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## HEALTH PSYCHOLOGY | RESEARCH ARTICLE

# Recovery from radiation anxiety and posttraumatic growth among community dwellers after the nuclear disaster in Fukushima

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**Abstract: Objective:** This study examined (1) the current status of posttraumatic growth (PTG) and (2) the relationship between recovery from radiation anxiety and PTG among community dwellers five years after the nuclear disaster in Fukushima.

**Design:** This was a cross-sectional study with 796 residents of Fukushima Prefecture (367 men and 429 women). A questionnaire survey assessed PTG with one question (“Have you gained anything through the disaster experience?” [yes/no]), and current and past radiation anxiety on a 5-point Likert-type scale. These two anxiety measures were combined to generate a new item “recovery from radiation anxiety” with three values (“no anxiety,” “recovered,” and “unrecovered”).

**Results:** Approximately half of participants experienced PTG (55.4%). Women were more likely to experience PTG than men. Multiple logistic regression showed that individuals who “recovered” from radiation anxiety were more likely to experience PTG (odds ratio (OR) = 1.99, 95% confidence interval (CI): 1.34–2.85), and that higher level of education (OR = 2.12, 95% CI: 1.28–3.49 for secondary education; OR = 3.95,

### ABOUT THE AUTHORS

Hajime Iwasa, PhD, is an associate professor in the Department of Public Health at Fukushima Medical University. He is interested in health issues among community residents, including psycho-social factors (including personality, leisure activity, mental health status, and post-traumatic growth).

Seiji Yasumura, MD, PhD, is a professor in the Department of Public Health at Fukushima Medical University, and a chairperson of the research group. He is interested in health issues (including prevention for lifestyle related disease, health communication) among community residents after the nuclear disaster. The research group (including **Hajime Iwasa, Nobuaki Moriyama, Yujiro Kuroda, Chihiro Nakayama, Masatsugu Orui, Teruko Horiuchi, Takeo Nakayama, Minoru Sugita, and Seiji Yasumura**) was supported by Japan Society for the Promotion of Science (JSPS) KAKENHI. The research group mainly examined a relationship between information and health through a questionnaire survey for community residents in Fukushima prefecture five years after the nuclear disaster.

### PUBLIC INTEREST STATEMENT

Posttraumatic growth (PTG) refers to positive psychological change experienced as a result of the struggle with a major life crisis or traumatic events. Previous studies have reported evidence of PTG in various situations involving motor vehicle accidents, natural disasters, life-threatening disease, war veterans, and assault. To date, there is a paucity of knowledge regarding PTG occurring among community dwellers after nuclear disasters. The impact of the nuclear disaster would be unique compared to other natural and human-made disasters. The present study aimed to examine a relationship between recovery from radiation anxiety and PTG among community dwellers five years after the nuclear power plant incident in Fukushima. Our findings indicate that during the period of recovery from radiation anxiety, a positive psychological adjustment may occur and PTG might emerge as a result; our findings may be practically used to support sufferers of traumatic events in their recovery.

95% CI: 2.26–6.88 for higher education) and health literacy (OR = 1.34, 95% CI: 1.09–1.63 for one point increase) were also associated with the experience of PTG.

**Conclusion:** Our findings indicate that during the period of recovery from radiation anxiety, a positive psychological adjustment may occur and PTG might emerge as a result; our findings may be practically used to support sufferers of traumatic events in their recovery.

**Subjects:** Psychological Science; Health Psychology; Mental Health

**Keywords:** community residents; disaster; posttraumatic growth; radiation anxiety

Posttraumatic growth (PTG) refers to positive psychological change experienced as a result of the struggle with a major life crisis or traumatic events (Tedeschi & Calhoun, 1996). A scale assessing PTG, the Posttraumatic Growth Inventory (PTGI), identified five dimensions: (1) greater appreciation of life, (2) improved relationships with others, (3) better sense of personal strength, (4) recognition of new possibilities, and (5) spiritual development. Previous studies have reported evidence of PTG in various situations involving motor vehicle accidents (Zoellner, Rabe, Karl, & Maercker, 2008), natural disasters (Xu & Liao, 2011), life-threatening disease (Teixeira & Pereira, 2013), war veterans (Tsai, El-Gabalawy, Sledge, Southwick, & Pietrzak, 2015), and assault (Shakespeare-Finch & de Dassel, 2009).

