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# Changes in smoking status and their associations with disaster-related and psychosocial factors before and after a disaster: A survey in the evacuation area of Fukushima after the Great East Japan Earthquake, The Fukushima Health Management Survey



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# Effects of disaster-related and psychosocial factors on changes in smoking status after a disaster: A cross-sectional survey in the evacuation area of Fukushima after the Great East Japan Earthquake

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**Abstract**

**Objective:** To examine changes in smoking status and the related factors among the residents of the evacuation area in Fukushima after the Great East Japan Earthquake.

**Methods:** The subjects were 58,755 men and women of minimum age 20 years and who participated in the Fukushima Health Management Survey in 2012 after the disaster. The subjects were divided into four groups: 1) non-smokers before and after the disaster, 2) non-smokers before and smokers after the disaster, 3) smokers before and non-smokers after the disaster and 4) smokers before and after the disaster. Multivariate-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of changes in smoking status for disaster-related and psychosocial factors were tested by logistic regression analysis, stratified by smoking status before the disaster.

**Results:** Among 44,729 non-smokers before the disaster, 634 (1.4%) started smoking after the disaster. Among 14,025 smokers before the disaster, 1,564 (11.1%) quit smoking after the disaster. The multivariable-adjusted ORs (95%CIs) for the group that started smoking were 3.01 (2.55–3.55) for men, 0.69 (0.58–0.84) for higher educational attainment, 1.31 (1.10–1.56) for living in a rental housing/apartment, 1.24 (1.01–1.52) for house damaged, 1.45 (1.09–1.92) for history of mental illness, 1.29 (1.07–1.56) for experienced tsunami, 1.21 (1.01–1.46) for becoming unemployed, 1.67 (1.35–2.08) for

presence of traumatic symptoms and 1.38 (1.09–1.74) for non-specific mental illness. The adjusted ORs (95%CIs) for the group that quit smoking were 0.64 (0.57–0.72) for men, 1.31 (1.16–1.48) for higher education and 0.86 (0.76–0.98) for decreased income.

**Conclusion:** The proportion of smokers decreased slightly among residents in the evacuation area, and the quitting of smoking after the disaster was associated with disaster-related and psychosocial factors, especially living conditions, job status, experiences during the disaster and presence of traumatic symptoms and history of mental illness.

**Strengths and limitations of this study**

- The strengths of this study lie in the sample size and procedures, as it involved a large-scale survey (n = 58,755) to complete an inventory-based analysis of evacuees following the earthquake.
- Smoking status before and after the earthquake was investigated using a self-reported questionnaire after the disaster, and the number of cigarettes used among current smokers was not evaluated.
- This study had an overall low response rate (40.7%); therefore, the representativeness of the target population is uncertain.

**Keywords**

Disaster, Smoking cessation, Socioeconomic status, Population-based, Psychological stress.

## Introduction

The Great East Japan Earthquake that occurred on 11 March 2011 was one of the most disastrous events in the history of Japan. About 212,500 people in the Fukushima Prefecture were forced to evacuate due to the Fukushima Dai-ichi nuclear power plant accident following the earthquake and the subsequent tsunami that struck the plant. Six years after the disaster, 77,283 have still been evacuated as of March 2017.

The accident resulted in the disruption of normal lives of the people of Fukushima, loss of life, relocations, maladjustment to new circumstances and induced stressful situations for the evacuees.[1–3] A previous study reported that cumulative mental stress is partly associated with an increased risk of smoking due to increased impulsivity.[4] Furthermore, post-traumatic stress disorder (PTSD) might be associated with an increased risk of smoking.[5] Moreover, most previous studies reported that the proportion of smokers increased subsequent to disasters, such as Hurricane Katrina[7], earthquakes[8–9] and the September 11 terrorist attacks in New York City[5,10], while some studies did not support this view.[6] All previous studies, however, had adopted a limited sample size (n = 209–988) and did not examine the change in smoking status in individuals and the related factors. Therefore, a comprehensive examination with a large sample size would be necessary to determine the impact of smoking status post

disasters.

Among the evacuees in the Fukushima Prefecture, the proportion of overweight persons and the prevalence of hypertension, diabetes mellitus, dyslipidemia, polycythemia and atrial fibrillation increased one year after the nuclear power plant accident.[11–14] Therefore, the evacuees are expected to be at a greater risk of cardiovascular diseases if the proportion of current smoking increases, because smoking is a major risk factor for cardiovascular diseases.

Hence, we aim to examine the smoking status after the Fukushima Dai-ichi nuclear power plant accident among more than 100,000 people in the evacuation area of the Fukushima prefecture. The prevalence of severe degree of traumatic symptoms, psychological distress and anxiety after the nuclear accident are high among the residents of the evacuation area[3]. Hence, we also aim to examine the potential effects of disaster-related and psychosocial factors on changes in smoking status.

## Methods

### Participants

Following the Great East Japan Earthquake that occurred on 11 March 11 2011, the government designated evacuation instruction zones. Between January and October

2012, the evacuees participated in the Fukushima Health Management Survey of the Fukushima Dai-ichi Nuclear Power Plant Accident that started in 2011. The 'Mental Health and Lifestyle Survey', part of that longitudinal study, assesses how the disaster and subsequent lifestyle of people affect the mental status of the evacuees over a long period[1,3].

The target population of the survey was men and women aged minimum 15 years and living in the evacuation zones specified by the government. These zones included Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City, Kawamata Town, Iitate Village and a part of Date City. The questionnaire was mailed on 18 January 2012 to persons who had a certificate of residence in the evacuation area as on 11 March 2011. The number of residents who were born before 1 April 1995 (i.e. high school students or older) during the disaster was 180,604. The response rate for the participation was 40.7% (n = 73,569).

Since we sought to examine changes in smoking behaviour among the evacuees, we limited our data to men and women aged minimum 20 years, which is the legal smoking age. As a result, we used 58,754 subjects for the analysis. This survey was approved by the ethics review committee of the Fukushima Medical University (No. 1316).

**Smoking status**

In the questionnaire, the smoking status was determined by current smokers or current non-smokers just before the disaster; however, we did not distinguish people who never smoked or ex-smokers from current non-smokers. The smoking status 1-year after the disaster was determined by never smoked, ex-smokers and current smokers. Then, the changes in the smoking status before and after the disaster were categorized into four groups: 1) non-smokers before and after the disaster (non-smoking–non-smoking), 2) non-smokers before and smokers after the disaster (non-smoking–smoking), 3) smokers before and non-smokers after the disaster (smoking–non-smoking) and 4) smokers before and after the disaster (smoking–smoking).

**Socioeconomic and disaster-related and psychosocial variables**

Socioeconomic and disaster-related variables were assessed using the questionnaire responses, including living arrangements (own home, evacuation shelter, temporary housing, rental housing or apartment and relative's home), whether experienced living in evacuation shelters (yes or no), education level (elementary school, junior high school and high school, vocational college, junior college, university (4 years) and graduate

school), history of mental illness (yes or no), whether becoming unemployed (yes or no), whether income decreased (yes or no), whether house was damaged (yes or no), whether experienced tsunami before (yes or no), presence of traumatic symptoms assessed by PTSD Checklist-Stressor Specific Version [PCL-S] and non-specific psychological distress measured by the Japanese version of the Kessler Psychological Distress Scale.

We considered PCL-S score > 44 as indicating the presence of traumatic symptoms.[15–17] We regarded Kessler's K6 score ≥ 13 as indicating the presence of non-specific psychological distress.[18–23] Age was used as a categorical variable, defining three age groups (20–49, 50–64 and ≥65 years). Education level was categorized as lower (high school or less) or higher (additional vocational college or junior college experience or higher).

**Statistical analysis**

The chi-square test was used to compare the smoking status before and after the disaster. Disaster-related and socioeconomic variables were also compared among the categories of change in the smoking status before and after the disaster using the chi-squared test. We examined the impact of disaster-related and psychosocial variables on starting

smoking compared with continued non-smoking after the disaster among non-smokers before the disaster. We also examined the impact of these variables on quitting smoking compared with continued smoking among smokers before the disaster.

Age- and sex-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of the changes in smoking status for disaster-related and psychosocial variables were calculated by logistic regression analysis. We further adjusted for age, sex, living arrangement, experienced living in evacuation shelters, education level, history of mental illness, whether becoming unemployed, whether income decreased, whether house was damaged, whether experienced tsunami and presence of traumatic symptoms and non-specific psychological distress. We also concluded sex-specific analysis. P-values were obtained by a two-tailed test and $P < 0.05$ was regarded as statistically significant. All statistical analyses were conducted with software package SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

**Results**

The proportion of current smokers among a total of 58,754 men and women significantly decreased from 23.9% to 22.3% after the disaster ($P < 0.001$). The corresponding proportion among men changed from 37.5% to 35.2% ($P < 0.001$) and

that among women changed from 12.5% to 11.5% (P < 0.001). Among the participants, 634 (1.1%) men and women started smoking and 1,564 (2.7%) men and women quit smoking after the disaster. The corresponding proportions of starting and quitting smoking were, respectively, 1.4% and 3.7% for men and 0.8% and 1.8% for women.

Table 1 shows the participants' geographical, disaster-related and psychosocial variables according to the categories of changes in smoking status, i.e. according to the continued non-smoking or continued smoking group. The non-smoking–smoking group showed higher proportion than the non-smoking–non-smoking group among the following categories: men, younger ages, rental house/apartment, shelter living, house damage, history of mental illness, experience of tsunami, becoming unemployed, decreased income, traumatic symptoms and non-specific psychological distress.

Compared with the smoking–smoking group, the smoking–non-smoking group showed a higher proportion among the categories of women, older ages, higher education, history of mental illness, experience of tsunami and becoming unemployed, and a lower proportion among the categories of shelter living, decreased income, traumatic symptoms and non-specific psychological distress.

Table 2 shows age- and sex-adjusted and multivariable-adjusted ORs and 95% CIs for the group that started smoking after the disaster according to geographical,

disaster-related and psychosocial factors among 44,729 non-smokers before the disaster. The corresponding multivariable-adjusted ORs (95% CIs) were 3.01 (2.55–3.55) for men, 0.32 (0.26–0.39) for ages 50–64 years, 0.17 (0.14–0.22) for ages ≥65 years, 0.69 (0.58–0.84) for higher education (junior college and higher), 1.31 (1.10–1.56) for living in a rental housing/apartment, 1.24 (1.01–1.52) for house damaged, 1.45 (1.09–1.92) for history of mental illness, 1.29 (1.07–1.56) for experience of tsunami, 1.21 (1.01–1.46) for becoming unemployed, 1.67(1.35–2.08) for presence of traumatic symptoms and 1.38 (1.09–1.74) for presence of non-specific mental illness.

Table 3 indicates age- and sex-adjusted and multivariable-adjusted ORs and 95% CIs for the group that quit smoking after the disaster according to geographical, disaster-related and psychosocial factors among 14,025 smokers before the disaster. The corresponding multivariable-adjusted ORs (95% CIs) were 0.64 (0.57–0.72) for men, 1.89 (1.62–2.19) for ≥65 years, 1.31 (1.16–1.48) for higher education and 0.86 (0.76–0.98) for decreased income.

Since the proportion of current smokers was higher among men than women in Japan, we repeated the analysis according to sex; the results remained the same as the previous results (not shown in table).

## Discussion

One of the main findings from the present study is that 10 months after the March 2011 earthquake and the subsequent disastrous tsunami and nuclear power plant accident, the proportion of smokers decreased slightly among men and women aged ≥20 years in the evacuation area. The proportion of persons who quit smoking was higher than that of those who started smoking: 3.7% and 1.4% among men and 1.8% and 0.8% among women, respectively. Previous studies, however, reported that the proportion of current smokers increases after a disaster.[7-10]

In addition, the present study found that becoming unemployed, house being damaged, having experience of tsunami, presence of traumatic symptoms and non-specific psychological distress as well as being a male or younger, staying in a rental house/apartment or having a lower education was associated with increased risk of starting smoking. Factors associated with quitting smoking were being a female or older, having a higher education or stable income. Therefore, to prevent people from starting smoking after a disaster, effective management of traumatic symptoms and non-specific psychological distress may be required.

The National Health Nutrition Survey reported that there was no change in the proportions of smokers in Japan before and after the disaster: 19.5% in 2010 and 20.7%

in 2012.[24] A reason for the slight decrease in the proportion of current smokers after the disaster may be the decreased access to tobacco products, because the earthquake resulted in the damage of tobacco plantations, ceasing of tobacco production and disruption of railway and road transportation networks. The tobacco distribution stagnated after the disaster. According to a press release by Japan Tobacco Inc, the total cigarette sales volume in April 2011 decreased by 81.8% compared to April 2010 and domestic cigarette sales decreased by 74.8%. Furthermore, the cigarette sales volume between April and September 2011 decreased by 41.2% and the tobacco sales volume decreased by 20.4% compared to the same period the previous year.[25] These situations probably attributed to the smokers quitting smoking after the disaster.

Although the proportion of current smokers decreased slightly among the evacuees after the disaster, the proportion of current smokers was still higher in the evacuation area than in other areas of Japan. In the present study, the proportion of current smokers was 22.3% (35.2% men and 11.5% women), while the corresponding proportion in the national sample was 20.1% (32.4% men and 9.7% women) in 2011.[26]

The strengths of this survey lie in its size and procedures, as it involved a large-scale survey to complete an inventory-based analysis of evacuees following the earthquake. The present study has certain limitations. First, we investigated smoking

status before and after the earthquake using a self-reported questionnaire administered after the disaster. We did not evaluate the number of cigarettes among current smokers. Second, because the response rate to the present study was relatively low (41%), representativeness of the target populations is uncertain, and this may affect the results.

