrangement,  
16  
17 change of employment, and income. Due to the particular post-disaster situation,  
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19 change of employment and income due to the disaster were captured instead of job and  
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21 income level. Thus, in the present study, fewer years of education, living in non-home  
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23 conditions, and unemployment or decreased income due to the disaster represented  
24  
25 decreased socioeconomic status. We hypothesized that a decrease in socioeconomic  
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27 status due to the earthquake would be associated with exacerbated cardiovascular  
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29 symptoms among evacuees.  
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## 32 33 34 **Methods**

### 35 36 **Participants**

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38 The primary purpose of the Fukushima Health Management Survey was to monitor  
39  
40 the long-term health and lifestyle of Fukushima residents and to provide them with  
41  
42 appropriate care (15). The Fukushima Health Management Survey consisted of a basic  
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44 survey and four detailed surveys, namely: a thyroid ultrasound examination,  
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46 Comprehensive Health Check, Mental Health and Lifestyle Survey, and pregnancy and  
47  
48 birth survey (for details of these surveys see (1)). Individuals participating in the Mental  
49  
50 Health and Lifestyle Survey were included in the present study. Briefly, the target  
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52 population consisted of 210,189 officially registered victims of the Great East Japan  
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54 Earthquake. They were evacuated from the following zones: Hirono Town, Naraha  
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6 Town, Tomioka Town, Kawauchi Village, Futaba Town, Namie Town, Katsurao Village,  
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8 Minamisoma City, Tamura City, Yamakiya District of Kawamata Town, and Iitate Village.

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10 In 2012, 180,604 questionnaires were sent out, of which 73,569 were returned with  
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12 responses (40.7% response rate). Of the returned questionnaires, 136 were excluded  
13  
14 because they were blank or duplicated and 9,245 because they were filled in by a proxy.  
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16 After these exclusions, data from 73,433 individuals (32,301 men and 41,132 women)  
17  
18 were used for our analyses.  
19

20  
21 The study protocol was approved by the Ethics Committee of Fukushima Medical  
22  
23 University. Participants who returned self-administered questionnaires were considered  
24  
25 to have consented to participation in the study.  
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27

### 28 29 30 **Data collection and measurement**

31  
32 To investigate the health status and lifestyle of the refugees, the exacerbation of  
33  
34 headache, dizziness, palpitations, and shortness of breath was determined using a  
35  
36 self-report questionnaire. All participants were asked to answer the question 'Do you  
37  
38 have the following perceived symptoms after the earthquake?' and could choose  
39  
40 between the replies 'No', 'Yes', and 'Exacerbation'. In the present study we focused on  
41  
42 reports of 'Exacerbation'.  
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45  
46 To evaluate Posttraumatic Stress Disorder (PTSD) symptoms we used the  
47  
48 non-military version of the Posttraumatic Stress Disorder Checklist (PCL-S) (15): a  
49  
50 checklist of 17 self-reported items. The list is based on the Diagnostic and Statistical  
51  
52 Manual of Mental Disorders (4th edition, DSM-IV) criteria (16), and each item is rated  
53  
54 using a Likert-type scale from one ('not at all') to five ('extremely'). Participants were  
55  
56 requested to respond to the questions about each PTSD symptom separately and to  
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5 indicate whether they had experienced a given symptom during the past month. Based  
6  
7 on the sum of the scores of all 17 items, a total PCL-S score could range from 17 to 85  
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9 (15).  
10

11  
12 In addition to the PCL-S checklist, the following items were included in the  
13  
14 self-assessment and self-report questionnaires:  
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16  
17 1. Demographic characteristics

18  
19 The demographic characteristics that were surveyed included individuals' gender,  
20  
21 age group, mental health status, history of mental illness, incidence of PTSD symptoms,  
22  
23 smoking and drinking habits, and current physical activity levels. Age groups were  
24  
25 divided into childbearing age (20–49 years), middle age (50–64 years), and old age (65  
26  
27 years and older).  
28