On 11 March 2011, a massive earthquake and tsunami struck Japan (the Great East Japan Earthquake; GEJE), which caused the Fukushima Daiichi nuclear power plant (NPP) incident (Yasumura et al., 2012). Since then, there has been an urgent need to provide adequate support to evacuees with mental (Yabe et al., 2014) and physical health problems (Hasegawa et al., 2015; Ohira et al., 2016a, 2016b) both within and outside of Fukushima prefecture and gather scientific evidence for assisting future disaster survivors in Japan. In past nuclear disasters, it was reported that sufferers were prone to experiencing mental as well as physical health problems (Bromet, 2012; Bromet & Havenaar, 2007). In terms of immediate and sustained support for evacuees, mental health assistance is one of the most important factors. Fukushima Medical University provided telephone support for evacuees to maintain their mental health and help them recover from mental health problems at the early stage after the disaster (Horikoshi, Ohira, Yasumura, Yabe, & Maeda, 2017).

The impact of the nuclear disaster would be unique compared to other natural and human-made disasters because of the following reasons: 1. risk perception of the health effects of radiation exposure (including “delayed effect,” i.e., cancer incidence after a few decades, and “genetic effect,” i.e., radiation effects inherited by the next generation; Suzuki et al., 2015); 2. forced and long-term evacuation due to radioactive fallout in residential areas; and 3. emergence of new issues (including future selection of energy resources and handling safety and health information for residents of the disaster area). Therefore, its influence on health outcomes and occurrence of PTG would also be different. To date, there is a paucity of knowledge regarding PTG occurring among community dwellers after nuclear disasters. Previous studies have reported close relationships between PTG and resilience (Kong et al., 2018; Liu et al., 2018; Nishi et al., 2016). “Resilience has often been viewed as a stress-coping ability in the face of adversity, in other words, a psychological resource” (Nishi et al., 2016). Therefore, examining the current state of PTG and its associated factors among the sufferers of the Fukushima disaster would help to provide them with the relevant support and contribute to gathering scientific evidence to develop support strategies for mental health recovery for future disaster survivors in Japan.

Using an observational survey, this study (1) examined the current status of PTG (total proportions, age-, gender-, region-based differences) and (2) explored its associated factors, especially the relationship between recovery from radiation anxiety and PTG among community dwellers in Fukushima Prefecture five years after the NPP incident.

## 1. Methods

### 1.1. Participants

This survey targeted 2000 residents of Fukushima Prefecture aged 20 to 79. We divided Fukushima Prefecture into four areas based on the general regional classification of Aizu, Nakadōri, Hamadōri, and the evacuation area (including the restricted area, evacuation-prepared area, and deliberate evacuation area as assessed on 22 April 2011), and selected 500 residents from each area. The selection was based on a two-stage stratified random sampling (i.e., the first stage involved the sampling of regions and the second stage that of individuals). Nakadōri and Hamadōri included local municipalities that were partially in the evacuation area; thus, these were included in the evacuation area.

The survey was administered between August 15 and 17 October 2016, as an anonymous postal self-report questionnaire (named “Survey of Health and Information”; Kuroda, Iwasa, & Orui et al., 2018). We received 916 responses from 1985 survey participants (excluding those returned to the sender because no one was residing at the address). Among them, 117 questionnaires were excluded from the analyses for the following reasons: 55 had left the age or sex columns blank, 53 had missing values for PTG items, and 9 had missing values for radiation anxiety items. Additionally, 3 questionnaires of individuals who answered “no anxiety” at the time of the disaster and “anxiety” at the time of the survey were excluded from all analyses (see section 2.2). In total, data from 796 individuals (367 men and 429 women) were used in the final analyses. Table 1 shows participants’ baseline characteristics.

The present study was approved by the Fukushima Medical University Ethics Committee (Approval number: 2699). We considered a returned questionnaire as the participant’s consent to the objectives of the study and willingness for voluntary participation in it.

### 1.2. Measurements

[PTG] The item, “Although the experiences associated with the GEJE would have obviously been hugely negative for you, have you gained anything through the experience?” was used to assess PTG. Participants answered “yes/no”; if they answered “yes,” they wrote about their experiences of PTG freely. We administered a preliminary face-to-face interview to explore anxiety regarding health effects of radiation among community dwellers following the Fukushima disaster and its associations with information provided by various sources (including mass media, internet, and social media). This item for measuring PTG in the present study was created through suggestions from the preliminary study.

[Radiation anxiety] Participants were asked to rate the extent of their anxiety about the effects of radiation on their health due to the nuclear disaster on a 5-point Likert-type scale (1 = “None,” 2 = “Low,” 3 = “Somewhat,” 4 = “High,” and 5 = “Extreme”) at two time points (i.e., (1) at the time of the disaster [i.e., March 2011] and (2) at the time of the survey). Responses were dichotomized as “no” (answers 1–3) or “yes” (answers 4 and 5). In addition, these two anxiety measures were combined to generate a new item “recovery from anxiety” with three values (1 = “no anxiety” [“no” at the time of the disaster and survey], 2 = “recovery” [“yes” at the time of the disaster and “no” at the time of the survey], and 3 = “unrecovered” [“yes” at the time of the disaster and survey]). Participants who responded “no” at the time of the disaster and “yes” at the time of the survey were omitted from the analyses because their number was very small ( $n = 3$ ).

