Abstract

The occurrence of human growth after a stressful experience, such as a disaster, is called post-traumatic growth (PTG). PTG has been confirmed among people affected by the Great East Japan Earthquake (GEJE). We hypothesised that people who experienced PTG during the GEJE would be able to better respond to the coronavirus disease 2019 (COVID-19) compared to those who did not. This cross-sectional study conducted a survey via a posting method between 25 January and 16 February 2021. We randomly distributed questionnaires to 1800 residents of Fukushima and Miyagi prefectures aged 20–26 years. We included 582 participants who responded. PTG caused by the GEJE was significantly higher in the affected prefectures, especially among those who experienced the earthquake and tsunami. Furthermore, it was significantly associated with COVID-19-related responses, such as avoiding the three-Cs (i.e., closed spaces, crowded places, and close-contact settings), basic infection control, taking care of oneself under self-restraint, and getting enough rest and nutrition. This suggested that experiencing PTG may have enabled people affected by the GEJE to better respond to the COVID-19 pandemic. However, PTG was also associated with exclusive behaviours, although this association was weaker than that for other COVID-19-related responses. Hence, support for increased PTG during the post-disaster period was suggested.

19 Keywords: COVID-19; Post-traumatic growth; the Great East Japan Earthquake;
20 Fukushima Nuclear Accident

21

22 **1. Introduction**

23 The coronavirus disease 2019 (COVID-19) pandemic is a serious public health
24 emergency and threat to human health. The COVID-19 pandemic and its related measures,
25 including isolation, had a negative impact on people's mental health, such as anxiety, fear,
26 irritability, sleep disturbances, and substance dependence [1–6]. COVID-19 also severely
27 impacted the economy [7]. Under strict behavioural restrictions and economic conditions,
28 suicide rates increased in some countries, including Japan [8]. The COVID-19 pandemic
29 was regarded as a 'disaster'. During disasters, many people experience flashbacks,
30 nightmares, increased anxiety and tension, and loss of sense of reality due to pain, known
31 as post-traumatic stress disorder (PTSD). In contrast, after a stressful experience, such as
32 bereavement of a familiar person, personal injury, or disaster, post-traumatic growth
33 (PTG) may occur when people realise the importance of their relationships with others,
34 undergo a psychological transformation, and gain strength. In a previous study, 53% of
35 trauma survivors experienced PTG and became more positive regarding their lives and
36 the world [9, 10]. They also enjoyed greater life satisfaction, happiness, and psychological,

emotional, and physical well-being [11]. Predictors of PTG included gender, higher education, occupation (trained professionals), hope, positive coping, social support, and intentional rumination (interpretation of their trauma) [9]. Furthermore, PTG was higher among those who sought medical information, such as diagnosis and prognosis, and psychosocial information, such as a healthy lifestyle, information exchange with other patients, or mutual support forums [12]. Traumatic events can have a lasting impact, cause people to reflect on their experiences, and ultimately develop as individuals [13]. Previous studies focused on factors that predicted PTG. However, few studies have included the same group of people who faced multiple disasters. A study found that PTG after a strike at a hospital in Seattle before the COVID-19 pandemic allowed for an optimal organizational response against COVID-19 [14]. It is unclear whether PTG acquired in a former disaster results in better responses to difficulties in a later disaster among individuals who have experienced multiple disasters.

The Great East Japan Earthquake (GEJE), subsequent tsunami, and Fukushima nuclear power plant accident on 11 March 2011 caused enormous human suffering and economic damage. PTG was confirmed in people affected by the GEJE [15, 16]. Higher PTG was reported among younger individuals and those who engaged in intentional and intrusive rumination [16]. Therefore, clarifying the association between PTG acquired during the

GEJE and responses to COVID-19 among individuals was expected to generate foundational knowledge on the role of PTG in multiple disasters.

We investigated the association between PTG caused by the GEJE and responses related to COVID-19 among individuals who were children during the GEJE. We hypothesised that those who experienced PTG would take more effective infection control measures against COVID-19 and fewer exclusive actions than those who did not.

2. Materials and Methods

2.1. Survey design and participants

This was a cross-sectional study. The survey was conducted via a posting method between 25 January and 16 February 2021. Participants were randomly selected from the resident registers of Miyagi and Fukushima prefectures (900 each) from 1,800 people aged 20–26 years. These ages corresponded to those aged 10–15 years during the GEJE, respectively. We chose this age group as prior studies demonstrated that young people experienced more PTG due to the variety of education they received while growing up [17]. Generally, the Japanese curriculum defined compulsory education as between the ages of 7 to 15 years. This was equivalent to six and three years of elementary and junior high school, respectively. The compulsory education program did not cover education after junior high

73 school. However, many students entered senior high school between the ages of 15 and
74 18 years. Some students also entered four-year institutions post high school (18 to 22
75 years), while others attended two- or three-year universities after graduation. In 2020,
76 95.5% and 54.3% of students progressed to senior high school and university, respectively
77 [18].
78 Of the 1,800 residents, 609 (33.8%) responded. Of these, those with a difference of > 1
79 year between their age in the resident registry and age they answered and with missing
80 responses regarding PTG were excluded. Hence, 27 individuals were excluded (seven due
81 to disagreement in age group and 20 due to missing items related to COVID-19). Finally,
82 582 participants were included in the analysis.