29  
30 Mental health status, and specifically incidence and severity of depression, was  
31  
32 measured using the Japanese version of the K6 Kessler Psychological Distress Scale,  
33  
34 which has been validated by previous studies (17, 18). For the K6 assessment,  
35  
36 participants were asked if they had experienced any of the following symptoms during  
37  
38 the past 30 days: feeling so depressed that nothing could cheer them up, feeling that  
39  
40 everything was an effort, or feeling nervous, hopeless, restless, fidgety, or worthless.  
41  
42 Each question was rated on a 5-point Likert-type scale from zero (never experienced) to  
43  
44 four (experienced all of the time), with higher scores signifying worse mental health  
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46 status (the range of the scores was 0–24) (15). Additionally, we assessed participants'  
47  
48 history of mental illness via a 'yes' or 'no' question.  
49

50  
51 We obtained data on smoking and alcohol consumption habits using the following  
52  
53 categories, respectively: 'non-smoker', 'ex-smoker', or 'current smoker'; and alcohol  
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55 consumption 'once or more per month', 'less than once per month', or 'ex-drinker'.  
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6 Participants had four options to assess current physical activity level: 'daily', '2-4  
7 times/week', 'weekly', or 'nearly none'.  
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## 9 10 2. Socioeconomic variables

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12 Participants were required to select a description of their living arrangements from  
13 six options: evacuation shelter, temporary housing, rental housing or apartment, a  
14 relative's home, their own home, and other. The last option was considered  
15 non-informative due to its ambiguity and was thus excluded from analysis.  
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18  
19 Other socioeconomic variables included number of years of education (< 12 years,  
20 ≥12 years), change in employment status, and change in income level. By answering  
21 'Yes' to a change in employment status or income, the participant indicated s/he  
22 became unemployed or experienced decreased income since the disaster.  
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## 29 30 3. Disaster-related variables

31  
32 Disaster-related variables included experience of the tsunami (yes or no),  
33 experience of the nuclear power plant accident (defined as hearing the explosion; yes or  
34 no), losing someone close as a result of the disaster (yes or no), and damage to  
35 accommodation (none, partial damage, half destroyed, more than half destroyed, total  
36 destruction).  
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## 45 **Statistical analyses**

46  
47 The incidence of exacerbation of headache, dizziness, palpitations, and shortness of  
48 breath was compared between individuals with different demographic, socioeconomic,  
49 and disaster-related characteristics using chi-square tests. For the analyses of PTSD  
50 incidence, a PCL-S score of 50 was used as a cut-off (19). Individuals with a PCL-S of  
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6 50 or greater were apportioned to the 'high-scoring group' and compared to the  
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8 'low-scoring group' (PCL-S < 50) using chi-square tests.  
9

10 Odds ratios (ORs) and 95% confidence intervals (CIs) for each socioeconomic  
11 characteristic (living arrangement, employment status, income level, and number of  
12 years of education) were calculated using multiple logistic regression models.  
13  
14 Adjustment variables included sex (male, female), age (20–49, 50–64, ≥65 years),  
15 alcohol consumption (once or more per month, ex-drinker, less than once per month),  
16 smoking status (non-smoker, ex-smoker, current smoker), mental health distress (K6<3,  
17 K6≥13), hypertension history (yes or no), stroke history (yes or no), heart disease  
18 history (yes or no), physical activity (≥ daily, 2–4 times per week, weekly, never),  
19 tsunami experience (yes or no), radiation experience (yes or no), damage to  
20 accommodation (none, partial, half, more than half, total), and loss of family member  
21 (yes or no).  
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34 We conducted the above analyses separately based on sex as well as with both  
35 sexes combined. All analyses were conducted using SAS software version 9.4 (SAS  
36 Institute Inc., Cary, NC, USA).  
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## 43 **Results**

44 From the sample of 73,433 individuals, 1,893 (2.6%) reported exacerbation of  
45 headaches, 1,229 (1.7%) exacerbation of dizziness, 626 (0.9%) exacerbation of  
46 palpitations, and 434 (0.6%) exacerbation of shortness of breath (Table 1).  
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## 51 **Demographic characteristics**