[Other variables] The following data were recorded to describe the characteristics of the study participants and were used as covariates in the multivariable analyses: region where participants lived when the disaster occurred (dichotomized: evacuation zone or other), age, gender, education attainment, living arrangement (living alone or other), employment status (employed/unemployed), physical activity, alcohol intake, smoking, self-rated health (dichotomized: excellent/very good/good or fair/poor), and health literacy. Education attainment was assessed as four classes

**Table 1. Distribution of participants' characteristics (N = 796)**

	<b>Non-evacuation zone (n = 629)</b>	<b>Evacuation zone (n = 167)</b>	<b>p</b>
Age, mean (SD)	55.71 (14.89)	57.51 (15.05)	0.168
Gender (women), n (%)	335 (53.3)	94 (56.3)	0.485
Primary education, n (%) <sup>*1</sup>	77 (12.3)	31 (18.9)	0.040
Secondary education, n (%) <sup>*2</sup>	319 (51.1)	86 (52.4)	
Higher education, n (%) <sup>*3</sup>	228 (36.5)	47 (28.7)	
Living alone, n (%)	71 (11.3)	28 (16.9)	0.054
Employment (employed), n (%)	406 (65.2)	62 (38.0)	<0.001
Physical activity (yes), n (%)	327 (52.6)	95 (56.9)	0.321
Drinking, n (%)	181 (29.1)	53 (32.3)	0.423
Smoking, n (%)	124 (19.9)	38 (23.0)	0.377
Self-rated health (good), n (%)	317 (50.7)	59 (35.3)	<0.001
Health literacy (points), mean (SD)	3.11 (0.79)	3.12 (0.83)	0.912
Radiation anxiety at the time of the disaster, n (%)	219 (34.8)	68 (40.7)	0.158
Radiation anxiety at present, n (%)	68 (10.8)	33 (19.8)	0.002
Recovery from anxiety <sup>*4</sup>			
No anxiety, n (%)	410 (65.2)	99 (59.3)	0.008
Recovered from anxiety, n (%)	151 (24.0)	35 (21.0)	
Unrecovered from anxiety, n (%)	68 (10.8)	33 (19.8)	
PTG occurrence, n (%)	348 (55.3)	93 (55.7)	0.933

Note: <sup>\*1</sup> for compulsory, <sup>\*2</sup> for high school, <sup>\*3</sup> for vocational or university, <sup>\*4</sup> individuals who newly experienced anxiety ("no" at time of disaster and "yes" at time of survey) were omitted from analyses due to small sample size (2 in non-evacuation zone, 1 in evacuation zone). PTG = posttraumatic growth.

(primary, secondary, vocational school, or university) and classified into three categories (primary, secondary, or vocational school/university). Health literacy was measured using the communicative, and critical health literacy scale (CCHL) (Ishikawa & Kiuchi, 2010; Ishikawa, Takeuchi, & Yano, 2008). According to the World Health Organization (WHO), health literacy represents "the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health" (Nutbeam, 1998, p. 357). The CCHL is a self-administered questionnaire comprising five items assessing the degree of health literacy on a 5-point Likert scale. We used a mean score of the five items as the CCHL score (Ishikawa et al., 2008). Cronbach's alpha was 0.93.

### 1.3. Statistical analysis

First, we assessed frequencies of occurrence of PTG, and compared them according to age group (young: 20–39 vs. middle aged; 40–64 vs. older: 65–79), gender (men vs. women), and region (evacuation area vs. other) using the chi-square test. Second, we calculated frequencies of radiation anxiety at two points in time (i.e., at the time of the disaster and at the time of the survey), and divided participants into three groups according to recovery from radiation anxiety (i.e., no anxiety, recovered, and unrecovered) as indicated in the above section. Third, we conducted logistic regression analyses to test the independent associations in the relationship between recovery from radiation anxiety and PTG. Adjusted odds ratio (OR) estimates and confidence intervals (CI) for the groups recovering from radiation anxiety were calculated, controlling for age and gender (Model 1) and all above-mentioned covariates (Model 2). All probability values were two-tailed. We used IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY) for the analyses.