In conclusion, the proportion of smokers among evacuees in the Fukushima prefecture decreased slightly after the disaster. The changes in smoking status after the disaster were associated with disaster-related psychosocial factors, especially living conditions, becoming employed, experiences during the disaster and presence of traumatic symptoms and history of mental illness. Because the results of our study may show short-term changes in smoking status after the disaster, a long-term follow-up study is needed to examine the effects of the disaster-related factors on smoking status among evacuees.

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## Contributors

TO, SY, AO, MM, MH, NH, YS, HY and HT were responsible for data collection and overseeing study procedures. HN, TO and HI contributed to the design of the present study. HN conducted the analysis and prepared the manuscript. TO, SY, AO, MM, MH, NH, YS, HY, HT, MN, WZ, HI and KK made significant contributions to the critical interpretation of the results in terms of important practical content. All the authors read and approved the final version of the manuscript.

## Competing interests

None declared

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## Data sharing statement

No additional data are available.

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**Table 1.** Geographical, disaster-related and psycosotial factors according to the categories of change in smoking status among 58,754 men and women in the evacuation area.

| | Total | | Nonsmoking-Nonsmoking | | Nonsmoking-Smoking | | | Smoking-Smoking | | Smoking-Nonsmoking | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | P values | n | % | n | % | P values |
| **Geographical factor** | | | | | | | | | | | | |
| **Sex** | n=58754 | | n=44095 | | n=634 | | | n=12461 | | n=1564 | | |
| Men | 26764 | 45.6 | 16351 | 37.1 | 376 | 59.3 | <.0001 | 9040 | 72.5 | 997 | 63.7 | <.0001 |
| women | 31990 | 54.4 | 27744 | 62.9 | 258 | 40.7 | | 3421 | 27.5 | 567 | 36.3 | |
| **Age** | n=58754 | | | | | | | | | | | |
| Ages 20-49 years | 21479 | 36.6 | 13571 | 30.8 | 382 | 60.3 | | 6727 | 54.0 | 799 | 51.1 | |
| Ages 50–64 years | 18744 | 31.9 | 14136 | 32.1 | 147 | 23.2 | <.0001 | 4012 | 32.2 | 449 | 28.7 | <.0001 |
| Ages ≥65 years | 18531 | 31.5 | 16388 | 37.2 | 105 | 16.6 | | 1722 | 13.8 | 316 | 20.2 | |
| **Education level** | n=57076 | | | | | | | | | | | |
| Primary or middle school | 13383 | 23.4 | 10680 | 25.0 | 102 | 16.8 | | 2329 | 19.1 | 272 | 17.7 | |
| High school | 28331 | 49.6 | 20190 | 47.2 | 331 | 54.5 | | 6986 | 57.2 | 824 | 53.8 | |
| Vocational college, or Junior college | 10127 | 17.7 | 7849 | 18.4 | 116 | 19.1 | <.0001 | 1883 | 15.4 | 279 | 18.2 | <.0001 |
| University, or graduate school | 5235 | 9.2 | 4014 | 9.4 | 58 | 9.6 | | 1005 | 8.2 | 158 | 10.3 | |
| **Disaster-related factors** | | | | | | | | | | | | |
| **Living arrangement** | n=47099 | | | | | | | | | | | |
| Evacuation shelter | 522 | 1.1 | 401 | 1.1 | 8 | 1.6 | | 99 | 1.0 | 14 | 1.1 | |
| Temporary housing | 5343 | 11.3 | 3989 | 11.3 | 61 | 12.6 | | 1164 | 11.6 | 129 | 10.3 | |
| Rental house or apartment | 19330 | 41.0 | 13654 | 38.7 | 270 | 55.7 | | 4780 | 47.4 | 626 | 49.8 | |
| Relative's home | 2127 | 4.5 | 1731 | 4.9 | 21 | 4.3 | <.0001 | 325 | 3.2 | 50 | 4.0 | <.0001 |
| Own home | 17576 | 37.3 | 13862 | 39.3 | 101 | 20.8 | | 3252 | 32.3 | 361 | 28.7 | |
| Others | 2201 | 4.7 | 1644 | 4.7 | 24 | 4.9 | | 457 | 4.5 | 76 | 6.1 | |
| **Experienced living in evacuation shelters** | n=58754 | | | | | | | | | | | |
| Yes | 15865 | 27.0 | 11887 | 27.0 | 198 | 31.2 | <.0001 | 3365 | 27.0 | 415 | 26.5 | <.0001 |
| **House was damaged** | n=58754 | | | | | | | | | | | |
| Yes | 8706 | 14.8 | 6528 | 14.8 | 134 | 21.1 | <.0001 | 1812 | 14.5 | 232 | 14.8 | <.0001 |
| **History of mental illness** | n=57137 | | | | | | | | | | | |
| Yes | 3149 | 5.5 | 2332 | 5.4 | 60 | 9.9 | <.0001 | 662 | 5.5 | 95 | 6.2 | <.0001 |
| **Experience of disaster** | | | | | | | | | | | | |
| Experienced tsunami | n=58754 | | | | | | | | | | | |
| Yes | 11807 | 20.1 | 8559 | 19.4 | 176 | 27.8 | <.0001 | 2747 | 22.0 | 325 | 20.8 | <.0001 |
| **Psychosociall factors** | | | | | | | | | | | | |
| Unemployed | n=58754 | | | | | | | | | | | |
| Yes | 12255 | 20.9 | 8643 | 19.6 | 172 | 27.1 | <.0001 | 3016 | 24.2 | 424 | 27.1 | <.0001 |
| Income decreased | n=58754 | | | | | | | | | | | |
| Yes | 11141 | 19.0 | 7548 | 17.1 | 145 | 22.9 | <.0001 | 3117 | 25.0 | 331 | 21.2 | <.0001 |
| **Presence of traumatic symptoms(PCL-S) >=44** | n=58754 | | | | | | | | | | | |
| Yes | 12266 | 20.9 | 9247 | 21.0 | 210 | 33.1 | <.0001 | 2515 | 20.2 | 294 | 18.8 | <.0001 |
| **Presence of non-specific mental illness(K6)>=13** | n=58754 | | | | | | | | | | | |
| Yes | 8556 | 14.0 | 6337 | 14.4 | 157 | 24.8 | <.0001 | 1853 | 14.9 | 209 | 13.4 | <.0001 |

**TABLE 2** Age- and sex-adjusted and multivariable-adjusted ORs and 95% confidence intervals of started to smoking after the disaster according to geographical, disaster-related and psycosotial factors among 44,729 non-smokers before the disaster.

| | Age- and sex-adjusted model | | | | Multivariable-adjusted model[#] | | | |
|---|---|---|---|---|---|---|---|---|
| Model | OR | (95%CI) | | P values | OR | (95%CI) | | P values |
| n=44729 | | | | | | | | |
| **Geographical factor** | | | | | | | | |
| Men(versus women)[*] | 2.91 | 2.48 | - 3.42 | <.0001 | 3.01 | 2.55 | - 3.55 | <.0001 |
| **Age**[**] | | | | | | | | |
| Ages 20-49 years | 1.00 | | | | | | | |
| Ages 50–64 years | 0.34 | 0.28 | - 0.41 | <.0001 | 0.32 | 0.26 | - 0.39 | <.0001 |
| Ages ≥65 years | 0.19 | 0.16 | - 0.24 | <.0001 | 0.17 | 0.14 | - 0.22 | <.0001 |
| Higher education (junior college and higher)[***] | 0.68 | 0.57 | - 0.82 | <.0001 | 0.69 | 0.58 | - 0.84 | <.001 |
| **Disaster-related factors**[***] | | | | | | | | |
| **Living arrangement**[***] | | | | | | | | |
| Own home | 1.00 | | | | | | | |
| Evacuation Shelter | 1.53 | 0.75 | - 3.13 | 0.246 | 1.06 | 0.89 | - 1.26 | 0.531 |
| Temporary housing | 1.46 | 1.10 | - 1.93 | 0.009 | 1.20 | 0.90 | - 1.60 | 0.212 |
| Rental housing or apartment | 1.38 | 1.16 | - 1.64 | 0.000 | 1.31 | 1.10 | - 1.56 | 0.002 |
| Relative's home | 1.18 | 0.75 | - 1.85 | 0.467 | 1.14 | 0.73 | - 0.73 | 0.572 |
| **Experienced living in evacuation shelters**[***] | 1.22 | 1.03 | - 1.45 | 0.023 | 0.95 | 0.79 | - 1.14 | 0.555 |
| House was damaged | 1.64 | 1.35 | - 1.99 | <.0001 | 1.24 | 1.01 | - 1.52 | 0.042 |
| History of mental illness[***] | 2.03 | 1.54 | - 2.67 | <.0001 | 1.45 | 1.09 | - 1.92 | 0.011 |
| **Experience of disaster**[***] | | | | | | | | |
| Experienced tsunami | 1.57 | 1.32 | - 1.88 | <.0001 | 1.29 | 1.07 | - 1.56 | 0.007 |
| **Psychosociall factors**[***] | | | | | | | | |
| Unemployed | 1.53 | 1.28 | - 1.83 | <.0001 | 1.21 | 1.01 | - 1.46 | 0.042 |
| Income decreased | 1.18 | 0.97 | - 1.42 | 0.092 | 1.05 | 0.87 | - 1.28 | 0.597 |
| Presence of traumatic symptoms(PCL-S) ≥44[***] | 2.38 | 2.01 | - 2.83 | <.0001 | 1.67 | 1.35 | - 2.08 | <.0001 |
| Presence of non-specific mental illness(K6)≥13[***] | 2.26 | 1.88 | - 2.72 | <.0001 | 1.38 | 1.09 | - 1.74 | 0.008 |

[*]Age-Adjusted

[**]Sex-Adjusted

*** Age- and sex-adjusted

[#]Adjusted for age, sex, living arrangement, experienced living in evacuation shelters, Higher education, history of mental illness, unemployed, income decreased, experienced tsunami, presence of traumatic symptoms, and Presence of non-specific mental illness.

**TABLE 3** Age- and sex-adjusted and multivariable-adjusted ORs and 95% confidence intervals of quittied to smoking after the disaster according to geographical, disaster-related and psycosotial factors among 14,025 smokers before the disaster.

| | Age- and sex-adjusted model | | | | Multivariable-adjusted model[#] | | | |
|---|---|---|---|---|---|---|---|---|
| Model | OR | (95%CI) | | P values | OR | (95%CI) | | P values |
| n=14025 | | | | | | | | |
| **Geographical factor** | | | | | | | | |
| Men(versus women)[*] | 0.63 | 0.56 - | 0.71 | <.0001 | 0.64 | 0.57 - | 0.72 | <.0001 |
| **Age[**]** | | | | | | | | |
| Ages 20-49 years | 1.00 | | | | | | | |
| Ages 50–64 years | 1.02 | 0.90 - | 1.15 | 0.792 | 1.06 | 0.94 - | 1.20 | 0.362 |
| Ages ≥65 years | 1.74 | 1.51 - | 2.01 | <.0001 | 1.89 | 1.62 - | 2.19 | <.0001 |
| Higher education (junior college and higher)[***] | 1.32 | 1.17 - | 1.49 | <.0001 | 1.31 | 1.16 - | 1.48 | <.0001 |
| **Disaster-related factors[***]** | | | | | | | | |
| **Living arrangement[***]** | | | | | | | | |
| Own home | 1.00 | | | | | | | |
| Evacuation Shelter | 1.16 | 0.66 - | 2.04 | 0.613 | 0.97 | 0.86 - | 1.10 | 0.641 |
| Temporary housing | 0.90 | 0.74 - | 1.10 | 0.314 | 0.92 | 0.75 - | 1.13 | 0.417 |
| Rental housing or apartment | 1.09 | 0.97 - | 1.22 | 0.146 | 1.09 | 0.97 - | 1.23 | 0.145 |
| Relative's home | 1.24 | 0.91 - | 1.68 | 0.180 | 1.17 | 0.86 - | 1.60 | 0.319 |
| **Experienced living in evacuation shelters[***]** | 0.96 | 0.86 - | 1.09 | 0.543 | 0.91 | 0.79 - | 1.03 | 0.138 |
| House was damaged | 1.03 | 0.89 - | 1.19 | 0.705 | 1.03 | 0.88 - | 1.20 | 0.745 |
| History of mental illness[***] | 1.09 | 0.87 - | 1.37 | 0.436 | 1.16 | 0.92 - | 1.45 | 0.218 |
| **Experience of disaster[***]** | | | | | | | | |
| Experienced tsunami | 0.97 | 0.85 - | 1.11 | 0.652 | 0.98 | 0.85 - | 1.12 | 0.733 |
| **Psychosociall factors[***]** | | | | | | | | |
| Unemployed | 1.09 | 0.96 - | 1.23 | 0.171 | 1.10 | 0.97 - | 1.26 | 0.122 |
| Income decreased | 0.85 | 0.75 - | 0.97 | 0.012 | 0.86 | 0.76 - | 0.98 | 0.024 |
| Presence of traumatic symptoms(PCL-S)≥44[***] | 0.85 | 0.74 - | 0.97 | 0.016 | 0.88 | 0.75 - | 1.04 | 0.127 |
| Presence of non-specific mental illness(K6)≥13[***] | 0.83 | 0.71 - | 0.97 | 0.022 | 0.87 | 0.72 - | 1.05 | 0.148 |

[*]Age-Adjusted

[**]Sex-Adjusted

[***]Age- and sex-adjusted

[#]Adjusted for age, sex, living arrangement, experienced living in evacuation shelters, Higher education, history of mental illness, unemployed, income decreased, experienced tsunami, presence of traumatic symptoms, and Presence of non-specific mental illness.