52 The demographic characteristics of the population are summarized in Table 1.  
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54 Exacerbation of cardiovascular symptoms was significantly higher in women than in  
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6 men (3.5% versus 1.4% for headaches; 2.2% versus 1.1% for dizziness; 2.0% versus  
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8 0.9% for palpitations; and 0.9% versus 0.8% for shortness of breath). Young (20–49  
9  
10 years) individuals were more likely to experience exacerbation of headaches, dizziness,  
11  
12 or palpitations, while the 50–64 years age group more frequently experienced  
13  
14 exacerbation of shortness of breath. Individuals experiencing exacerbation of  
15  
16 cardiovascular symptoms were also more likely to suffer from depression ( $K6 \geq 13$ ) and  
17  
18 Posttraumatic Stress Disorder ( $PCL \geq 50$ ), and commonly had a history of hypertension,  
19  
20 stroke, or heart disease. Neither smoking nor alcohol consumption increased the  
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22 occurrence of exacerbated cardiovascular symptoms. Notably, symptom exacerbation  
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24 was most pronounced in individuals who were not physically active daily.  
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### 27 **Socioeconomic variables**

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30 Refugees living in their own or a relative's home were less likely to experience  
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32 exacerbated cardiovascular symptoms (Table 1). Of the refugees living in their own  
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34 home: 1.4% reported exacerbation of headache, 0.9% of dizziness, 1.6% of palpitations,  
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36 and 1.0% of shortness of breath. The corresponding statistics for refugees living in  
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38 temporary housing and rental houses or apartments were: 2.8%, 1.9%, 1.3%, and 1.2%  
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40 and 3.5%, 2.1%, 1.8%, and 1.0%, respectively.  
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44 In the group that were unemployed due to the disaster: 4.2% of the individuals  
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46 reported exacerbation of headache, 2.5% of dizziness, 2.1% of palpitations, and 1.1%  
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48 shortness of breath, while the corresponding statistics for the group that did not lose  
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50 their jobs after the disaster were: 2.2%, 1.5%, 1.4%, and 0.8%. Exacerbation of most  
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52 cardiovascular symptoms was higher in subjects whose income decreased due to the  
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54 disaster compared to those who maintained income levels (3.6% versus 2.4% for  
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6 exacerbation of headache, 2.0% versus 1.6% for exacerbation of dizziness, and 1.7%  
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8 versus 1.4% for exacerbation of palpitation).

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10 Additionally, exacerbation of most cardiovascular symptoms was higher among  
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12 individuals who were educated for 12 years or more compared to those who were less  
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14 educated (2.9% versus 1.9% for exacerbation of headache, 1.8% versus 1.4% for  
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16 exacerbation of dizziness, and 1.6% versus 1.2% for exacerbation of palpitation).  
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### 19 20 21 **Disaster-related variables**

22  
23 The group that experienced the tsunami and the nuclear power plant accident were  
24  
25 more likely to experience exacerbated cardiovascular symptoms. Among those who had  
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27 experienced the tsunami: 3.2% reported exacerbation of headache, 2.2% of dizziness,  
28  
29 1.7% of palpitations, and 1.7% of shortness of breath, compared to 2.4%, 1.6%, 1.5%,  
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31 and 0.8%, respectively, among those with no experience of the tsunami. The  
32  
33 corresponding statistics for individuals that had heard the nuclear power plant accident  
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35 were 3.1%, 2.1%, 1.9%, and 1.1% compared to 2.1%, 1.2%, 1.0%, and 0.6% for those  
36  
37 that had not.  
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### 40 41 **Multiple Logistic Regression analyses**