83 **2.2. Questionnaire and analysis**

84 The Japanese version of the Post-Traumatic Growth Inventory (PTGI) was used, with
85 permission from the original author [19]. The expanded version (PTGI-X-J) used 25 items
86 to measure five domains: relating to others, new possibilities, personal strength, spiritual
87 and existential changes, and appreciation of life. Participants were asked to indicate the
88 degree to which they ‘experienced’ or ‘did not experience’ change as a result of the GEJE
89 (0 = did not experience; 5 = experienced to a great degree). The scores ranged from 0 to
90 125, and higher scores indicated greater PTG.

We used 12 questionnaire items regarding the participants' attitudes toward COVID-19, their practices regarding their responses, and their perceptions of health, with permission from the original author (1 (very untrue) to 5 (very true)) [20]. We also created and added 12 items, which included items regarding health promotion behaviour, as well as stigma and exclusive behaviour observed after the COVID-19 pandemic (1 (strongly disagree) to 5 (strongly agree)). We included these items to broadly examine how existing PTG affected people's behaviour in response to another disaster. Concerns were raised during the COVID-19 outbreak regarding changes in basic health promotion behaviours [21] and exclusionary behaviours, such as stigma against at-risk populations [22, 23]. Therefore, we utilized these items to assess whether people who experienced PTG would engage in 'good behaviours', such as health-promoting behaviours, or 'bad behaviours', such as stigma and exclusionary behaviours. Covariates were also assessed considering their associations with PTG. Participants' relationships with others (social networks; score range: 0–30) [24], sources of information they trusted [25], and literacy regarding health information on the Internet (e-health literacy; score range: 8–40) were also enquired [26]. Questions on participants' attributes included their place of residence during the GEJE, experiences during the disaster (i.e. earthquake, tsunami, or nuclear power plant accident [experience of hearing the explosion]) [27], damage to their houses [28], relocation

experience, age, gender, and occupation (Table 1).

2.3. Statistical analysis

Cronbach's alpha coefficient for the PTGI-X-J (25 items) was calculated. Factor analysis was conducted on responses to COVID-19, and the number of factors was determined via parallel analysis [29]. Missing data were excluded. Maximum likelihood and Promax rotation were used for factor analysis. Subsequently, Cronbach's alpha coefficients were estimated for the items in each factor, with absolute factor loadings of ≥ 0.4.

A *t*-test and one-way analysis of variance were used to evaluate the differences in PTG or factor scores of COVID-19 responses. Regarding age, participants were divided into two groups based on the median values: younger (< 23 years) and older (≥ 23 years). Regarding e-health literacy and social network, participants were divided into two groups based on previous reports [24, 26]: high (≥ 25) and low (< 25) and strong (≥ 12) and weak (< 12), respectively. For analysis on gender and the other items, 580 and 582 people were analysed, respectively. Pearson's correlations were used to evaluate the associations between PTG and factor scores of COVID-19 responses.

A multiple regression analysis was conducted, adjusted for the covariates that showed significant associations ($p < 0.05$) with both PTG and any COVID-19 responses. The outcome variables were the factor scores of the COVID-19 responses. Although

"none/any of the three disaster experiences" was significant as a univariate, this item was not included as a covariate in the multiple regression analysis as the presence or absence of earthquake and tsunami experience were included as covariates. The explanatory variable was the PTG score. Covariates included age, occupation, place of residence during the GEJE, earthquake experience, tsunami experience, trusted information (newspapers), e-health literacy, and social networks. Variance inflation factors (VIF) were 1.186, 4.276, and 4.291 for the exposure factor PTG, place of residence during the GEJE (Fukushima), and place of residence during the GEJE (Miyagi and Iwate), respectively. All other items were ≤ 1.743, which indicated low multicollinearity. IBM SPSS Statistics version 24 was used for analysis.

2.4. Ethics

This study was approved by the Ethics Committee of Fukushima Medical University (Approval No: General 2020-182). Consent was obtained from all the participants. Participants submitted the questionnaire after being informed of the study purpose and their right to withdraw.

3. Results

Cronbach's alpha coefficient for the PTGI-X-J (25 items) was 0.960 and the overall mean

score was 52.00 (Table 2). The mean score of the PTGI-J (21 items), often assessed in previous studies [30], was 43.40. PTG scores were significantly higher for those who were younger, self-employed or company employees, considered newspapers as trusted information sources, resided in the affected prefectures during the GEJE (especially Fukushima), had experienced the tsunami, whose houses had been half or completely destroyed, had high e-health literacy, and strong social networks.