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

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract (P1-6)** | 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 |
| **Introduction (P7-8)** | | |
| Background/rationale **(P7)** | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives **(P8)** | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods (P8-11)** | | |
| Study design **(P8)** | 4 | Present key elements of study design early in the paper |
| Setting **(P8)** | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants **(P8-9)** | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—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<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables **(P10-P11)** | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement **(P8-P11)** | 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 **(P8-9)** | 10 | Explain how the study size was arrived at |
| Quantitative variables **(P10-11)** | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods **(P11-12)** | 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*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | |
|---|---|---|
| **Results (P12-14)** | | |
| Participants **(P12)** | 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 **(P13-14)** | 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) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data **(P13-14)** | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—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 (P14-16)** | | |
| Key results **(P14-16)** | 18 | Summarise key results with reference to study objectives |
| Limitations **(P16-17)** | 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 **(P17)** | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability **P17** | 21 | Discuss the generalisability (external validity) of the study results |
| **Other information (P18-19)** | | |
| 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 |

*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.

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# Effects of disaster-related and psychosocial factors on changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake



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| | Psychological stress |
|---|---|
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# Effects of disaster-related and psychosocial factors on changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake

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**Keywords**

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**Word count**

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## Abstract

**Objective:** Few studies have comprehensively examined the changes in smoking status and related factors after a disaster. We examined these factors amongst the residents of the evacuation area in Fukushima after the Great East Japan Earthquake.

**Methods:** The subjects were 58,755 men and women aged ≥20 years who participated in the Fukushima Health Management Survey in 2012 after the disaster. Using the self-administered questionnaire, the smoking status was determined by current smokers or current non-smokers before and after the disaster. The subjects were divided into 1) non-smokers before and after the disaster, 2) non-smokers before and smokers after the disaster, 3) smokers before and non-smokers after the disaster and 4) smokers before and after the disaster. In age- and sex-adjusted and multivariable-adjusted models, the prevalence ratios (PRs) and 95% confidence intervals (CIs) of changes in smoking status for demographic, disaster-related and psychosocial factors were tested by logistic regression analysis, stratified by smoking status before the disaster.

**Results:** Among 44,729 non-smokers before the disaster, 634(1.4%) started smoking after the disaster. Among 14,025 smokers before the disaster, 1,564(11.1%) quit smoking after the disaster. As a result, the proportion of smokers decreased from 21.2%

to 19.6% in the evacuation area. In the multivariable model, factors significantly associated with start-smoking were being a male or younger, having a lower education staying in a rental house/apartment, house being damaged, having experienced a tsunami, changes in jobs, presence of traumatic symptoms and non-specific psychological distress. On the other hand, factors associated with quit-smoking were being a female or older, having a higher-education and stable income.

**Conclusion:** The proportion of smokers decreased slightly amongst residents in the evacuation area. The changes in smoking status were associated with disaster-related psychosocial factors, particularly changes in living conditions, having experienced a tsunami, changes in jobs and post-traumatic stress disorder.

## Strengths and limitations of this study

The strengths of this study lie in the sample size and procedures, as it involved a large-scale survey (n = 58,755) to complete an inventory-based analysis of evacuees following the earthquake.

Smoking status before and after the earthquake was investigated using a self-administered questionnaire after the disaster, and the number of cigarettes used among current smokers was not evaluated.

This study had an overall low response rate (40.7%); therefore, the representativeness of the target population is uncertain.

## Introduction

The Great East Japan Earthquake that occurred on March 11, 2011 was one of the most disastrous events in the history of Japan. About 212,500 people in the Fukushima Prefecture were forced to evacuate due to the Fukushima Dai-ichi nuclear power plant accident following the earthquake and the subsequent tsunami that struck the plant. Six years after the disaster, 77,283 have still been evacuated as of March 2017.

The accident resulted in the disruption of normal lives of the people of Fukushima, loss of life, relocations, maladjustment to new circumstances and induced stressful situations for the evacuees.[1–3] A previous study reported that cumulative mental stress is partly associated with an increased risk of smoking due to increased impulsivity.[4] Furthermore, post-traumatic stress disorder (PTSD) might be associated with an increased risk of smoking.[5] Moreover, most of previous studies reported that the proportion of smokers increased subsequent to disasters, such as Hurricane Katrina[6–8], earthquakes[9–10] and the September 11 terrorist attacks in New York City[5,11], All previous studies, however, had adopted a limited sample size ranging between 209 and, 988, and did not examine the change in smoking status in individuals and the related factors. Therefore, the comprehensive examination with a large sample size would be necessary to determine the impact of smoking status by disasters.

Amongst the evacuees in Fukushima Prefecture, the prevalence of overweight, hypertension, diabetes mellitus, dyslipidaemia, polycythaemia and atrial fibrillation increased one year after the nuclear power plant accident.[12–15] Therefore, the evacuees are expected to be at a greater risk of cardiovascular diseases if the proportion of current smoking increases because smoking is a major risk factor for cardiovascular diseases.

Hence, we aim to examine the smoking status after the Fukushima Dai-ichi nuclear power plant accident among more than 100,000 people in the evacuation area of the Fukushima prefecture. The prevalence of severe degree of traumatic symptoms, psychological distress and anxiety after the nuclear accident are high among the residents of the evacuation area[3]. Hence, we also aim to examine the associations of disaster-related and psychosocial impacts on changes in smoking status.

## Methods

### Participants

Following the Great East Japan Earthquake that occurred on March 11, 2011, the government designated evac**u**ation instruction zones. Between January and October 2012, the evacuees participated in the Fukushima Health Management Survey of the Fukushima Dai-ichi Nuclear Power Plant Accident that started in 2011. The 'Mental

Health and Lifestyle Survey', part of that longitudinal study, assesses how the disaster and subsequent lifestyle of people affect the mental status of the evacuees over a long period[1,3].

The target population of the survey was men and women aged minimum 15 years and living in the evacuation zones specified by the government. These zones included Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City, Kawamata Town, Iitate Village and a part of Date City. The questionnaire was mailed on 18 January 2012 to persons who had a certificate of residence in the evacuation area as on 11 March 2011. The number of residents who were born before 1 April 1995 (i.e. high school students or older) during the disaster was 180,604. The response rate for the participation was 40.7% (n = 73,569). We used the help of experts to guarantee precision when entering the data. We also double checked all of the entered data.

Since we sought to examine changes in smoking behaviour among the evacuees, we limited our data to men and women aged minimum 20 years, which is the legal smoking age in Japan. As a result, we used 58,754 subjects for the analysis.

However, "living arrangement" and "experienced living in evacuation shelters" were suggested to be associated with each other and "became unemployed" and "income has

decreased" were also suggested to be associated with each other, therefore, "changes in jobs" and "living arrangement" were used in the multivariate.

The purpose of this study was explained to all responders in a cover letter distributed with the questionnaire. The cover letter clearly indicated that the return of the questionnaires would be regarded as consent for study participation. The survey data collection took 10 months (January to October of 2012), during which approximately 80% of the responses were obtained. This survey was approved by the ethics review committee of Fukushima Medical University (No. 1316).

Using the questionnaire, the smoking status was determined by current smokers or current non-smokers just before the disaster; however, we did not distinguish people who never smoked or ex-smokers from current non-smokers. The smoking status 1-year after the disaster was determined by never smoked, ex-smokers and current smokers. Then, the changes in the smoking status before and after the disaster were categorized into four groups as shown in Figure 1: 1) non-smokers before and after the disaster (non-smokers), 2) non-smokers before and smokers after the disaster (starters), 3) smokers before and non-smokers after the disaster (quitters) and 4) smokers before and after the disaster (smokers).

**Socioeconomic and disaster-related and psychosocial variables**

Socioeconomic and disaster-related variables were assessed using the questionnaire responses, including living arrangements (own home, evacuation shelter, temporary housing, rental housing or apartment and relative's home), whether experienced living in evacuation shelters (yes or no), education level (elementary school, junior high school and high school, vocational college, junior college, university (4 years) and graduate school), history of mental illness (yes or no), whether becoming unemployed (yes or no), whether income decreased (yes or no), whether house was damaged (yes or no), whether experienced tsunami before (yes or no), presence of traumatic symptoms assessed by the Japanese version of PTSD Checklist-Stressor Specific Version [PCL-S] and non-specific psychological distress measured by the Japanese version of the Kessler Psychological Distress Scale [K6]. These Japanese versions were reported to be validated.[16–20]

We considered PCL-S score > 44 as indicating the presence of traumatic symptoms.[16,17,21] We regarded Kessler's K6 score ≥ 13 as indicating the presence of non-specific psychological distress.[22–24] Age was used as a categorical variable, defining three age groups (20–49, 50–64 and ≥65 years). Education level was categorized as lower (high school or less) or higher (additional vocational college or junior college

experience or higher).

**Statistical analysis**

The chi-square test was used to compare the smoking status before and after the disaster. Disaster-related and socioeconomic variables were also compared among the categories of change in the smoking status before and after the disaster using the chi-squared test. We examined the impact of demographic, disaster-related and psychosocial variables on start smoking compared with continued non-smoking after the disaster among non-smokers before the disaster. We also examined the impact of these variables on quit smoking compared with continued smoking among smokers before the disaster.

Age- and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of the changes in smoking status for demographic, disaster-related and psychosocial variables were calculated by logistic regression analysis. In the multivariable-adjusted model, the adjustments were made for age (years), sex, and other related factors estimated as statistically significant by the age- and sex-adjusted model. The potential related factors were educational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, changes in jobs, becoming unemployed, decreased income, presence of traumatic symptoms and non-specific psychological

distress.

Because the proportion of smokers was largely different between men and women, we also conducted the multivariable analyses stratified by sex. P-values were obtained by a two-tailed test and $P < 0.05$ was regarded as statistically significant. All statistical analyses were performed using software package SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

**Results**

The proportion of current smokers among a total of 58,754 men and women significantly decreased from 23.9% to 22.3% after the disaster ($P < 0.001$). The corresponding proportion among men changed from 37.5% to 35.2% ($P < 0.001$) and that among women changed from 12.5% to 11.5% ($P < 0.001$). Among the participants, 634 (1.1%) men and women started smoking and 1,564 (2.7%) men and women quit smoking after the disaster. The corresponding proportions of starting and quitting smoking were, respectively, 1.4% and 3.7% for men and 0.8% and 1.8% for women.

Table 1 shows the participants' demographic, disaster-related and psychosocial variables according to the categories of changes in smoking status, i.e. non-smokers, starters, quitters and smokers The smoking starters showed the higher proportions than

non-smokers as for the following categories: men, younger ages, rental house/apartment, shelter living, house damage, history of mental illness, having experienced a tsunami, becoming unemployed, decreased income, traumatic symptoms and non-specific psychological distress.

Compared with smokers, quitters showed the higher proportion among the categories of women, older ages, higher education, history of mental illness, having experienced a tsunami and becoming unemployed, and a lower proportion among the categories of shelter living, decreased income, traumatic symptoms and non-specific psychological distress.