42  
43 Table 2 summarizes the odds ratios (ORs) and 95% CIs of each socioeconomic  
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45 characteristics for exacerbation of headache, dizziness, palpitations, and shortness of  
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47 breath. Living arrangement emerged as a risk factor for exacerbated cardiovascular  
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49 symptoms from our models, which were adjusted for multiple demographic-, health-,  
50  
51 and disaster-related variables. Compared to participants living in their own home (OR =  
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53 1), those living in relatives' homes had greater probability of experiencing exacerbation  
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55 of headache (1.58; 95% CI 1.19–2.09) and dizziness (1.42; 95% CI 1.02–1.98).  
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6 Similarly, those living in rental houses or apartments had greater chance of  
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8 experiencing exacerbated headache (1.54; 95% CI 1.32–1.80), dizziness (1.45; 95% CI  
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10 1.20–1.75), palpitations (1.25; 95% CI 1.03–1.51), and shortness of breath (1.76; 95%  
11  
12 CI 1.35–2.28). Participants living in evacuation shelters had increased probability of  
13  
14 experiencing exacerbation of headache (1.80; 95% CI 1.09–2.96) and refugees living in  
15  
16 temporary housing similarly had increased likelihood of experiencing exacerbation of  
17  
18 headache (1.42; 95% CI 1.15–1.72), dizziness (1.40; 95% CI 1.09–1.79), and shortness  
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20 of breath (1.49; 95% CI 1.07–2.08).  
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22  
23 Loss of employment also emerged as a risk factor that increased the probability of  
24  
25 cardiovascular symptom exacerbation. Compared to evacuees that remained employed  
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27 (OR = 1), those that lost their employment were at higher risk of experiencing  
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29 exacerbation of headache (1.28; 95% CI 1.12–1.46), dizziness (1.26; 95% CI 1.07–  
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31 1.48), and palpitation (1.21; 95% CI 1.01–1.45). In an unadjusted model, we found a  
32  
33 significant positive association between unemployment and exacerbation of  
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35 palpitations; however, after adjusting for multiple relevant variables, this association  
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37 was not significant.  
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41 There was no association between decreased income and exacerbated  
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43 cardiovascular symptoms, except for headaches. In this case, adjusting for multiple  
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45 variables resulted in an increased odds ratio for exacerbation of headaches both in an  
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47 analysis combining the sexes (1.39, 95% CI 1.22–1.60) and in separate analyses of  
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49 men and women. Number of years of education was also not associated with  
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51 exacerbated cardiovascular symptoms in multiple-adjusted models in the present study.  
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## 55 Discussion

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6 We demonstrated that a decrease in socioeconomic status due to the Great East  
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8 Japan Earthquake was associated with exacerbated cardiovascular symptoms among  
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10 evacuees. Compared with participants living in their own home, people of both genders  
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12 living in relatives' homes, evacuation shelters, temporary housing, or rental houses or  
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14 apartments were more likely to experience exacerbation of headache, dizziness,  
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16 palpitations, or shortness of breath. Similarly, loss of employment and reduced income  
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18 due to the disaster increased the risk of experiencing exacerbated symptoms.  
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21 The following three points should be considered in the context of our results. Firstly,  
22  
23 earthquakes are definitely associated with increased cardiovascular disease, including  
24  
25 sudden cardiac death and acute myocardial infarction (2-14), and our results are  
26  
27 consistent with these earlier findings. The Hanshin-Awaji earthquake was associated  
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29 with increased cardiovascular disease that persisted for longer than a month. Further,  
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31 an increase in the number of individuals with acute myocardial infarction, especially  
32  
33 women, was particularly evident during the four weeks immediately following the  
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35 disaster (9). After the Great East Japan Earthquake, the incidences of reported  
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37 cardioembolic stroke increased in the 3–9 months following the disaster (10), as did the  
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39 incidence of other cardiovascular diseases (11-14). Our study contributes to the  
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41 reported incidences of cardiovascular disease using self-report questionnaires rather  
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43 than death certificates and by demonstrating that exacerbated cardiovascular  
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45 symptoms occurred among evacuees after the disaster.  
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50 Secondly, increases in cardiovascular events and exacerbated cardiovascular  
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52 symptoms can be attributed to post-disaster distress or mental problems. Studies have  
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54 suggested that extremely stressful experiences, such as earthquakes, can trigger  
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56 cardiovascular events (20-22). Acute major stress and chronic stress (i.e. the  
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6 cumulative load of minor daily stress) can have long-term consequences, which can be  
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8 perceived as stressful themselves and a potential threat to one's environment, thereby  
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10 inducing a variety of negative emotional responses, such as fear, anxiety, sadness,  
11  
12 anger, hostility, and depression (4,23). In turn, these emotional responses may lead to  
13  
14 hypertension or cardiovascular events (20-22). A recent study suggests that PTSD was  
15  
16 frequently noted in cardiovascular disease patients six months after the Great East  
17  
18 Japan Earthquake. The patients with PTSD were more likely to experience a  
19  
20 combination of acute myocardial infarction, stroke, heart disease, and death (24). In the  
21  
22 current study, all individuals exhibiting exacerbated cardiovascular symptoms were  
23  
24 more likely to have depression ( $K6 \geq 13$ ) or Posttraumatic Stress Disorder ( $PCL \geq 50$ ).  
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26 Logistic regression analyses also showed that depression and Posttraumatic Stress  
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28 Disorder were both independently associated with exacerbated cardiovascular  
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30 symptoms (data not shown).  
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34 Thirdly, although post-disaster increases in cardiovascular events were widely  
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36 reported in previous studies, investigation of socioeconomic factors that influenced  
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38 these events during the evacuation term of refugees was limited. Previous studies  
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40 reported that one year after the Wenchuan Earthquake in China, depression severity  
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42 among refugees varied with income, housing status, and social support (25). This  
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44 indicated that, through its impact on income, the earthquake was indirectly associated  
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46 with life satisfaction and depression (26). Another study showed that six months after  
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48 the 2011 Christchurch earthquake in New Zealand, on average lower income per home  
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50 contributed unequivocally to earthquake-related distress and dysfunction (27). A recent  
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52 study also showed that six months after the Great East Japan Earthquake tsunami  
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experience, property loss, and poverty were associated with PTSD in cardiovascular disease patients and had an adverse prognostic impact (24).