**Table 2. Logistic regression analysis of the relationship between recovery from anxiety and posttraumatic growth (N = 796)**

	Unadjusted (Model 0)			Adjusted (Model 1) <sup>*4</sup>			Adjusted (Model 2) <sup>*5</sup>		
	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
No anxiety (ref.)	1			1			1		
Recovered from anxiety	2.11	1.48-3.01	<0.001	2.07	1.45-2.97	<0.001	1.99	1.36-2.91	<0.001
Unrecovered from anxiety	1.27	0.83-1.95	0.276	1.22	0.80-1.89	0.355	1.21	0.76-1.93	0.431
Age (for 1 year increase)	-	-	-	0.99	0.98-1.00	0.074	1.01	0.99-1.02	0.235
Gender (for women)	-	-	-	1.35	1.01-1.79	0.042	1.20	0.88-1.64	0.256
Primary education (ref.) <sup>*1</sup>	-	-	-	-	-	-	1		
Secondary education <sup>*2</sup>	-	-	-	-	-	-	2.17	1.30-3.60	0.003
Higher education <sup>*3</sup>	-	-	-	-	-	-	4.02	2.29-7.04	<0.001
Living alone (for yes)	-	-	-	-	-	-	0.95	0.59-1.53	0.846
Area (for evacuation zone)	-	-	-	-	-	-	1.02	0.69-1.51	0.908
Employment (for employed)	-	-	-	-	-	-	0.96	0.68-1.37	0.953
Self-rated health (for good)	-	-	-	-	-	-	0.95	0.69-1.29	0.729
Health literacy (for 1 point increase)	-	-	-	-	-	-	1.33	1.10-1.62	0.005

Note: <sup>\*1</sup> for compulsory, <sup>\*2</sup> for high school, <sup>\*3</sup> for vocational or university, <sup>\*4</sup> Adjusted for age and gender (Model 1), <sup>\*5</sup> Adjusted for all covariates (Model 2). OR = odds ratio, CI = confidence interval.

## 2. Results

### 2.1. Frequencies of PTG

The number of participants who had experienced PTG was 441 (55.4%) in total. Free comments about PTG included the following: “I recognized the importance of life,” “I re-confirmed the importance of family bonds and cooperation in a community,” “The importance of materials that we need in daily life (e.g., water, food, and electricity),” “Collecting and screening information in times of emergency,” and “We have to consider public infrastructures (e.g., energy supply, traffic routes, and public transportation) around our life as well as the utilization of nuclear power plants and their administration.”

The numbers (and percentages) of participants who experienced PTG were as follows: 188 (51.2%) men and 253 (59.0%) women; in terms of age group, 72 (60.5%) young, 220 (57.3%) middle-aged, and 149 (51.2%) older participants; regarding place of residence, 348 (55.3%) dwellers in the evacuation zone and 93 (55.7%) dwellers in other regions. The chi-square test revealed that women were more likely to experience PTG than men ( $\chi^2 = 4.806$ ,  $p < 0.01$ ). Meanwhile, differences between age groups ( $\chi^2 = 3.882$ ,  $p = 0.144$ ) and inter-regional differences ( $\chi^2 = 0.001$ ,  $p = 0.980$ ) were not significant.

### 2.2. Frequency of recovery from radiation anxiety

The number of participants who experienced radiation anxiety at the time of the disaster was 287 (36.1%), and 101 (12.7%) experienced radiation anxiety at the time of the survey. From those who experienced radiation anxiety at the time of the disaster, two thirds recovered from anxiety ( $n = 186$ , 64.8%) and one third remained anxious ( $n = 101$ , 35.2%).

There was no difference between regions in the proportion of participants who experienced radiation anxiety at the time of the disaster (68 [40.7%] dwellers in the evacuation area vs. 219 [34.8%] in non-evacuation areas,  $p = 0.158$ ). Meanwhile, there was a significant difference between the regions in the proportion of participants who experienced radiation anxiety at the time of the survey (33 [19.8%] in the evacuation area vs. 68 [10.8%] in non-evacuation areas,  $p < 0.01$ ).

### 2.3. Relationship between PTG and recovery from radiation anxiety

A logistic regression analysis was performed to examine the factors associated with PTG (Table 2). “Recovered from radiation anxiety” was independently and significantly associated with PTG (OR = 1.99, 95% CI: 1.36–2.91,  $p < 0.01$ ). “Unrecovered from anxiety” was not significantly associated with PTG (OR = 1.21, 95% CI: 0.76–1.93,  $p = 0.43$ ). Interactions between recovery from anxiety (both recovered and unrecovered) and region were not significant.