**Table 1.** Demographic, disaster-related and psycosotial factors according to the categories of changes in smoking status among 58,754 men and women in the evacuation area.

| | Total | | Non-smokers | | Starters | | | Smokers | | Quitters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | P values | n | % | n | % | P values |
| **Demographic characteristics** | | | | | | | | | | | | |
| **Sex** | n=58754 | | n=44095 | | n=634 | | | n=12461 | | n=1564 | | |
| Men | 26764 | 45.6 | 16351 | 37.1 | 376 | 59.3 | <.0001 | 9040 | 72.5 | 997 | 63.7 | <.0001 |
| women | 31990 | 54.4 | 27744 | 62.9 | 258 | 40.7 | | 3421 | 27.5 | 567 | 36.3 | |
| **Age group** | n=58754 | | | | | | | | | | | |
| Ages 20-49 years | 21479 | 36.6 | 13571 | 30.8 | 382 | 60.3 | <.0001 | 6727 | 54.0 | 799 | 51.1 | <.0001 |
| Ages 50–64 years | 18744 | 31.9 | 14136 | 32.1 | 147 | 23.2 | | 4012 | 32.2 | 449 | 28.7 | |
| Ages ≥65 years | 18531 | 31.5 | 16388 | 37.2 | 105 | 16.6 | | 1722 | 13.8 | 316 | 20.2 | |
| **Educational attainment** | n=57076 | | | | | | | | | | | |
| Primary or middle school | 13383 | 23.4 | 10680 | 25.0 | 102 | 16.8 | <.0001 | 2329 | 19.1 | 272 | 17.7 | <.0001 |
| High school | 28331 | 49.6 | 20190 | 47.2 | 331 | 54.5 | | 6986 | 57.2 | 824 | 53.8 | |
| Vocational | 10127 | 17.7 | 7849 | 18.4 | 116 | 19.1 | | 1883 | 15.4 | 279 | 18.2 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| college, or Junior college | | | | | | | | | | | | |
| University, or graduate school | 5235 | 9.2 | 4014 | 9.4 | 58 | 9.6 | | 1005 | 8.2 | 158 | 10.3 | |
| **History of mental illness** | n=57137 | | | | | | | | | | | |
| Yes | 3149 | 5.5 | 2332 | 5.4 | 60 | 9.9 | <.0001 | 662 | 5.5 | 95 | 6.2 | <.0001 |
| **Disaster-related factors** | | | | | | | | | | | | |
| **Living arrangement** | n=47099 | | | | | | | | | | | |
| Evacuation shelter | 522 | 1.1 | 401 | 1.1 | 8 | 1.6 | | 99 | 1.0 | 14 | 1.1 | |
| Temporary housing | 5343 | 11.3 | 3989 | 11.3 | 61 | 12.6 | | 1164 | 11.6 | 129 | 10.3 | |
| Rental house or apartment | 19330 | 41.0 | 13654 | 38.7 | 270 | 55.7 | <.0001 | 4780 | 47.4 | 626 | 49.8 | <.0001 |
| Relative's home | 2127 | 4.5 | 1731 | 4.9 | 21 | 4.3 | | 325 | 3.2 | 50 | 4.0 | |
| Own home | 17576 | 37.3 | 13862 | 39.3 | 101 | 20.8 | | 3252 | 32.3 | 361 | 28.7 | |
| Others | 2201 | 4.7 | 1644 | 4.7 | 24 | 4.9 | | 457 | 4.5 | 76 | 6.1 | |
| **Experienced living in evacuation shelters** | n=58754 | | | | | | | | | | | |
| Yes | 15865 | 27.0 | 11887 | 27.0 | 198 | 31.2 | <.0001 | 3365 | 27.0 | 415 | 26.5 | <.0001 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **House damage** | n=58754 | | | | | | | | | | | |
| Yes | 8706 | 14.8 | 6528 | 14.8 | 134 | 21.1 | <.0001 | 1812 | 14.5 | 232 | 14.8 | <.0001 |
| **Experience of disaster** | | | | | | | | | | | | |
| Having experienced a tsunami | n=58754 | | | | | | | | | | | |
| Yes | 11807 | 20.1 | 8559 | 19.4 | 176 | 27.8 | <.0001 | 2747 | 22.0 | 325 | 20.8 | <.0001 |
| **Psychosociall factors** | | | | | | | | | | | | |
| Changes in jobs | n=58754 | | | | | | | | | | | |
| Yes | 2542 | 4.3 | 1599 | 3.6 | 56 | 8.8 | <.0001 | 798 | 6.4 | 89 | 5.7 | <.0001 |
| Becoming unemployed | n=58754 | | | | | | | | | | | |
| Yes | 12255 | 20.9 | 8643 | 19.6 | 172 | 27.1 | <.0001 | 3016 | 24.2 | 424 | 27.1 | <.0001 |
| Decreased Income | n=58754 | | | | | | | | | | | |
| Yes | 11141 | 19.0 | 7548 | 17.1 | 145 | 22.9 | <.0001 | 3117 | 25.0 | 331 | 21.2 | <.0001 |
| **Presence of traumatic symptoms(PCL-S) >=44** | n=58754 | | | | | | | | | | | |
| Yes | 12266 | 20.9 | 9247 | 21.0 | 210 | 33.1 | <.0001 | 2515 | 20.2 | 294 | 18.8 | <.0001 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Presence of non-specific mental illness(K6)>=13** | n=58754 | | | | | | | | | | | |
| Yes | 8556 | 14.0 | 6337 | 14.4 | 157 | 24.8 | <.0001 | 1853 | 14.9 | 209 | 13.4 | <.0001 |

Table 2 indicates age- and sex-adjusted PRs and 95% CIs for the group that start smoking after the disaster according to demographic, disaster-related and psychosocial factors among 44,729 smokers before the disaster. The corresponding age- and sex-adjusted PRs (95% CIs) were 2.91 (2.48–3.42) for men, 5.17 (4.15–6.43) for ages 20–49 years, 1.74 (1.35–2.23) for ages 50–64 years, 0.68 (0.57–0.82) for higher education (junior college and higher), 2.03 (1.54–2.67) for history of mental illness, 1.46 (1.10–1.93) for living in a temporary housing, 1.38 (1.16–1.64) for living in a rental housing/apartment, 1.64 (1.35–1.99) for house damage, 1.57 (1.32–1.88) for having experienced a tsunami, 1.57 (1.18–2.08) for changes in jobs, 1.53 (1.28–1.83) for becoming unemployed, 1.18 (0.97–1.42) for decreased Income, 2.38 (2.01–2.83) for presence of traumatic symptoms and 2.26 (1.88–2.72) for presence of non-specific mental illness.

Age- and sex-adjusted and multivariable-adjusted PRs and 95% CIs of start smoking after the disaster according to demographic, disaster-related and psychosocial factors among 44,729 non-smokers before the disaster. The corresponding multivariable-adjusted PRs (95% CIs) were 3.01 (2.55–3.55) for men, 5.55 (4.40–7.00) for ages 20–49 years, 1.81 (1.40–2.33) for ages 50–64 years, 0.69 (0.57–0.83) for higher education (junior college and higher) , 1.45 (1.09–1.93) for history of mental illness,

1.33 (1.12–1.58) for living in a rental housing/apartment, 1.24 (1.01–1.50) for house damaged, 1.29 (1.07–1.55) for having experienced a tsunami, 1.41 (1.05–1.89) for changes in jobs, 1.19 (0.99–1.43) for becoming unemployed, 1.70 (1.37–2.11) for presence of traumatic symptoms and 1.38 (1.09–1.75) for presence of non-specific mental illness. These associations did not differ substantially between men and women (Supplemental Table 1).

Age- and sex-adjusted and multivariable-adjusted PRs and 95% CIs of start smoking after the disaster according to demographic, disaster-related and psychosocial factors among 44,729 non-smokers before the disaster. The corresponding multivariable-adjusted PRs (95% CIs) were 3.01 (2.55–3.55) for men, 5.55 (4.40–7.00) for ages 20–49 years, 1.81 (1.40–2.33) for ages 50–64 years, 0.69 (0.57–0.83) for higher education (junior college and higher) , 1.45 (1.09–1.93) for history of mental illness, 1.33 (1.12–1.58) for living in a rental housing/apartment, 1.24 (1.01–1.50) for house damaged, 1.29 (1.07–1.55) for having experienced a tsunami, 1.41 (1.05–1.89) for changes in jobs, 1.19 (0.99–1.43) for becoming unemployed, 1.70 (1.37–2.11) for presence of traumatic symptoms and 1.38 (1.09–1.75) for presence of non-specific mental illness. These associations did not differ substantially between men and women (Supplemental Table 1).

**TABLE 2.** **Age-** and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals of start smoking after the disaster according to geographical, disaster-related and psycosotial factors among 44,729 non-smokers before the disaster.

| | Age- and sex-adjusted model | | | Multivariable-adjusted model# | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=44729 | | | | | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | 2.91 | 2.48 - 3.42 | <.0001 | 3.01 | 2.55 - 3.55 | <.0001 |
| **Age group**** | | | | | | |
| Ages 20-49 years | 5.17 | 4.15 - 6.43 | <.0001 | 5.55 | 4.40 - 7.00 | <.0001 |
| Ages 50–64 years | 1.74 | 1.35 - 2.23 | <.0001 | 1.81 | 1.40 - 2.33 | <.0001 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (verus lower eduction)** | 0.68 | 0.57 - 0.82 | <.0001 | 0.69 | 0.57 - 0.83 | <.0001 |
| **History of mental illness** Yes(versus No) | 2.03 | 1.54 - 2.67 | <.0001 | 1.45 | 1.09 - 1.93 | 0.010 |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation Shelter | 1.53 | 0.75 - 3.13 | 0.246 | 1.36 | 0.66 - 2.78 | 0.409 |
| Temporary housing | 1.46 | 1.10 - 1.93 | 0.009 | 1.25 | 0.94 - 1.66 | 0.127 |
| Rental housing or apartment | 1.38 | 1.16 - 1.64 | <.001 | 1.33 | 1.12 - 1.58 | 0.001 |
| Relative's home | 1.18 | 0.75 - 1.85 | 0.467 | 1.14 | 0.72 - 1.78 | 0.580 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Own home (Ref.) | 1.00 | | | | 1.00 | | | |
| **House damage** | | | | | | | | |
| Yes(versus No) | 1.64 | 1.35 | - | 1.99 <.0001 | 1.24 | 1.01 | - | 1.50 0.038 |
| **Experience of disaster** | | | | | | | | |
| Having experienced a tsunami | | | | | | | | |
| Yes(versus No) | 1.57 | 1.32 | - | 1.88 <.0001 | 1.29 | 1.07 | - | 1.55 0.008 |
| **Psychosociall factors** | | | | | | | | |
| Changes in jobs | | | | | | | | |
| Yes(versus No) | 1.57 | 1.18 | - | 2.08 0.002 | 1.41 | 1.05 | - | 1.89 0.023 |
| Becoming unemployed | | | | | | | | |
| Yes(versus No) | 1.53 | 1.28 | - | 1.83 <.0001 | 1.19 | 0.99 | - | 1.43 0.064 |
| Decreased Income | | | | | | | | |
| Yes(versus No) | 1.18 | 0.97 | - | 1.42 0.092 | | | | |
| Presence of traumatic | | | | | | | | |
| symptoms(PCL-S) | 2.38 | 2.01 | - | 2.83 <.0001 | 1.70 | 1.37 | - | 2.11 <.0001 |
| ≥44(versus ≤43) | | | | | | | | |
| Presence of non-specific mental | | | | | | | | |
| illness(K6) | 2.26 | 1.88 | - | 2.72 <.0001 | 1.38 | 1.09 | - | 1.75 0.007 |
| ≥13(versus ≤12) | | | | | | | | |

*Age-Adjusted

**Sex-Adjusted

#Adjusted for age and sex, and eduational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, changes in jobs,becoming unemployed, decreased Income, presence of traumatic symptoms and presence of non-specific mental illness except for the variable of interest.

Table 3 indicates age- and sex-adjusted PRs and 95% CIs of quit smoking after the disaster according to demographic, disaster-related and psychosocial factors among 14,025 smokers before the disaster. Age- and sex-adjusted PRs (95% CIs) were 0.63 (0.56–0.71) for men, 0.58 (0.50–0.66) for 20–49 years, 0.59 (0.50–0.68) for 50–64 years, 1.32 (1.17–1.49) for higher education , 0.85 (0.75–0.97) for decreased Income, 0.85 (0.74–0.97) for presence of traumatic symptoms and 0.83 (0.71–0.97) for presence of non-specific mental illness.

The corresponding multivariable-adjusted PRs (95% CIs) were 0.63 (0.56–0.71) for men, 0.53 (0.46–0.62) for 20–49 years, 0.57 (0.48–0.66) for 50–64 years and 1.31 (1.16–1.47) for higher education, 0.89 (0.76–0.98) for decreased Income, 0.89 (0.76–1.05) for presence of traumatic symptoms and 0.89 (0.74–1.07) for presence of non-specific mental illness. These associations did not differ substantially between men and women (Supplemental Table 2)

**TABLE 3.** Age- and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals of quit smoking after the disaster according to geographical, disaster-related and psycosotial factors among 14,025 smokers before the disaster.

| | Age- and sex-adjusted model | | | Multivariable-adjusted model# | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=14025 | | | | | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | 0.63 | 0.56 - 0.71 | <.0001 | 0.63 | 0.56 - 0.71 | <.0001 |
| **Age group**** | | | | | | |
| Ages 20-49 years | 0.58 | 0.50 - 0.66 | <.0001 | 0.53 | 0.46 - 0.62 | <.0001 |
| Ages 50–64 years | 0.59 | 0.50 - 0.68 | <.0001 | 0.57 | 0.48 - 0.66 | <.0001 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (versus lower education)** | 1.32 | 1.17 - 1.49 | <.0001 | 1.31 | 1.16 - 1.47 | <.0001 |
| **History of mental illness** | | | | | | |
| Yes(versus No) | 1.09 | 0.87 - 1.37 | 0.436 | | | |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation Shelter | 1.16 | 0.66 - 2.04 | 0.613 | 1.20 | 0.68 - 2.12 | 0.537 |
| Temporary housing | 0.90 | 0.74 - 1.10 | 0.314 | 0.95 | 0.78 - 1.16 | 0.614 |
| Rental housing or apartment | 1.09 | 0.97 - 1.22 | 0.146 | 1.12 | 1.00 - 1.25 | 0.061 |
| Relative's home | 1.24 | 0.91 - 1.68 | 0.180 | 1.20 | 0.88 - 1.63 | 0.256 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **House damage** | | | | | | | | | |
| Yes(versus No) | 1.03 | 0.89 | - | 1.19 | 0.705 | | | | |
| **Experience of disaster** | | | | | | | | | |
| Having experienced a tsunami | | | | | | | | | |
| Yes(versus No) | 0.97 | 0.85 | - | 1.11 | 0.652 | | | | |
| **Psychosociall factors** | | | | | | | | | |
| Changes in jobs | | | | | | | | | |
| Yes(versus No) | 0.94 | 0.75 | - | 1.18 | 0.594 | | | | |
| Becoming unemployed | | | | | | | | | |
| Yes(versus No) | 1.09 | 0.96 | - | 1.23 | 0.171 | | | | |
| Decreased Income | | | | | | | | | |
| Yes(versus No) | 0.85 | 0.75 | - | 0.97 | 0.012 | 0.86 | 0.75 | - 0.98 | 0.019 |
| Presence of traumatic symptoms(PCL-S) | | | | | | | | | |
| ≥44(versus ≤43) | 0.85 | 0.74 | - | 0.97 | 0.016 | 0.89 | 0.76 | - 1.05 | 0.160 |
| Presence of non-specific mental | | | | | | | | | |
| illness(K6) | 0.83 | 0.71 | - | 0.97 | 0.022 | 0.89 | 0.74 | - 1.07 | 0.209 |
| ≥13(versus ≤12) | | | | | | | | | |

*Age-Adjusted

**Sex-Adjusted

#Adjusted for age and sex, and educational attainment, living arrangement, decreased Income, presence of traumatic symptoms and presence of non-specific mental illness except for the variable of interest.