This study revealed 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 neighborhood 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

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6 earthquake, low household income contributed strongly to earthquake-related distress  
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8 (27). In the present study, we found a significant association between disaster-related  
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10 unemployment and exacerbation of some cardiovascular symptoms. However, the  
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12 subsistence allowance given to refugees by the Japanese government may have  
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14 reduced this effect by reducing the impact of refugees' lowered economic  
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16 circumstances.  
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19 Educational level was inversely associated with cardiovascular disease risk in  
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21 previous studies (30, 31). However, in our study, the number of years that individuals  
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23 had been educated was not associated with exacerbated cardiovascular  
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25 symptoms. This may be due to post-disaster conditions. In the present study, factors  
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27 related to the earthquake, tsunami, and the nuclear accident, and unemployment or  
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29 decreased income due to the disasters had a large influence on exacerbated  
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31 cardiovascular symptoms. This result may have superseded any potential impact of  
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33 education levels.  
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36 Our understanding of disaster-related stress on cardiovascular disease remains  
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38 incomplete. A clinical study from the 1995 Hanshin-Awaji earthquake compared pre-  
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40 and post- blood pressure levels in well-controlled hypertension patients and showed an  
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42 18mmHg increase in diastolic blood pressure two weeks after the earthquake (32).  
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44 Although 'white-coat hypertension' (patients exhibiting increased blood pressure in  
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46 clinical settings) partly contributed to the results, some patients developed sustained  
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48 hypertension that persisted for one year after the earthquake (32). One study found that  
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50 there were increased levels of cholesterol and triglycerides in patients a few weeks after  
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52 an earthquake (3), whereas another studies failed to show significantly higher total  
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54 cholesterol or HDL-cholesterol during the two weeks following the Hanshin-Awaji  
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5 earthquake (6). Thus, the extent to which changes in the blood lipid profile contribute to  
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7 exacerbated cardiovascular symptoms several months after the Great East Japan  
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9 Earthquake remains unknown. Chronic psychological stress is also associated with  
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11 increased insulin resistance (4). A recent study after the Great East Japan Earthquake  
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13 found that the negative effects of the disaster on metabolic factors were greater among  
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15 evacuees than non-evacuees (33), which may also contribute to the occurrence of  
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17 exacerbated cardiovascular symptoms among evacuees.  
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21 Although the results of the present study is limited to residents in the Fukushima  
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23 prefecture after the Great East Japan Earthquake, it would provide inspiration for the  
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25 future studies among evacuees after disasters. As well, our study suggests early  
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27 improvements in the provision of living conditions for the evacuees could be achieved by  
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29 several ways: providing speedy restorations of the access to their own homes; providing  
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31 more employment opportunity for the evacuees and providing more financial support. For  
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33 future disasters, the present study would provide epidemiological basic for governments and  
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35 authorities to act as soon as possible for preparation.  