Additionally, secondary education (OR = 2.17, 95% CI: 1.30–3.60,  $p < 0.01$ ) and higher education (OR = 4.02, 95% CI: 2.29–7.04,  $p < 0.01$ ) were independently and significantly associated with PTG. Health literacy was independently and significantly associated with PTG (for one-point increase: OR = 1.33, 95% CI: 1.10–1.62,  $p < 0.01$ ). Interactions between education and region, and between health literacy and region were not significant.

## 3. Discussion

Approximately half of participants experienced PTG (55.4%). This result is similar to that of a previous study, which reported a PTG prevalence of 51.1% one year after the Sichuan earthquake in 2008, using a cut-off value of total scores above the 75th percentile in the PTGI (Xu & Liao, 2011). The present study found that women were more likely than men to experience PTG. This finding is consistent with previous studies assessing PTG with the PTGI (Tedeschi & Calhoun, 1996) among college students living in a community that had experienced major traumatic events (Bates, Trajstman, & Jackson, 2004), and among sufferers of the Sichuan earthquake (Xu & Liao, 2011). In addition to the general trend of gender difference in PTG, there may be a unique characteristic concerning radiation disasters. Evacuee mothers of young children were reportedly

more likely to experience anxiety for radiation effects on their health following the Chernobyl nuclear disaster (Bromet & Havenaar, 2007). Risk perception of radiation exposure (including delayed and genetic effects) was reportedly higher among women than men (Suzuki et al., 2015). As one possibility, these results suggest that women with higher anxiety for radiation effects and risk perception of radiation exposure after the disaster may be likely to seek support from families, friends, and the government, which may result in them experiencing PTG. Indeed, the PTGI (Tedeschi & Calhoun, 1996) includes a factor named “Relating to others,” which includes items such as “I better accept needing others,” “I more clearly see that I can count on people in times of trouble,” and “I have a greater sense of closeness with others.” Additionally, free comments about PTG in the present study included “I re-confirmed the importance of family bonds and cooperation in a community.”

This study did not find significant age-related differences in the experience of PTG. Despite the nonsignificant finding, the proportion of respondents developing PTG tended to decrease with older age. This finding is partly consistent with previous studies that reported negative correlations between age and PTG in cancer survivors (Boyle, Stanton, Ganz, & Bower, 2017; Manne et al., 2004), and sufferers in the Sichuan earthquake (Xu & Liao, 2011). Therefore, previous findings and our results suggest that PTG may decrease as individuals grow older.

Contrary to expectation, region-based differences in PTG were not found. We initially expected dwellers in the evacuation zone to be more likely to experience PTG than those in other districts because of their psychological and physical burden due to the immediate impact after the disaster and long-term evacuation, with relation to findings which suggest a relationship between the extent of trauma experiences and occurrence of PTG (Schubert, Schmidt, & Rosner, 2016; Xu & Liao, 2011).

This study confirmed that the proportion of participants who had radiation anxiety decreased from the time of the disaster to the time of the survey. This suggests that people living in Fukushima Prefecture tended to be in the process of recovering from radiation anxiety. However, out of the participants who experienced radiation anxiety at the time of the disaster, a third did not recover. In addition, there were region-based differences in radiation anxiety at the time of the survey. This may be because the impact of the NPP incident continues to affect the mental health of sufferers in the evacuation zone. Therefore, sustained support is needed for sufferers in the evacuation zone, such as telephone support programs (Horikoshi et al., 2017) and risk communication with residents (Murakami et al., 2017).

This study found that people who recovered from radiation anxiety were more likely to experience PTG, which suggests that during the recovery process, a positive psychological adjustment might occur, with PTG emerging as a result. For instance, individuals who experience traumatic events are prone to seek support from families, friends, and the government, which may result in positive psychological adjustment (Tang, 2006; Xu & Liao, 2011). Research has also reported a positive correlation between PTG and resilience (Kong et al., 2018; Liu et al., 2018; Nishi et al., 2016). A prospective cohort study may demonstrate whether individuals who have not recovered from radiation anxiety might also experience PTG in the future along with recovery from anxiety. The findings in this study may contribute to the provision of effective support to those experiencing disasters or accidents, leading to recovery from such traumatic experiences. In fact, similar findings have been applied to the treatment of individuals with posttraumatic stress disorder (PTSD) in clinical psychology (Zoellner, Rabe, Karl, & Maercker, 2011).