## Discussion

One of the main findings from the present study is that the proportion of smokers decreased slightly among men and women aged ≥20 years in the evacuation area from 23.9% to 22.3% at 10 to 20 months after the March 2011 earthquake and the subsequent disastrous tsunami and nuclear power plant accident. The proportion of persons who quit smoking was higher than that of those who started smoking: 3.7% and 1.4% among men and 1.8% and 0.8% among women, respectively.

By contrast, previous studies have reported that the proportion of current smokers increased after a disaster: from 34.4% to 52.5% amongst men and women one year after Hurricane Katrina[8] and from 22.6% to 23.4% amongst men and women aged ≥18 years 6 months after the terrorist attacks in Manhattan on September 11th, 2001.[9]

In the present study, we found that factors associated with quitting smoking were being a female, older age, having a higher education and having a stable income. Conversely, the factors associated with initiating smoking included being a male, younger age, having a lower education, staying in a rental house/apartment, experiencing damage to one's house, having experienced a tsunami, changes in jobs, the presence of traumatic symptoms and non-specific psychological distress. Our results on traumatic symptoms and non-specific psychological distress were consistent with

findings from previous studies on Hurricane Katrina, the September 11th terrorist attacks and the Canterbury Great Earthquake; these studies all showed that post-traumatic stress disorder (PTSD) was a major factor for initiating smoking.[6,7,9] Therefore, the management of PTSD might help prevent some individuals from initiating smoking.

The National Health Nutrition Survey in Japan reported that the proportion of smokers in Japan before and after the disaster increased slightly from 19.5% (95% CI, 20.0 to 20.9%) in 2010 to 20.7% (95% CI, 18.6 to 20.3%) in 2012.[25] One reason for the slight decrease in the proportion of current smokers in Fukushima after the disaster may be the decreased access to tobacco products. The earthquake damaged tobacco plantations, ceasing tobacco production and disrupting railway and road transportation networks in the areas damaged by the earthquake. Tobacco distribution stagnated after the disaster. According to a press release by Japan Tobacco Inc., the total cigarette sales volume in April 2011 decreased by 81.8% compared to April 2010, and domestic cigarette sales decreased by 74.8%. Furthermore, the cigarette sales volume between April and September 2011 decreased by 41.2% and the tobacco sales volume decreased by 20.4% compared to the same period the previous year.[26] These situations likely contributed to quitting smoking after the disaster in Fukushima.

Although the proportion of current smokers decreased slightly among the evacuees after the disaster, the proportion of current smokers was still higher in the evacuation area than in other areas of Japan. In the present study, the proportion of current smokers was 22.3% (35.2% men and 11.5% women), while the corresponding proportion in the national sample was 20.1% (32.4% men and 9.7% women) in 2012.[27]

The strengths of this survey lie in its size and procedures, as it involved a large-scale survey to complete an inventory-based analysis of evacuees following the earthquake.

The present study has several limitations. First, we investigated smoking status before and after the earthquake using a self-reported questionnaire administered after the disaster that involved a cross-sectional study design; this may have led to recall bias. Second, we did not assess the number of cigarettes smoked amongst current smokers, and thus we could not examine dose-response relationships. Third, because the response rate in the present study was relatively low (41%), the representativeness of target populations was uncertain. Furthermore, if non-responders tended to be smokers or beginning smokers, the proportion of smokers after the disaster could be underestimated. Lastly, there were no data from non-disaster exposed areas for comparison, except for

national data on the prevalence of smoking.

In conclusion, The proportion of smokers decreased slightly amongst residents in the evacuation area. The changes in smoking status were associated with disaster-related psychosocial factors, particularly changes in living conditions, having experienced a tsunami, changes in jobs and post-traumatic stress disorder. A long-term follow-up study is necessary to examine the effects of disaster-related factors on smoking status amongst evacuees.

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**Contributors**

HN, TO and HI contributed to the design of the present study. TO, SY, AO, MM, MH, NH, YS, HY and HT were responsible for data collection and overseeing study procedures. The analysis was conducted by HN. The manuscript was written by HN. TO, SY, AO, MM, MH, NH, YS, HY, HT, MN, WZ, HI and KK made significant contributions to the critical interpretation of the results in terms of important practical content. All the authors read and approved the final version of the manuscript.

**Competing interests**

None declared

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**Data sharing statement**

No additional data are available.

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## List of Figures

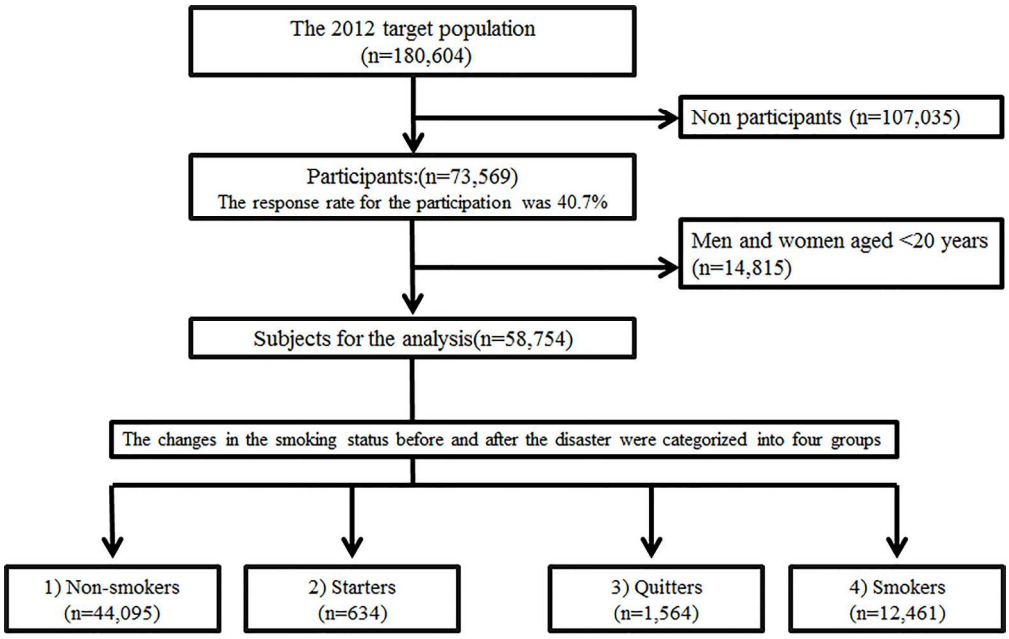


Figure 1. Flow chart for the determination of smoking status

289x182mm (300 x 300 DPI)

**Supplement Table 1.** Multivariable-adjusted prevalence ratios (PRs) and 95% confidence intervals of start smoking after the disaster according to geographical, disaster-related and psycosotial factors among 44,729 non-smokers before the disaster.

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=44729 | n=16727 | | | n=28002 | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | | | | | | |
| **Age group**** | | | | | | |
| Ages 20-49 years | 5.73 | 4.26 - 7.70 | <.0001 | 4.81 | 3.29 - 7.01 | <.0001 |
| Ages 50–64 years | 2.02 | 1.47 - 2.77 | <.0001 | 1.39 | 0.90 - 2.13 | 0.135 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (verus lower eduction)** | 0.68 | 0.53 - 0.87 | 0.002 | 0.71 | 0.54 - 0.95 | 0.020 |
| **History of mental illness** | | | | | | |
| Yes(versus No) | 1.24 | 0.82 - 1.86 | 0.304 | 1.79 | 1.20 - 2.66 | 0.005 |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation Shelter | 1.22 | 0.49 - 3.05 | 0.671 | 1.59 | 0.50 - 5.12 | 0.436 |
| Temporary housing | 0.96 | 0.65 - 1.43 | 0.840 | 1.57 | 1.03 - 1.03 | 0.034 |
| Rental housing or apartment | 1.25 | 1.00 - 1.57 | 0.056 | 1.34 | 1.02 - 1.76 | 0.039 |
| Relative's home | 1.11 | 0.61 - 2.03 | 0.725 | 1.12 | 0.56 - 2.23 | 0.745 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** | | | | | | |
| Yes(versus No) | 1.44 | 1.11 - 1.86 | 0.006 | 0.99 | 0.70 - 1.39 | 0.953 |
| **Experience of disaster** | | | | | | |
| Having experienced a tsunami Yes(versus No) | 1.44 | 1.14 - 1.81 | 0.002 | 1.05 | 0.76 - 1.46 | 0.756 |
| **Psychosociall factors** | | | | | | |
| Changes in jobs Yes(versus No) | 1.70 | 1.19 - 2.44 | 0.004 | 1.02 | 0.60 - 1.74 | 0.936 |
| Becoming unemployed Yes(versus No) | 0.99 | 0.76 - 1.29 | 0.922 | 1.47 | 1.13 - 1.92 | 0.004 |
| Decreased Income Yes(versus No) | 1.05 | 0.83 - 1.34 | 0.694 | 0.93 | 0.67 - 1.31 | 0.692 |
| Presence of traumatic symptoms(PCL-S) ≥44(versus ≤43) | 1.30 | 0.96 - 1.75 | 0.090 | 2.31 | 1.68 - 3.18 | <.0001 |
| Presence of non-specific mental illness(K6) ≥13(versus ≤12) | 1.75 | 1.28 - 2.39 | 0.001 | 1.00 | 0.70 - 1.42 | 0.995 |

#Adjusted for age, and eduational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, changes in jobs,becoming unemployed, decreased Income, presence of traumatic symptoms and presence of non-specific mental illness except for the variable of interest.

**Supplemental Table 2.** Multivariable-adjusted prevalence ratios (PRs) and 95% confidence intervals of quit smoking after the disaster according to geographical, disaster-related and psycosotial factors among 14,025 smokers before the disaster.

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=14025 | n=10037 | | | n=3998 | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | | | | | | |
| **Age group**** | | | | | | |
| Ages 20-49 years | 0.43 | 0.36 - 0.51 | <.0001 | 0.92 | 0.65 - 1.30 | 0.620 |
| Ages 50–64 years | 0.59 | 0.50 - 0.71 | <.0001 | 0.58 | 0.40 - 0.86 | 0.007 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (verus lower eduction)** | 1.33 | 1.14 - 1.55 | <.001 | 1.34 | 1.10 - 1.63 | 0.003 |
| **History of mental illness** | | | | | | |
| Yes(versus No) | | | | | | |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation Shelter | 1.15 | 0.59 - 2.25 | 0.675 | 1.42 | 0.48 - 4.24 | 0.529 |
| Temporary housing | 1.05 | 0.83 - 1.33 | 0.684 | 0.73 | 0.50 - 1.07 | 0.111 |
| Rental housing or apartment | 1.11 | 0.96 - 1.29 | 0.152 | 1.12 | 0.92 - 1.35 | 0.251 |
| Relative's home | 1.21 | 0.83 - 1.77 | 0.329 | 1.19 | 0.70 - 2.05 | 0.522 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** | | | | | | |
| Yes(versus No) | | | | | | |
| **Experience of disaster** | | | | | | |
| Having experienced a tsunami | | | | | | |
| Yes(versus No) | | | | | | |
| **Psychosociall factors** | | | | | | |
| Changes in jobs | | | | | | |
| Yes(versus No) | | | | | | |
| Becoming unemployed | | | | | | |
| Yes(versus No) | | | | | | |
| Decreased Income | | | | | | |
| Yes(versus No) | 0.85 | 0.72 - 0.99 | 0.038 | 0.94 | 0.74 - 1.18 | 0.573 |
| Presence of traumatic symptoms(PCL-S) | | | | | | |
| ≥44(versus ≤43) | 0.98 | 0.79 - 1.20 | 0.811 | 0.75 | 0.58 - 0.98 | 0.031 |
| Presence of non-specific mental illness(K6) | | | | | | |
| ≥13(versus ≤12) | 1.01 | 0.80 - 1.28 | 0.947 | 0.79 | 0.59 - 1.07 | 0.129 |

#Adjusted for age, and educational attainment, living arrangement, decreased Income, presence of traumatic symptoms and presence of non-specific mental illness except for the variable of interest.