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39 The large scale of assessment and assessment under post-disaster  
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41 conditions provides considerable credibility for the present study. Additionally, our study  
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43 is the first to identify an inverse relationship between low socioeconomic status  
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45 and exacerbated cardiovascular symptoms from an evacuee self-report questionnaire  
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47 after a disaster; thus, our results will be useful for generating guidelines for evacuee  
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49 health. However, the following limitations of this study should be considered. Firstly, the  
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51 study was based on a subjective self-response survey. However it is reasonable to  
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53 expect respondents to understand that the studied symptoms are related to stress  
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55 and/or autonomic nervous system disorders. Further information, such as the incidence  
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5 of cardiovascular disease, should be captured. Although the studied symptoms are not  
6 necessarily logical predictors of cardiovascular diseases, several previous studies have  
7 shown that headaches are suggestive of an incremental risk of stroke (34, 35), and  
8 other studies have also shown that vertigo or dizziness and chest pain are associated  
9 with cardiovascular problems (36, 37). We also conducted an analyses on a subsample  
10 of individuals' self-reported information, which suggested that all of the  
11 discussed symptoms were associated with a diagnosis of hypertension in the last year,  
12 and that exacerbation of dizziness, palpitation, and shortness of breath were associated  
13 with a diagnosis of heart disease in the last year (data not shown). Therefore, our study  
14 of these four symptoms may be helpful for developing plans to improve evacuees'  
15 health to some extent.  
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30 Secondly, both the Great East Japan Earthquake and also the accompanied nuclear  
31 accident had a large psychological impact on the evacuees. Due to this unusual  
32 situation, the present study cannot be entirely compared with other studies. Thirdly, the  
33 overall response rate to questionnaires was low (40.7%) and sampling skews may have  
34 resulted in biased data.  
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40 Fourthly, under the unusual social circumstances that follow a major disaster, the  
41 health symptoms perceived by evacuees may be strongly influenced by changes in  
42 family relationships (e.g. death and physical separation) among the evacuees. However,  
43 the present study did not capture these data. Moreover, other socioeconomic factors,  
44 such as household income, and other cardiovascular risk factors, such as blood  
45 pressure and cholesterol levels, were also not captured in the present study.  
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53 Additionally, although most questionnaires were collected in the same period (from Jan  
54 2012 to Mar 2012), it is possible that the timing of the survey affected the perceived  
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6 cardiovascular symptoms. Finally, other environmental factors, such as temperature,  
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8 food supplies, and medical facilities may also affect cardiovascular problems (38, 39).

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10 These data were also not collected in the present study. The potential associations  
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12 observed in this study will be further investigated over an extended period.

13  
14 In conclusion, the present study was the first to identify a relationship between lower  
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16 socioeconomic status due to the Great East Japan Earthquake and exacerbated  
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18 cardiovascular symptoms among evacuees. Our findings will provide baseline  
19  
20 information for future periodic health examinations and for the development of health  
21  
22 guidelines for evacuees.  
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28  
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30  
31 plans and was supported by the national 'Health Fund for Children and Adults Affected  
32  
33 by the Nuclear Incident'.  
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### 36 37 38 **Contributors**

39  
40 WZ and TO designed the study. TO, SY, MM, MH. NH, YS, HY, MH, HT, and AO were  
41  
42 responsible for data collection and supervising the study. The analyses were conducted  
43  
44 by WZ and TO. The manuscript was written by WZ. All the authors assisted with revision  
45  
46 of the manuscript, and read and approved the final version of the manuscript.  
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8 plans and was supported by the national 'Health Fund for Children and Adults Affected  
9  
10 by the Nuclear Incident'.  
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#### 12 13 14 **Declaration of interests**