On the other hand, our finding regarding the relationship between recovery from radiation anxiety and experiencing PTG should not be readily applied to assist sufferers. Studies have reported a close and positive relationship between PTG and PTSD (Schubert et al., 2016). In addition, a study reported a close relationship between scores on the avoidance subscale of PTSD symptoms and PTG, suggesting that PTG might possibly occur as a result of avoidant coping strategies after traumatic events (Nishi, Matsuoka, & Kim, 2010). The current and previous findings

provide the following suggestions: (1) the effort to draw out meaning from traumatic events should not be forced; (2) individuals who experience PTG may not necessarily progress in their recovery from traumatic symptoms. Thus, applying our finding regarding the relationship between recovery from radiation and PTG to assist sufferers should be done with caution; paying attention to the above issues is important. In the future, obtaining similar evidence is required, and their practical implications should be considered carefully.

Our study found that individuals who have a higher level of education were more likely to experience PTG. This finding agreed with a previous finding (Xu & Liao, 2011). Moreover, those with a higher level of health literacy were also more likely to experience PTG. Speculatively, considering both findings (i.e., education and health literacy), individuals who have highly penetrating insight may be prone to experience PTG through difficult situations such as a nuclear disaster. A previous study reported a relationship between health literacy and radiation anxiety among residents in Fukushima, suggesting that improving health literacy could alleviate radiation anxiety (Kuroda et al., 2018). Therefore, health literacy may be practically used for supporting sufferers in the face of a difficult problem of radiation anxiety.

Our study has limitations. First, the sample's representativeness may be restricted, given that the response rate (45.8% = 916/2000) was not high; therefore, our participants might differ from non-participants in terms of health characteristics because of self-selection bias (Horikoshi, Iwasa, Yasumura, & Maeda, 2017; Iwasa et al., 2007). Second, because we used a cross-sectional design in our study, we cannot infer causality in the relationship between recovery from radiation anxiety and PTG occurrence. In other words, we cannot know whether our result is due to the effect of recovery from radiation anxiety on PTG or vice versa. A further study using a longitudinal approach is needed to ascertain a causal relationship between recovery from radiation anxiety and PTG. Third, our results might be subject to recall bias regarding the subjective response to "anxiety regarding the effect of radiation on health at the time of the disaster" because we administered the self-report survey five years after the disaster. Thus, responses were likely to have been affected by the current situation of the evacuees at the time of the survey. Fourth, the outcome measure used in our study has not been validated for assessing PTG. Most studies measured PTG using psychological scales with evaluations of validity and reliability, such as the PTGI (Tedeschi & Calhoun, 1996), Stress-Related Growth Scale (Park, Cohen, & Murch, 1996), and Benefit Finding Scale (Antoni et al., 2001). Thus, our outcome measure is not well-established as a PTG measure. Finally, we did not identify study participants as sufferers who directly experienced significant traumatic events. Some reports measure PTG while restricting study participants to individuals who experienced traumatic events (i.e., life-threatening events) using a standard definition of traumatic events in PTSD in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). However, this study did not collect enough information to apply this definition. Nevertheless, a very large number of individuals who lived in broad areas in Fukushima Prefecture were affected by the GEJE because of the earthquake, tsunami, and the NPP incident, and many experienced forced or voluntary evacuation because of the disaster. In addition, they repeatedly witnessed the resulting chaotic situations (including the tsunami and NPP incident) through mass media. Accordingly, the majority of the study participants were very likely to have experienced traumatic stress.

In conclusion, our study examined (1) the current status of PTG and (2) the relationship between PTG and recovery from radiation anxiety among community dwellers in all of Fukushima Prefecture five years after the nuclear incident. Our study found that around 55% of participants had experienced PTG; there was a gender difference in PTG occurrence; and recovery from radiation anxiety was independently and significantly associated with PTG. Additionally, higher levels of education and health literacy were independently and significantly associated with PTG. Our findings suggest that during the period of recovery from radiation anxiety, psychological changes may occur with PTG emerging as a result. Our findings may be applied when practically supporting individuals with PTSD in their recovery. However, in order to put these findings to practical use, further evidence should be collected.

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### Declaration of conflicting interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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### Author contributions

YK, CN, TN and SY conceived and designed the study. NM, YK, CN, TN and MS provided critical suggestions for analysis. All authors contributed to discussing the statistical methods and the interpretation of the findings as epidemiological, gerontology, and public health specialists. HI analyzed the data and wrote the manuscript. All of the authors read and approved the final manuscript.