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

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract (P1-6)** | 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 |
| **Introduction (P7-8)** | | |
| Background/rationale **(P7)** | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives **(P8)** | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods (P8-13)** | | |
| Study design **(P8)** | 4 | Present key elements of study design early in the paper |
| Setting **(P8)** | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants **(P8-9)** | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—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<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables **(P10-P11)** | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement **(P8-P11)** | 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 (**P19**) | 9 | Describe any efforts to address potential sources of bias |
| Study size **(P8-9)** | 10 | Explain how the study size was arrived at |
| Quantitative variables **(P10-11)** | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods **(P12-13)** | 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*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | |
|---|---|---|
| **Results (P13-25)** | | |
| Participants **(P13)** | 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 **(P13-18)** | 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) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data **(P19-25)** | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results **(P14-16)** | 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 (P25-29)** | | |
| Key results **(P26-28)** | 18 | Summarise key results with reference to study objectives |
| Limitations **(P28-29)** | 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 **(P29)** | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability **P29** | 21 | Discuss the generalisability (external validity) of the study results |
| **Other information (P30-30)** | | |
| Funding **(P30)** | 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 |

*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.

BMJ Open

# Associations of disaster-related and psychosocial factors with changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake



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| | |
|---|---|
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| | |

# Associations of disaster-related and psychosocial factors with changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake

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## Abstract

**Objective:** Few studies have comprehensively examined changes in smoking status and related factors after a disaster. We examined these factors amongst residents of an evacuation area in Fukushima after the Great East Japan Earthquake.

**Methods:** The study participants included 58,755 men and women aged ≥20 years who participated in the Fukushima Health Management Survey in 2012 after the disaster. Smoking status was classified as either current smokers or current non-smokers before and after the disaster. The participants were divided into the following groups: 1) non-smokers both before and after the disaster, 2) non-smokers before and smokers after the disaster, 3) smokers before and non-smokers after the disaster and 4) smokers both before and after the disaster. The adjusted prevalence ratios and 95% confidence intervals of changes in smoking status for demographic, disaster-related and psychosocial factors were tested using logistic regression analysis that was stratified by smoking status before the disaster.

**Results:** Amongst the 44,729 participants who were non-smokers before the disaster, 634 (1.4%) began smoking after the disaster. Amongst the 14,025 smokers before the disaster, 1,564 (11.1%) quit smoking after the disaster, and the proportion of smokers in the evacuation area consequently decreased from 21.2% to 19.6%. In the multivariable

model, factors significantly associated with beginning smoking included being a male, being younger, having a lower education, staying in a rental house/apartment, house being damaged, having experienced a tsunami, change jobs and the presence of traumatic symptoms and non-specific psychological distress. On the contrary, factors associated with quitting smoking included being a female, being older, having a higher education and having a stable income.

**Conclusion:** The proportion of smokers slightly decreased amongst residents in the evacuation area. The changes in smoking statuses were associated with disaster-associated psychosocial factors, particularly changes in living conditions, having experienced a tsunami, change jobs and developing post-traumatic stress disorder.

**Strengths and limitations of this study**

- The strengths of this study lie in the sample size and procedures: a large-scale survey (n = 58,755) was used for completing an inventory-based analysis of evacuees following the earthquake.
- Smoking status before and after the earthquake was investigated using a self-administered questionnaire, and the number of cigarettes used amongst current smokers was not evaluated.

- The present study had a low overall response rate (40.7%); therefore, the representativeness of the target population remains uncertain.

## Introduction

The Great East Japan Earthquake that occurred on 11 March 2011 was one of the most disastrous events in the history of Japan. More than 160,000 people in the Fukushima Prefecture were forced to evacuate because of the Fukushima Dai-ichi nuclear power plant accident following the earthquake and the subsequent tsunami that struck the plant. Six years after the disaster, 77,283 have been evacuated as of March 2017.

The accident resulted in the disruption of normal lives of the people of Fukushima, including loss of life, relocations, maladjustment to new circumstances and induced stressful situations for the evacuees.[1–3] A previous report stated that cumulative mental stress is partly associated with an increased risk of smoking because of increased impulsivity.[4] Furthermore, post-traumatic stress disorder (PTSD) may be associated with an increased risk of smoking.[5] Moreover, most studies reported the proportion of smokers to have increased subsequent to disasters such as Hurricane Katrina[6–8], earthquakes[9–10] and the September 11 terrorist attacks in New York City.[5,11] However, all previous studies comprised a limited sample size that ranged between 209 and 988 individuals and did not examine the change in smoking status in individuals and the associated factors. This warranted a comprehensive examination with a large sample size for determining the effect of disasters on smoking status.

Amongst the evacuees in Fukushima Prefecture, the prevalences of overweight, hypertension, diabetes mellitus, dyslipidaemia, polycythaemia and atrial fibrillation increased one year after the nuclear power plant accident.[12–15] Therefore, the evacuees are potentially at a greater risk of cardiovascular diseases if the proportion of current smoking increases because smoking is a major risk factor associated with cardiovascular diseases.

Therefore, we aimed to examine the smoking status after the Fukushima Dai-ichi nuclear power plant accident amongst more than 100,000 people in the evacuation area of the Fukushima Prefecture. The prevalences of a severe degree of traumatic symptoms, psychological distress and anxiety after the nuclear accident are high amongst the residents of the evacuation area[3]. Hence, we also aimed to examine the associations of disaster-related and psychosocial factors with changes in smoking status.

## Methods

### Participants

The government designated evacuation instruction zones following the Great East Japan Earthquake that occurred on 11 March 2011. Between January and October 2012, the evacuees participated in the Fukushima Health Management Survey of the Fukushima

Dai-ichi Nuclear Power Plant Accident that commenced in 2011. The 'Mental Health and Lifestyle Survey', which is part of the mentioned longitudinal study, assesses how the disaster and subsequent lifestyle of people affect the mental status of the evacuees over a long period of time[1,3].

The target population of the survey included men and women at least 15 years of age who lived in the following evacuation zones specified by the government: Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City, Kawamata Town, Iitate Village and a part of Date City. The questionnaire was mailed on 18 January 2012 to persons who had a certificate of residence in the evacuation area as of 11 March 2011. Of all the residents in the area during the disaster, 180,605 had been born prior to 1 April 1995 (i.e., high school students or older). The participant response rate was 40.7% (n = 73,569). We used the help of experts for guaranteeing precision when entering the data, and we double checked all entered data.

Since we sought to examine changes in smoking behaviour amongst the evacuees, we limited our data to men and women who were least 20 years old, which is the legal smoking age in Japan. Consequently, we used 58,754 participants for the analysis.

The purpose of this study was explained to all the respondents in a cover letter

distributed with the questionnaire. The cover letter clearly indicated that the return of the questionnaires would be regarded as consent for study participation. The survey data collection was completed in 10 months (from January to October 2012). This survey was approved by the ethics review committee of Fukushima Medical University (No. 1316).

The questionnaire was used for determining smoking status, which was classified as current smokers or current non-smokers just before the disaster; however, we did not distinguish participants who had never smoked or ex-smokers from current non-smokers. Smoking status one year after the disaster was classified as never smoked, ex-smokers and current smokers. Next, the changes in the smoking status before and after the disaster were categorized into four groups as shown in Figure 1: 1) non-smokers both before and after the disaster (non-smokers), 2) non-smokers before and smokers after the disaster (starters), 3) smokers before and non-smokers after the disaster (quitters) and 4) smokers both before and after the disaster (smokers).

**Socioeconomic and disaster-related and psychosocial variables**

Socioeconomic and disaster-related variables were assessed using the questionnaire responses. The assessed variables included living arrangements (own home, evacuation

shelter, temporary housing, rental housing or apartment and relative's home); whether they had ever lived in evacuation shelters (yes or no); education level (elementary school, junior high school and high school, vocational college, junior college, university [four years] and graduate school); history of mental illness (yes or no); whether they became unemployed (yes or no); whether their income decreased (yes or no); whether their house was damaged (yes or no); whether they had experienced a tsunami before (yes or no); the presence of traumatic symptoms assessed by the Japanese version of PTSD Checklist-Stressor Specific Version [PCL-S] and the presence of non-specific psychological distress measured using the Japanese version of the Kessler Psychological Distress Scale [K6]. These Japanese versions were reported to be validated.[16–20]

We considered a PCL-S score >44 as indicative of the presence of traumatic symptoms.[16,17,21] We regarded a Kessler's K6 score ≥13 as indicative of the presence of non-specific psychological distress.[22–24] Age was used as a categorical variable and participants were classified into three age groups (20–49, 50–64 and ≥65 years). Education level was categorized as lower (high school or less) or higher (additional vocational college or junior college experience or higher).

**Statistical analysis**

The chi-square test was used for comparing the smoking status before and after the disaster. Disaster-related and socioeconomic variables were also compared amongst the categories of changes in smoking status before and after the disaster using the chi-square test.

We examined the association of demographic, disaster-related and psychosocial variables between those who began smoking compared with those who remained non-smokers after the disaster amongst all non-smokers before the disaster. We also examined the association of these variables between those who quit smoking compared with those who continued smoking amongst all smokers before the disaster.

Age- and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of the changes in smoking status for demographic, disaster-related and psychosocial variables were calculated using logistic regression analysis. In the multivariable-adjusted model, adjustments were made for age (years), sex and other associated factors estimated as statistically significant by the age- and sex-adjusted model. The potential associated factors were educational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, change jobs, becoming unemployed, decreased income, the presence of traumatic symptoms and the presence

of non-specific psychological distress. Because the proportion of smokers largely differed between men and women, we also conducted the multivariable analyses stratified by sex. P values were obtained using a two-tailed test, and $P < 0.05$ was regarded as statistically significant. All statistical analyses were performed using the software package SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

**Patient and Public Involvement**

Patients and public were not involved in the present study. Patient consent is not required.

**Results**

The proportion of current smokers amongst the total of 58,754 men and women significantly decreased from 23.9% to 22.3% after the disaster ($P < 0.001$). The corresponding proportion amongst men decreased from 37.5% to 35.2% ($P < 0.001$), whereas that amongst women decreased from 12.5% to 11.5% ($P < 0.001$). Amongst the participants, 634 (1.1%) men and women began smoking after the disaster and 1,564 (2.7%) men and women quit smoking after the disaster. The corresponding proportions of initiating and quitting smoking were 1.4% and 3.7% for men and 0.8% and 1.8% for women, respectively.

Table 1 shows the participants' demographic, disaster-related and psychosocial

variables in accordance with the categories of changes in smoking status, i.e., non-smokers, starters, quitters and smokers. Compared with non-smokers, the beginner smokers displayed higher proportions of men, younger ages, rental house/apartment, shelter living, house damage, history of mental illness, having experienced a tsunami, becoming unemployed, decreased income, traumatic symptoms and non-specific psychological distress.

Compared with smokers, the quitters displayed higher proportions of women, older age, higher education, history of mental illness, having experienced a tsunami and becoming unemployed and lower proportions of shelter living, decreased income, traumatic symptoms and non-specific psychological distress.

**Table 1.** Demographic, disaster-related and psychosocial factors according to the categories of changes in smoking status amongst 58,754 men and women in the evacuation area.