15  
16 We declare that we have no competing interests.  
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#### 20 21 22 23 **Patient consent**

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25 Obtained.  
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#### 28 29 30 **Data sharing statement**

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32 No additional data are available.  
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1 Table 1. Characteristics of survey participants and correlated incidence of exacerbation of cardiovascular related symptoms.  
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	Exacerbation of headache	Exacerbation of dizziness	Exacerbation of palpitation	Exacerbation of shortness of breath
	No. (%)	No. (%)	No. (%)	No. (%)
<b>Sex</b>				
Men	466 (1.4)	341 (1.1)	277 (0.9)	257 (0.8)
Women	1,427 (3.5)	888 (2.2)	808 (2.0)	369 (0.9)
<b>Age</b>				
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)
<b>Mental health Status</b>				
K6<13	1,092 (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)
<b>Post traumatic stress disorder</b>				
No	1,062 (1.7)	653 (1.0)	542 (0.9)	323 (0.5)
Yes	831 (8.0)	576 (5.5)	543 (5.2)	303 (2.9)
<b>Smoking status</b>				
Non-smoker	1,104 (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	1,067 (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	1,216 (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	1,799 (2.6)	1,146 (1.7)	1,799 (1.5)	576 (0.8)
Yes	94 (2.4)	83 (2.2)	94 (1.6)	50 (1.3)

**Heart disease history**

No	1,691 (2.6)	1,025 (1.6)	1,691 (2.6)	432 (0.7)
Yes	202 (10.7)	204 (2.8)	202 (4.0)	194 (2.7)

**Unemployment**

No	1,293 (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	1,432 (2.4)	968 (1.6)	870 (1.4)	506 (0.8)
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Yes	461 (3.6)	261 (2.0)	215 (1.7)	120 (0.9)
<b>Living arrangement</b>				
Evacuation shelter	213 (2.5)	12 (1.6)	5 (0.7)	5 (0.7)
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)
<b>Tsunami experience</b>				
No	1,424 (2.4)	908 (1.6)	830 (1.4)	458 (0.8)
Yes	469 (3.2)	321 (2.2)	255 (1.7)	168 (1.1)
<b>Radiation experience</b>				
No	717 (2.1)	426 (1.2)	358 (1.0)	201 (0.6)
Yes	1,176 (3.1)	803 (2.1)	727 (1.9)	425 (1.1)
<b>Damage to house</b>				
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)
<b>Loss of family member</b>				
No	552 (3.9)	363 (2.6)	296 (2.1)	199 (1.4)
Yes	1,291 (2.3)	825 (1.5)	759 (1.3)	404 (0.7)
<b>Number of years of education</b>				

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4	<12 years (reference)	352 (1.9)	265 (1.4)	223 (1.2)	202 (1.1)
5	≥12 years	1,471 (2.9)	916 (1.8)	822 (1.6)	397 (0.8)

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Table 2. Odds ratios (OR) and 95% confidence intervals (CIs) for cardiovascular related symptoms obtained from multiple logistic regression analyses

		Exacerbation of Headache			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	2.03 (1.58-2.62)	1.58 (1.19-2.09)	1.95 (1.11-2.57)	1.46 (1.06-2.02)
	Rental house or apartment	2.21 (1.93-2.54)	1.54 (1.32-1.80)	1.83 (1.34-2.53)	1.46 (1.22-1.75)
	Evacuation shelter	2.01 (1.24-3.25)	1.80 (1.09-2.96)	2.24 (0.99-5.16)	1.61 (0.85-3.03)
	Temporary housing	2.13 (1.77-2.56)	1.42 (1.15-1.72)	1.69 (1.11-3.43)	1.36 (1.06-1.73)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.70 (1.53-1.88)	1.28 (1.12-1.46)	1.36 (1.04-1.78)	1.26 (1.09-1.47)
<b>Income decrease</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.56 (1.40-1.74)	1.39 (1.22-1.60)	1.39 (1.08-1.78)	1.39 (1.17-1.63)
<b>Number of years of education</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	≥12 years	1.02 (0.89-1.16)	1.04 (0.81-1.63)	1.25 (0.91-1.73)	0.97 (0.80-1.17)