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### References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, DC, USA: American Psychiatric Publishing.
- Antoni, M. H., Lehman, J. M., Kilbourn, K. M., Boyers, A. E., Culver, J. L., Alferi, S. M., ... Carver, C. S. (2001). Cognitive-behavioral stress management intervention decreases the prevalence of depression and enhances benefit finding among women under treatment for early-stage breast cancer. *Journal of Health Psychology*, 20, 20–32.
- Bates, G. W., Trajstman, S. E., & Jackson, C. A. (2004). Internal consistency, test-retest reliability and sex differences on the posttraumatic growth inventory in an Australian sample with trauma. *Psychological Reports*, 94, 793–794. doi:10.2466/pr0.94.3.793-794

- Boyle, C. C., Stanton, A. L., Ganz, P. A., & Bower, J. E. (2017). Posttraumatic growth in breast cancer survivors: Does age matter? *Psychooncology*, 26, 800–807. doi:10.1002/pon.4091
- Bromet, E. J. (2012). Mental health consequences of the Chernobyl disaster. *Journal of Radiological Protection*, 32, N71–N75. doi:10.1088/0952-4746/32/1/N71
- Bromet, E. J., & Havenaar, J. M. (2007). Psychological and perceived health effects of the Chernobyl disaster: A 20-year review. *Health Physics*, 93, 516–521. doi:10.1097/01.HP.0000279635.14108.02
- Hasegawa, A., Tanigawa, K., Ohtsuru, A., Yabe, H., Maeda, M., Shigemura, J., ... Chhem, R. K. (2015). Health effects of radiation and other health problems in the aftermath of nuclear accidents, with an emphasis on Fukushima. *Lancet*, 386, 479–488. doi:10.1016/S0140-6736(15)61106-0
- Horikoshi, N., Iwasa, H., Yasumura, S., & Maeda, M. (2017). The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima health management survey. *Fukushima Journal of Medical Science*, 63, 152–159. doi:10.5387/fms.2017-03
- Horikoshi, N., Ohira, T., Yasumura, S., Yabe, H., & Maeda, M. (2017). The effect of telephone support to evacuees with risks of hypertension and diabetes mellitus after a disaster: The Fukushima health management survey. [*Nihon Koshu Eisei Zasshi*] *Japanese Journal of Public Health*, 64, 70–77 (in Japanese).
- Ishikawa, H., & Kiuchi, T. (2010). Health literacy and health communication. *BioPsychoSocial medicine*, 4, 18. doi:10.1186/1751-0759-4-18
- Ishikawa, H., Takeuchi, T., & Yano, E. (2008). Measuring functional, communicative, and digital health literacy among diabetic patients. *Diabetes Care*, 31, 874–879. doi:10.2337/dc07-1932
- Iwasa, H., Yoshida, H., Kim, H., Yoshida, Y., Kwon, J., Sugiura, M., ... Suzuki, T. (2007). A mortality comparison of participants and non-participants in a comprehensive health examination among elderly people living in an urban Japanese community. *Aging Clinical and Experimental Research*, 19, 240–245.
- Kong, L., Fang, M., Ma, T., Li, G., Yang, F., Meng, Q., ... Li, P. (2018). Positive affect mediates the relationships between resilience, social support and posttraumatic growth of women with infertility. *Psychology, Health & Medicine*, 23, 707–716. doi:10.1080/13548506.2018.1447679
- Kuroda, Y., Iwasa, H., Orui, M., Moriyama, N., Nakayama, C., & Yasumura, S. (2018). Association between health literacy and radiation anxiety among residents after a nuclear accident: Comparison between evacuated and non-evacuated areas. *International Journal of Environmental Research and Public Health*, 15, 1430. doi:10.3390/ijerph15061188
- Liu, Y., Li, Y., Chen, L., Li, Y., Qi, W., & Yu, L. (2018). Relationships between family resilience and post-traumatic growth in breast cancer survivors and caregiver burden. *Psychooncology*, 27, 1284–1290. doi:10.1002/pon.4668
- Manne, S., Ostroff, J., Winkel, G., Goldstein, L., Fox, K., & Grana, G. (2004). Posttraumatic growth after breast cancer: Patient, partner, and couple perspectives. *Psychosomatic Medicine*, 66, 442–454.
- Murakami, M., Sato, A., Matsui, S., Goto, A., Kumagai, A., Tsubokura, M., ... Ochi, S. (2017). Communicating with residents about risks following the Fukushima nuclear accident. *Asia-Pacific Journal of Public Health / Asia-Pacific Academic Consortium for Public*