| | Total | | Non-smokers | | Starters | | | Smokers | | Quitters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | P values | n | % | n | % | P values |
| **Demographic characteristics** | | | | | | | | | | | | |
| **Sex** | n = 58754 | | n = 44095 | | n = 634 | | | n = 12461 | | n = 1564 | | |
| Men | 26764 | 45.6 | 16351 | 37.1 | 376 | 59.3 | <.0001 | 9040 | 72.5 | 997 | 63.7 | <.0001 |
| Women | 31990 | 54.4 | 27744 | 62.9 | 258 | 40.7 | | 3421 | 27.5 | 567 | 36.3 | |
| **Age group** | n = 58754 | | | | | | | | | | | |
| 20–49 years | 21479 | 36.6 | 13571 | 30.8 | 382 | 60.3 | | 6727 | 54.0 | 799 | 51.1 | |
| 50–64 years | 18744 | 31.9 | 14136 | 32.1 | 147 | 23.2 | <.0001 | 4012 | 32.2 | 449 | 28.7 | <.0001 |
| ≥65 years | 18531 | 31.5 | 16388 | 37.2 | 105 | 16.6 | | 1722 | 13.8 | 316 | 20.2 | |
| **Educational attainment** | n = 57076 | | | | | | | | | | | |
| Primary or middle school | 13383 | 23.4 | 10680 | 25.0 | 102 | 16.8 | | 2329 | 19.1 | 272 | 17.7 | |
| High school | 28331 | 49.6 | 20190 | 47.2 | 331 | 54.5 | | 6986 | 57.2 | 824 | 53.8 | |
| Vocational college or Junior college | 10127 | 17.7 | 7849 | 18.4 | 116 | 19.1 | <.0001 | 1883 | 15.4 | 279 | 18.2 | <.0001 |
| University or graduate school | 5235 | 9.2 | 4014 | 9.4 | 58 | 9.6 | | 1005 | 8.2 | 158 | 10.3 | |
| **History of mental illness** | n = 57137 | | | | | | | | | | | |
| Yes | 3149 | 5.5 | 2332 | 5.4 | 60 | 9.9 | <.0001 | 662 | 5.5 | 95 | 6.2 | <.0001 |
| **Disaster-related factors** | | | | | | | | | | | | |
| **Living arrangement** | n = 47099 | | | | | | | | | | | |
| Evacuation shelter | 522 | 1.1 | 401 | 1.1 | 8 | 1.6 | <.0001 | 99 | 1.0 | 14 | 1.1 | <.0001 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temporary housing | 5343 | 11.3 | 3989 | 11.3 | 61 | 12.6 | | 1164 | 11.6 | 129 | 10.3 | |
| Rental house or apartment | 19330 | 41.0 | 13654 | 38.7 | 270 | 55.7 | | 4780 | 47.4 | 626 | 49.8 | |
| Relative's home | 2127 | 4.5 | 1731 | 4.9 | 21 | 4.3 | | 325 | 3.2 | 50 | 4.0 | |
| Own home | 17576 | 37.3 | 13862 | 39.3 | 101 | 20.8 | | 3252 | 32.3 | 361 | 28.7 | |
| Others | 2201 | 4.7 | 1644 | 4.7 | 24 | 4.9 | | 457 | 4.5 | 76 | 6.1 | |
| **Experienced living in evacuation shelters** | n = 58754 | | | | | | | | | | | |
| Yes | 15865 | 27.0 | 11887 | 27.0 | 198 | 31.2 | <.0001 | 3365 | 27.0 | 415 | 26.5 | <.0001 |
| **House damage** | n = 58754 | | | | | | | | | | | |
| Yes | 8706 | 14.8 | 6528 | 14.8 | 134 | 21.1 | <.0001 | 1812 | 14.5 | 232 | 14.8 | <.0001 |
| **Experience of disaster** | | | | | | | | | | | | |
| Having experienced a tsunami | n = 58754 | | | | | | | | | | | |
| Yes | 11807 | 20.1 | 8559 | 19.4 | 176 | 27.8 | <.0001 | 2747 | 22.0 | 325 | 20.8 | <.0001 |
| **Psychosocial factors** | | | | | | | | | | | | |
| Change jobs | n = 58754 | | | | | | | | | | | |
| Yes | 2542 | 4.3 | 1599 | 3.6 | 56 | 8.8 | <.0001 | 798 | 6.4 | 89 | 5.7 | <.0001 |
| Becoming unemployed | n = 58754 | | | | | | | | | | | |
| Yes | 12255 | 20.9 | 8643 | 19.6 | 172 | 27.1 | <.0001 | 3016 | 24.2 | 424 | 27.1 | <.0001 |
| Decreased income | n = 58754 | | | | | | | | | | | |
| Yes | 11141 | 19.0 | 7548 | 17.1 | 145 | 22.9 | <.0001 | 3117 | 25.0 | 331 | 21.2 | <.0001 |
| **Presence of traumatic symptoms (PCL-S) ≥44** | n = 58754 | | | | | | | | | | | |
| Yes | 12266 | 20.9 | 9247 | 21.0 | 210 | 33.1 | <.0001 | 2515 | 20.2 | 294 | 18.8 | <.0001 |
| **Presence of non-specific mental illness (K6) ≥13** | n = 58754 | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yes | 8556 | 14.0 | 6337 | 14.4 | 157 | 24.8 | <.0001 | 1853 | 14.9 | 209 | 13.4 | <.0001 |

Table 2 indicates age- and sex-adjusted PRs and 95% CIs for the group that started smoking after the disaster according to demographic, disaster-related and psychosocial factors amongst the 44,729 smokers before the disaster. The corresponding age- and sex-adjusted PRs (95% CIs) were as follows: 2.91 (2.48–3.42) for men, 5.17 (4.15–6.43) for ages 20–49 years, 1.74 (1.35–2.23) for ages 50–64 years, 0.68 (0.57–0.82) for higher education (junior college and higher), 2.03 (1.54–2.67) for a history of mental illness, 1.46 (1.10–1.93) for living in temporary housing, 1.38 (1.16–1.64) for living in a rental house/apartment, 1.64 (1.35–1.99) for house damage, 1.57 (1.32–1.88) for having experienced a tsunami, 1.57 (1.18–2.08) for change jobs, 1.53 (1.28–1.83) for becoming unemployed, 1.18 (0.97–1.42) for decreased income, 2.38 (2.01–2.83) for the presence of traumatic symptoms and 2.26 (1.88–2.72) for the presence of non-specific mental illness.

The age- and sex-adjusted and multivariable-adjusted PRs and 95% CIs of participants who started smoking after the disaster according to demographic, disaster-related and psychosocial factors were calculated amongst the 44,729 non-smokers before the disaster. The corresponding multivariable-adjusted PRs (95% CIs) were as follows: 3.01 (2.55–3.55) for men, 5.55 (4.40–7.00) for ages 20–49 years, 1.81 (1.40–2.33) for ages 50–64 years, 0.69 (0.57–0.83) for higher education (junior college and

higher), 1.45 (1.09–1.93) for a history of mental illness, 1.33 (1.12–1.58) for living in a rental house/apartment, 1.24 (1.01–1.50) for house damage, 1.29 (1.07–1.55) for having experienced a tsunami, 1.41 (1.05–1.89) for change jobs, 1.19 (0.99–1.43) for becoming unemployed, 1.70 (1.37–2.11) for the presence of traumatic symptoms and 1.38 (1.09–1.75) for the presence of non-specific mental illness. These associations did not substantially differ between men and women (Supplemental Table 1).

**TABLE 2.** Age- and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of starting smoking after the disaster according to demographic, disaster-related and psychosocial factors amongst 44,729 non-smokers before the disaster.

| | Age- and sex-adjusted model | | | Multivariable-adjusted model[#] | | |
|---|---|---|---|---|---|---|
| Model | PR | (95% CI) | P values | PR | (95% CI) | P values |
| n = 44729 | | | | | | |
| **Demographic characteristics** | | | | | | |
| Men (versus women)[*] | 2.91 | 2.48 - 3.42 | <.0001 | 3.01 | 2.55 - 3.55 | <.0001 |
| **Age group**[**] | | | | | | |
| Ages 20–49 years | 5.17 | 4.15 - 6.43 | <.0001 | 5.55 | 4.40 - 7.00 | <.0001 |
| Ages 50–64 years | 1.74 | 1.35 - 2.23 | <.0001 | 1.81 | 1.40 - 2.33 | <.0001 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment Vocational college, junior college or more (versus lower education)** | 0.68 | 0.57 - 0.82 | <.0001 | 0.69 | 0.57 - 0.83 | <.0001 |
| **History of mental illness** Yes (versus No) | 2.03 | 1.54 - 2.67 | <.0001 | 1.45 | 1.09 - 1.93 | 0.010 |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation shelter | 1.53 | 0.75 - 3.13 | 0.246 | 1.36 | 0.66 - 2.78 | 0.409 |
| Temporary housing | 1.46 | 1.10 - 1.93 | 0.009 | 1.25 | 0.94 - 1.66 | 0.127 |
| Rental house or apartment | 1.38 | 1.16 - 1.64 | <.001 | 1.33 | 1.12 - 1.58 | 0.001 |
| Relative's home | 1.18 | 0.75 - 1.85 | 0.467 | 1.14 | 0.72 - 1.78 | 0.580 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** Yes (versus No) | 1.64 | 1.35 - 1.99 | <.0001 | 1.24 | 1.01 - 1.50 | 0.038 |
| **Experience of disaster** | | | | | | |
| Having experienced a tsunami Yes (versus No) | 1.57 | 1.32 - 1.88 | <.0001 | 1.29 | 1.07 - 1.55 | 0.008 |
| **Psychosocial factors** | | | | | | |
| Change jobs Yes (versus No) | 1.57 | 1.18 - 2.08 | 0.002 | 1.41 | 1.05 - 1.89 | 0.023 |
| Becoming unemployed Yes (versus No) | 1.53 | 1.28 - 1.83 | <.0001 | 1.19 | 0.99 - 1.43 | 0.064 |
| Decreased income Yes (versus No) | 1.18 | 0.97 - 1.42 | 0.092 | | | |
| Presence of traumatic symptoms (PCL-S) ≥44(versus ≤43) | 2.38 | 2.01 - 2.83 | <.0001 | 1.70 | 1.37 - 2.11 | <.0001 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Presence of non-specific mental illness (K6) ≥13 (versus ≤12) | 2.26 | 1.88 | - | 2.72 | <.0001 | 1.38 | 1.09 | - | 1.75 | 0.007 |

*Age-adjusted

**Sex-adjusted

#Adjusted for age and sex, educational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, change jobs, becoming unemployed, decreased income, the presence of traumatic symptoms and the presence of non-specific mental illness except for the variable of interest.

Table 3 indicates the age- and sex-adjusted PRs and 95% CIs of quitting smoking after the disaster according to demographic, disaster-related and psychosocial factors amongst the 14,025 smokers before the disaster. The age- and sex-adjusted PRs (95% CIs) were 0.63 (0.56–0.71) for men, 0.58 (0.50–0.66) for 20–49 years, 0.59 (0.50–0.68) for 50–64 years, 1.32 (1.17–1.49) for higher education, 0.85 (0.75–0.97) for decreased income, 0.85 (0.74–0.97) for the presence of traumatic symptoms and 0.83 (0.71–0.97) for the presence of non-specific mental illness.

The corresponding multivariable-adjusted PRs (95% CIs) were 0.63 (0.56–0.71) for men, 0.53 (0.46–0.62) for 20–49 years, 0.57 (0.48–0.66) for 50–64 years, 1.31 (1.16–1.47) for higher education, 0.89 (0.76–0.98) for decreased income, 0.89 (0.76–1.05) for the presence of traumatic symptoms and 0.89 (0.74–1.07) for the presence of non-specific mental illness. These associations did not substantially differ between men and women (Supplemental Table 2).

**TABLE 3.** Age- and sex-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of quitting smoking after the disaster according to demographic, disaster-related and psychosocial factors amongst the 14,025 smokers before the disaster.

| | Age- and sex-adjusted model | | | Multivariable-adjusted model[#] | | |
|---|---|---|---|---|---|---|
| Model | PR | (95% CI) | P values | PR | (95% CI) | P values |
| n = 14025 | | | | | | |
| **Demographic characteristics** | | | | | | |
| Men (versus women)[*] | 0.63 | 0.56 - 0.71 | <.0001 | 0.63 | 0.56 - 0.71 | <.0001 |
| **Age group**[**] | | | | | | |
| Ages 20–49 years | 0.58 | 0.50 - 0.66 | <.0001 | 0.53 | 0.46 - 0.62 | <.0001 |
| Ages 50–64 years | 0.59 | 0.50 - 0.68 | <.0001 | 0.57 | 0.48 - 0.66 | <.0001 |
| Ages ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (versus lower education)** | 1.32 | 1.17 - 1.49 | <.0001 | 1.31 | 1.16 - 1.47 | <.0001 |
| **History of mental illness** | | | | | | |
| Yes (versus No) | 1.09 | 0.87 - 1.37 | 0.436 | | | |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation shelter | 1.16 | 0.66 - 2.04 | 0.613 | 1.20 | 0.68 - 2.12 | 0.537 |
| Temporary housing | 0.90 | 0.74 - 1.10 | 0.314 | 0.95 | 0.78 - 1.16 | 0.614 |
| Rental house or apartment | 1.09 | 0.97 - 1.22 | 0.146 | 1.12 | 1.00 - 1.25 | 0.061 |
| Relative's home | 1.24 | 0.91 - 1.68 | 0.180 | 1.20 | 0.88 - 1.63 | 0.256 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** | | | | | | |
| Yes (versus No) | 1.03 | 0.89 - 1.19 | 0.705 | | | |
| **Experience of disaster** | | | | | | |
| Having experienced a tsunami<br>Yes (versus No) | 0.97 | 0.85 - 1.11 | 0.652 | | | |
| **Psychosocial factors** | | | | | | |
| Change jobs<br>Yes (versus No) | 0.94 | 0.75 - 1.18 | 0.594 | | | |
| Becoming unemployed<br>Yes (versus No) | 1.09 | 0.96 - 1.23 | 0.171 | | | |
| Decreased income<br>Yes (versus No) | 0.85 | 0.75 - 0.97 | 0.012 | 0.86 | 0.75 - 0.98 | 0.019 |
| Presence of traumatic symptoms (PCL-S)<br>≥44 (versus ≤43) | 0.85 | 0.74 - 0.97 | 0.016 | 0.89 | 0.76 - 1.05 | 0.160 |
| Presence of non-specific mental illness (K6)<br>≥13 (versus ≤12) | 0.83 | 0.71 - 0.97 | 0.022 | 0.89 | 0.74 - 1.07 | 0.209 |

*Age-adjusted

**Sex-adjusted

#Adjusted for age and sex, educational attainment, living arrangement, decreased income, the presence of traumatic symptoms and the presence of non-specific mental illness except for the variable of interest.

## Discussion

A primary finding of the present study is that the proportion of smokers slightly decreased amongst men and women aged ≥20 years in the evacuation area from 23.9% to 22.3% at 10 to 20 months after the March 2011 earthquake and the subsequent disastrous tsunami and nuclear power plant accident. The proportion of participants who quit smoking was higher than the proportion of those who started smoking, which were 3.7% and 1.4% amongst men and 1.8% and 0.8% amongst women, respectively.