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		Exacerbation of Dizziness			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) <sup>f</sup> or women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.98 (1.46-2.69)	1.42 (1.02-1.98)	0.96 (0.49-1.91)	1.66 (1.13-2.43)
	Rental house or apartment	2.27 (1.91-2.69)	1.45 (1.20-1.75)	1.28 (0.92-1.79)	1.55 (1.23-1.96)
	Evacuation shelter	1.84 (1.02-3.32)	1.39 (0.74-2.59)	0.85 (0.26-2.77)	1.83 (0.87-3.84)
	Temporary housing	2.09 (1.68-2.61)	1.40 (1.09-1.79)	1.51 (1.00-2.28)	1.36 (1.00-1.85)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.65 (1.45-1.87)	1.26 (1.07-1.48)	1.27 (0.94-1.73)	1.20 (0.98-1.45)
<b>Income decrease</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.37 (1.19-1.57)	1.18 (0.99-1.40)	1.12 (0.83-1.51)	1.22 (0.98-1.51)
<b>Number of years of education</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	≥12 years	1.17 (1.01-1.37)	1.13 (0.94-1.36)	1.08 (0.80-1.47)	1.14 (0.90-1.44)

		Exacerbation of Palpitation			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.70 (1.23-2.34)	1.23 (0.87-1.74)	1.25 (0.57-2.71)	1.21 (0.82-1.78)
	Rental house or apartment	1.90 (1.60-2.25)	1.25 (1.03-1.51)	1.73 (1.17-2.53)	1.11 (0.89-1.39)
	Evacuation shelter	0.74 (0.30-1.80)	0.51 (0.19-1.39)	0.93 (0.22-3.92)	0.35 (0.09-1.45)
	Temporary housing	1.32 (1.03-1.69)	0.82 (0.62-1.10)	1.19 (0.69-2.04)	0.72 (0.51-1.01)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.46 (1.27-1.68)	1.21 (1.01-1.45)	1.29 (0.91-1.83)	1.20 (0.97-1.48)
<b>Income decrease</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.07-1.44)	1.14 (0.94-1.38)	1.46 (1.05-2.03)	1.00 (0.80-1.28)
<b>Number of years of education</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	≥12 years	1.28 (1.09-1.50)	1.14 (0.93-1.39)	1.15 (0.79-1.67)	1.00 (0.81-1.23)

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		Exacerbation of Shortness of Breath			
		OR(95%CI) <sup>a</sup>	OR(95%CI) <sup>b</sup>	OR(95%CI) for men <sup>b</sup>	OR(95%CI) for women <sup>b</sup>
<b>living arrangement</b>	<b>Own home (Reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Relatives' home	1.60 (1.02-2.52)	1.16 (0.71-1.90)	0.95 (0.42-2.16)	1.33 (0.72-2.63)
	Rental house or apartment	2.34 (1.85-2.96)	1.76 (1.35-2.28)	1.50 (1.01-2.22)	1.98 (1.39-2.81)
	Evacuation shelter	1.33 (0.54-3.27)	1.20 (0.48-3.00)	1.73 (0.60-4.95)	0.52 (0.07-3.79)
	Temporary housing	2.29 (1.72-3.06)	1.49 (1.07-2.08)	1.25 (0.75-2.09)	1.72 (1.10-2.68)
<b>Unemployment</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.55 (1.29-1.87)	1.13 (0.89-1.44)	1.06 (0.73-1.55)	1.17 (0.85-1.60)
<b>Income decrease</b>	<b>No (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	Yes	1.24 (1.01-1.52)	1.14 (0.89-1.47)	1.18 (0.83-1.69)	1.10 (0.77-1.57)
<b>Number of years of education</b>	<b>&lt;12 years (reference)</b>	1.00(reference)	1.00(reference)	1.00(reference)	1.00(reference)
	≥12 years	0.94 (0.78-1.13)	0.84 (0.67-1.06)	0.76 (0.54-1.07)	0.90 (0.66-1.23)

- a. Adjusted for age and sex.
- b. 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).