- Health*, 29, 745–895. doi:10.1177/1010539516681841
- Nishi, D., Kawashima, Y., Noguchi, H., Usuki, M., Yamashita, A., Kido, Y., & Matsuoka, Y. J. (2016). Resilience, post-traumatic growth, and work engagement among health care professionals after the Great East Japan Earthquake: A 4-year prospective follow-up study. *Journal of Occupational Health*, 58, 347–353. doi:10.1539/joh.16-0002-OA
- Nishi, D., Matsuoka, Y., & Kim, Y. (2010). Posttraumatic growth, posttraumatic stress disorder and resilience of motor vehicle accident survivors. *BioPsychoSocial medicine*, 4, 7. doi:10.1186/1751-0759-4-7
- Nutbeam, D. (1998). Health promotion glossary. *Health Promotion International*, 13, 349–364. doi:10.1093/heapro/13.4.349
- Ohira, T., Hosoya, M., Yasumura, S., Satoh, H., Suzuki, H., Sakai, A., ... Shibata, Y. (2016a). Evacuation and risk of hypertension After the Great East Japan Earthquake: The Fukushima health management survey. *Hypertension*, 68, 558–564. doi:10.1161/HYPERTENSIONAHA.116.07499
- Ohira, T., Hosoya, M., Yasumura, S., Satoh, H., Suzuki, H., Sakai, A., ... Abe, M. (2016b). Effect of evacuation on body weight after the Great East Japan Earthquake. *American Journal of Preventive Medicine*, 50, 553–560. doi:10.1016/j.amepre.2015.10.008
- Park, C. L., Cohen, L. H., & Murch, R. L. (1996). Assessment and prediction of stress-related growth. *Journal of Personality*, 64, 71–105.
- Schubert, C. F., Schmidt, U., & Rosner, R. (2016). Posttraumatic growth in populations with posttraumatic stress disorder—a systematic review on growth-related psychological constructs and biological variables. *Clinical Psychology & Psychotherapy*, 23, 469–486. doi:10.1002/cpp.1985
- Shakespeare-Finch, J., & de Dassel, T. (2009). Exploring posttraumatic outcomes as a function of childhood sexual abuse. *Journal of Child Sexual Abuse*, 18, 623–640. doi:10.1080/10538710903317224
- Suzuki, Y., Yabe, H., Yasumura, S., Ohira, T., Niwa, S.-I., Ohtsuru, A., ... Abe, M. (2015). Psychological distress and the perception of radiation risks: The Fukushima health management survey. *Bulletin of the World Health Organization*, 93, 598–605. doi:10.2471/BLT.14.146498
- Tang, C. S. (2006). Positive and negative postdisaster psychological adjustment among adult survivors of the Southeast Asian earthquake-tsunami. *Journal of Psychosomatic Research*, 61, 699–705. doi:10.1016/j.jpsychores.2006.07.014
- Tedeschi, R. G., & Calhoun, L. G. (1996). The posttraumatic growth inventory: Measuring the positive legacy of trauma. *Journal of Traumatic Stress*, 9, 455–471.
- Teixeira, R. J., & Pereira, M. G. (2013). Factors contributing to posttraumatic growth and its buffering effect in adult children of cancer patients undergoing treatment. *Journal of Psychosocial Oncology*, 31, 235–265. doi:10.1080/07347332.2013.778932
- Tsai, J., El-Gabalawy, R., Sledge, W. H., Southwick, S. M., & Pietrzak, R. H. (2015). Post-traumatic growth among veterans in the USA: Results from the national health and resilience in veterans study. *Psychological Medicine*, 45, 165–179. doi:10.1017/S0033291714001202
- Xu, J., & Liao, Q. (2011). Prevalence and predictors of posttraumatic growth among adult survivors one year following 2008 Sichuan earthquake. *Journal of Affective Disorders*, 133, 274–280. doi:10.1016/j.jad.2011.03.034
- Yabe, H., Suzuki, Y., Mashiko, H., Nakayama, Y., Hisata, M., Niwa, S.-I., ... Abe, M. (2014). Psychological distress after the Great East Japan Earthquake and Fukushima Daiichi nuclear power plant accident: Results of a mental health and lifestyle survey through the Fukushima health management survey in FY2011 and FY2012. *Fukushima Journal of Medical Science*, 60, 57–67.
- Yasumura, S., Hosoya, M., Yamashita, S., Kamiya, K., Abe, M., Akashi, M., ... Ozasa, K. (2012). Study protocol for the Fukushima health management survey. *Journal of Epidemiology / Japan Epidemiological Association*, 22, 375–383.
- Zoellner, T., Rabe, S., Karl, A., & Maercker, A. (2008). Posttraumatic growth in accident survivors: Openness and optimism as predictors of its constructive or illusory sides. *Journal of Clinical Psychology*, 64, 245–263. doi:10.1002/jclp.20441
- Zoellner, T., Rabe, S., Karl, A., & Maercker, A. (2011). Post-traumatic growth as outcome of a cognitive-behavioural therapy trial for motor vehicle accident survivors with PTSD. *Psychology and Psychotherapy*, 84, 201–213. doi:10.1348/147608310X520157



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