On the contrary, studies have reported that the proportion of current smokers increases after a disaster: from 34.4% to 52.5% amongst men and women one year after Hurricane Katrina[8] and from 22.6% to 23.4% amongst men and women aged ≥18 years 6 months after the terrorist attacks in Manhattan on 11 September 2001.[9]

In the present study, we found that factors associated with quitting smoking included being a female, older age, having a higher education and having a stable income. In contrast, factors associated with initiating smoking included being a male, younger age, having a lower education, staying in a rental house/apartment, experiencing damage to one's house, having experienced a tsunami, change jobs, the presence of traumatic symptoms and the presence of non-specific psychological distress. The findings of this study regarding traumatic symptoms and non-specific

psychological distress were consistent with findings from previous studies on Hurricane Katrina, the September 11 terrorist attacks and the Canterbury Great Earthquake; all these studies revealed that PTSD was a major factor for initiating smoking.[6,7,9] Therefore, the management of PTSD may help prevent individuals from initiating smoking.

The National Health Nutrition Survey in Japan reported that the proportion of smokers in Japan before and after the disaster slightly increased from 19.5% (95% CI, 20.0 to 20.9%) in 2010 to 20.7% (95% CI, 18.6 to 20.3%) in 2012.[25] One reason for the slight decrease in the proportion of current smokers in Fukushima after the disaster may be the decreased access to tobacco products. The earthquake damaged tobacco plantations, which ceased tobacco production and disrupted railway and road transportation networks in the areas that were damaged by the earthquake. Tobacco distribution stagnated after the disaster. According to a press release by Japan Tobacco Inc., the total cigarette sales volume in April 2011 decreased by 81.8% compared with April 2010, and domestic cigarette sales decreased by 74.8%. Furthermore, the cigarette sales volume between April and September 2011 decreased by 41.2%, whereas the tobacco sales volume decreased by 20.4% compared with the same period in the previous year.[26] These situations likely contributed to participants quitting smoking after

the disaster in Fukushima.

Even though the proportion of current smokers slightly decreased amongst the evacuees after the disaster, the proportion of current smokers was still higher in the evacuation area than in other areas of Japan. In the present study, the proportion of current smokers was 22.3% (35.2% men and 11.5% women), whereas the corresponding proportion in the national sample was 20.1% (32.4% men and 9.7% women) in 2012.[27]

The strengths of this survey lie in its size and procedures because it involved a large-scale survey for completing an inventory-based analysis of evacuees following the earthquake.

This study has several limitations. First, we investigated smoking status before and after the earthquake using a self-reported questionnaire administered after the disaster that involved a cross-sectional study design; this may have led to recall bias. Second, we did not assess the number of cigarettes smoked amongst current smokers; thus, we could not examine dose–response relationships. Third, because the response rate in the present study was relatively low (41%), the representativeness of target populations was uncertain. Furthermore, if non-responders tended to be smokers or beginner smokers, the proportion of smokers after the disaster could be underestimated. Because smoking

status changes more frequently in the teenage years, psychosocial factors may influence smoking status, particularly in teenagers. Unfortunately, the questions associated with smoking status were limited to men and women 20 years of age and older in the present study. Therefore, we did not evaluate an association between psychosocial factors and smoking status amongst the participants aged <20 years. Lastly, no data were present from non-disaster exposed areas for comparison, except for national data on the prevalence of smoking.

In conclusion, the proportion of smokers slightly decreased amongst residents in the evacuation area. The changes in smoking status were associated with disaster-related psychosocial factors, particularly changes in living conditions, having experienced a tsunami, switching jobs and developing PTSD. A long-term follow-up study is warranted for examining the effects of disaster-related factors on smoking status amongst evacuees.

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**Contributors**

HN, TO and HI contributed to the design of the present study. TO, SY, AO, MM, MH, NH, YS, HY and HT were responsible for data collection and overseeing the study procedures. The analysis was conducted by HN. The manuscript was written by HN. TO, SY, AO, MM, MH, NH, YS, HY, HT, MN, WZ, HI and KK made significant contributions to the critical interpretation of the results in terms of important practical content. All authors read and approved the final version of the manuscript.

**Competing interests**

None declared.

**Patient consent**

Not required.

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**Data sharing statement**

No additional data are available.

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**List of Figures**

**Figure 1 Flow chart for determining smoking status**

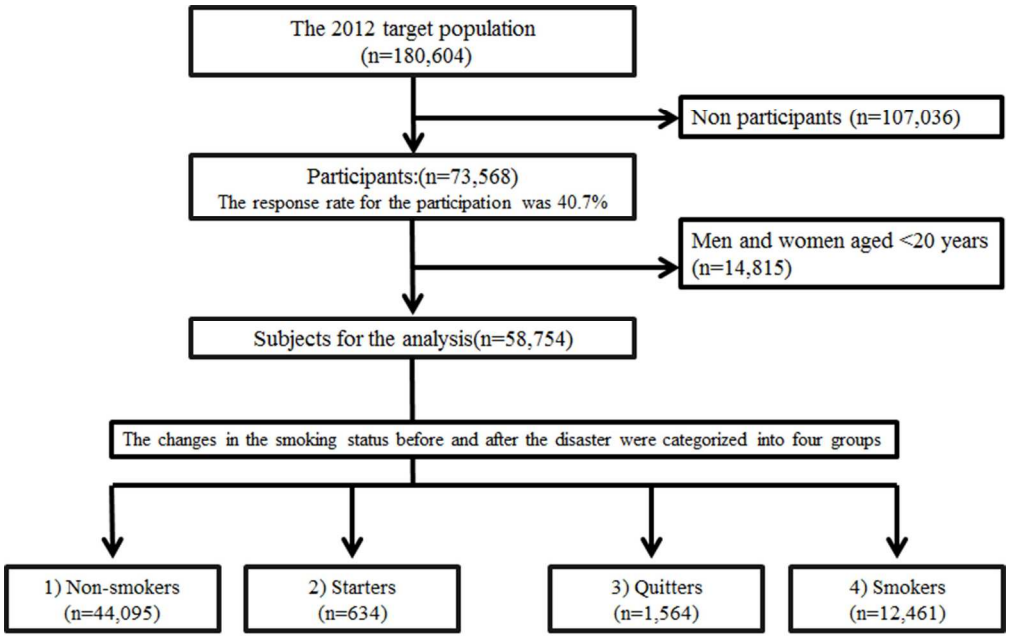


Figure 1 Flow chart for determining smoking status

289x182mm (300 x 300 DPI)

**Supplement Table 1.** Multivariable-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of starting smoking after the disaster according to demographic, disaster-related and psychosocial factors among 44,729 non-smokers before the disaster.

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=44729 | n=16727 | | | n=28002 | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | | | | | | |
| **Age group**** | | | | | | |
| 20–49 years | 5.73 | 4.26 - 7.70 | <.0001 | 4.81 | 3.29 - 7.01 | <.0001 |
| 50–64 years | 2.02 | 1.47 - 2.77 | <.0001 | 1.39 | 0.90 - 2.13 | 0.135 |
| ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (versus lower education)** | 0.68 | 0.53 - 0.87 | 0.002 | 0.71 | 0.54 - 0.95 | 0.020 |
| **History of mental illness** Yes(versus No) | 1.24 | 0.82 - 1.86 | 0.304 | 1.79 | 1.20 - 2.66 | 0.005 |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation shelter | 1.22 | 0.49 - 3.05 | 0.671 | 1.59 | 0.50 - 5.12 | 0.436 |
| Temporary housing | 0.96 | 0.65 - 1.43 | 0.840 | 1.57 | 1.03 - 1.03 | 0.034 |
| Rental house or apartment | 1.25 | 1.00 - 1.57 | 0.056 | 1.34 | 1.02 - 1.76 | 0.039 |
| Relative's home | 1.11 | 0.61 - 2.03 | 0.725 | 1.12 | 0.56 - 2.23 | 0.745 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** Yes(versus No) | 1.44 | 1.11 - 1.86 | 0.006 | 0.99 | 0.70 - 1.39 | 0.953 |
| **Experience of disaster** Having experienced a tsunami Yes(versus No) | 1.44 | 1.14 - 1.81 | 0.002 | 1.05 | 0.76 - 1.46 | 0.756 |
| **Psychosocial factors** | | | | | | |
| Change jobs Yes(versus No) | 1.70 | 1.19 - 2.44 | 0.004 | 1.02 | 0.60 - 1.74 | 0.936 |
| Becoming unemployed Yes(versus No) | 0.99 | 0.76 - 1.29 | 0.922 | 1.47 | 1.13 - 1.92 | 0.004 |
| Decreased Income Yes(versus No) | 1.05 | 0.83 - 1.34 | 0.694 | 0.93 | 0.67 - 1.31 | 0.692 |
| Presence of traumatic symptoms(PCL-S) ≥44(versus ≤43) | 1.30 | 0.96 - 1.75 | 0.090 | 2.31 | 1.68 - 3.18 | <.0001 |
| Presence of non-specific mental illness(K6) ≥13(versus ≤12) | 1.75 | 1.28 - 2.39 | 0.001 | 1.00 | 0.70 - 1.42 | 0.995 |

#Adjusted for age, and eduational attainment, history of mental illness, living arrangement, house damage, having experienced a tsunami, change jobs,becoming unemployed, decreased Income, the presence of traumatic symptoms and the presence of non-specific mental illness except for the variable of interest.

**Supplemental Table 2.** Multivariable-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of quitting smoking after the disaster according to demographic, disaster-related and psychosocial factors among 14,025 smokers before the disaster.

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| Model | PR | (95%CI) | P values | PR | (95%CI) | P values |
| n=14025 | n=10037 | | | n=3998 | | |
| **Demographic characteristics** | | | | | | |
| Men(versus women)* | | | | | | |
| **Age group**** | | | | | | |
| 20–49 years | 0.43 | 0.36 - 0.51 | <.0001 | 0.92 | 0.65 - 1.30 | 0.620 |
| 50–64 years | 0.59 | 0.50 - 0.71 | <.0001 | 0.58 | 0.40 - 0.86 | 0.007 |
| ≥65 years (Ref.) | 1.00 | | | 1.00 | | |
| **Educational attainment** | | | | | | |
| **Vocational college, junior college or more (versus lower education)** | 1.33 | 1.14 - 1.55 | <.001 | 1.34 | 1.10 - 1.63 | 0.003 |
| **History of mental illness** | | | | | | |
| Yes(versus No) | | | | | | |
| **Disaster-related factors** | | | | | | |
| **Living arrangement** | | | | | | |
| Evacuation shelter | 1.15 | 0.59 - 2.25 | 0.675 | 1.42 | 0.48 - 4.24 | 0.529 |
| Temporary housing | 1.05 | 0.83 - 1.33 | 0.684 | 0.73 | 0.50 - 1.07 | 0.111 |
| Rental house or apartment | 1.11 | 0.96 - 1.29 | 0.152 | 1.12 | 0.92 - 1.35 | 0.251 |
| Relative's home | 1.21 | 0.83 - 1.77 | 0.329 | 1.19 | 0.70 - 2.05 | 0.522 |
| Own home (Ref.) | 1.00 | | | 1.00 | | |
| **House damage** | | | | | | |
| Yes(versus No) | | | | | | |
| **Experience of disaster** | | | | | | |
| Having experienced a tsunami | | | | | | |
| Yes(versus No) | | | | | | |
| **Psychosocial factors** | | | | | | |
| Change jobs | | | | | | |
| Yes(versus No) | | | | | | |
| Becoming unemployed | | | | | | |
| Yes(versus No) | | | | | | |
| Decreased Income | 0.85 | 0.72 - 0.99 | 0.038 | 0.94 | 0.74 - 1.18 | 0.573 |
| Yes(versus No) | | | | | | |
| Presence of traumatic symptoms(PCL-S) | 0.98 | 0.79 - 1.20 | 0.811 | 0.75 | 0.58 - 0.98 | 0.031 |
| ≥44(versus ≤43) | | | | | | |
| Presence of non-specific mental illness(K6) | 1.01 | 0.80 - 1.28 | 0.947 | 0.79 | 0.59 - 1.07 | 0.129 |
| ≥13(versus ≤12) | | | | | | |

#Adjusted for age, and educational attainment, living arrangement, decreased Income, the presence of traumatic symptoms and the presence of non-specific mental illness except for the variable of interest.

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

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract (P1-6)** | 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 |
| **Introduction (P7-8)** | | |
| Background/rationale **(P7)** | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives **(P8)** | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods (P8-13)** | | |
| Study design **(P8)** | 4 | Present key elements of study design early in the paper |
| Setting **(P8)** | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants **(P8-9)** | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—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<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables **(P10-P11)** | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement **(P8-P11)** | 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 (**P19**) | 9 | Describe any efforts to address potential sources of bias |
| Study size **(P8-9)** | 10 | Explain how the study size was arrived at |
| Quantitative variables **(P10-11)** | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods **(P12-13)** | 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*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | |
|---|---|---|
| **Results (P13-25)** | | |
| Participants **(P13)** | 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 **(P13-18)** | 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) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data **(P19-25)** | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results **(P14-16)** | 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 (P25-29)** | | |
| Key results **(P26-28)** | 18 | Summarise key results with reference to study objectives |
| Limitations **(P28-29)** | 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 **(P29)** | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability **P29** | 21 | Discuss the generalisability (external validity) of the study results |
| **Other information (P30-30)** | | |
| Funding **(P30)** | 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 |

*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.