The parallel analysis identified five factors (Table 3). Cronbach's alpha coefficients for the items with an absolute factor loadings of ≥ 0.4 were 0.851, 0.669, 0.616, 0.676, and 0.762 for factors 1–5, respectively. Factor analysis revealed that factor 1 had high factor loadings for the three Cs (closed spaces, close-contact settings, and crowded places) avoidance: 'avoid closed spaces with poor ventilation', 'avoid close contact settings, such as close-range conversations', 'avoid crowded places with many people nearby', and 'avoid places where they overlap (3 Cs)'. Factor 2 had high factor loadings for no exclusive behaviour, such as 'keep the distance from foreigners when I see them', 'feel uncomfortable when I see out-of-prefecture license plate numbers', 'have stocked up on masks', and 'have stocked up on toilet papers' (all reversed items). Factor 3 had high loadings for basic infection control measures, such as handwashing, cough etiquette, and mask-wearing. Factor 4 showed high factor loadings for health management under self-

163 restraint, as found in ‘have exercised to maintain health under the self-restraint’ and ‘have
164 engaged in some kind of activity to reduce stress during the self-restraint’. Factor 5
165 showed high factor loadings for items regarding rest and nutrition: ‘got sufficient rest and
166 sleep’ and ‘ate a nutritious diet’.
167 Results of the univariate analyses of the COVID-19 responses are shown in Tables S1 and
168 S2 in the Supplementary Materials. The multiple regression analysis showed that PTG
169 was significantly associated with all factors of COVID-19 responses (Table 4).
170 Significant positive associations were found for factors 1 and 3–5, whereas a significant
171 negative association was found for factor 2. The standardised partial regression
172 coefficients for PTG for factors 1–5 were 0.231, −0.167, 0.364, 0.337, and 0.324,
173 respectively. Furthermore, they were higher for PTG for factors 1, 3, 4, and 5 than those
174 for other variables (Table 4).
175

176 **4. Discussion**

177 This study evaluated the hypothesis that individuals who were children during the GEJE
178 and experienced PTG would take effective infection control measures against COVID-19
179 and exhibit non-exclusive behaviour during the pandemic.
180 The PTGI-J scores in our study were 52.00 and 43.40 for 25 and 21 items, respectively.

In previous studies, scores for the 21 item scale were 36.95 and 39.63 among medical university students in Fukushima 1 month after the GEJE [15] and adult survivors eight years after the Wenchuan earthquake, respectively [31]. The scores in our study were higher than those in previous studies. This may be since the study investigated participants approximately 10 years after the GEJE. Furthermore, they had more opportunities to experience PTG through school education and other means, such as social networks. There was also a difference in PTG between the younger and older groups (aged 20–22 and 23–26 years, equivalent to elementary school and junior high school students at the time of the earthquake, respectively). This may be due to the fact that the younger group had a longer educational period after the earthquake and spent more time in an environment where PTG was more likely to occur. Higher PTG was also observed among those who experienced the disaster or lived in prefectures affected by the disaster, which confirmed the PTG theory: individuals who experienced a disaster gained PTG. Furthermore, PTG was higher among those with strong social networks. This finding was consistent with a previous report [32]. However, although there was an inverted U-shaped relationship between exposure to a disaster and PTG [33], in the present study, those who experienced a disaster showed higher PTG than those who did not, especially those who experienced the tsunami. Disaster-related items (place of

199 residence during the GEJE, disaster experience, and damage to houses) and social
200 networks along with other factors, which included age, occupation, trusted information,
201 and e-health literacy, were significantly associated with PTG. This finding provided new
202 insights into the possible predictors of PTG.
203 The parallel analysis extracted five factors: 3Cs avoidance, no exclusive behaviour, basic
204 infection control, taking care of oneself under self-restraint, and getting enough rest and
205 nutrition. The univariate analysis revealed that the five-factor scores were associated with
206 PTG, age, gender, occupation, place of residence at the time of the GEJE, disaster
207 experience, trusted information source, e-health literacy, and social networks. In
208 particular, women and those with higher e-health literacy tended to take actions related to
209 infectious disease control (factors 1 and 3). In addition, those who trusted newspapers
210 were likely to implement basic infection control measures (factors 1 and 3). A previous
211 study reported similar findings; women with higher levels of knowledge regarding the
212 pandemic and more information regarding COVID-19 were more likely to take infection
213 control measures [34–36].
214 The multiple regression analysis showed that PTG was significantly and positively
215 associated with factor scores 1 and 3–5, adjusted for the covariates. Those who developed
216 PTG were more likely to implement the three Cs avoidance, basic infection control, health

management under self-restraint, and rest or nutrition. In particular, the standardised partial regression coefficients of PTG of these factor scores were larger than those of the other variables, which indicated the important role of PTG in COVID-19 responses. A previous study reported that people reflected on and learnt from a crisis and applied what they had learned to respond better to COVID-19 [5]. Another study also revealed that COVID-19 control behaviours were associated with empathy for others, a component of PTG [37–39]. PTG acquisition, which included the ability to empathise with others, may have promoted preventive behaviours against COVID-19 after a disaster experience.

In contrast, factor 2 showed a weak negative association with PTG. This indicated that people with higher PTG behaved more exclusively toward others after the COVID-19 pandemic. This finding contradicted our hypothesis. Although exclusivity was not desirable, this result could be interpreted as those who have had a threat of infection were more likely to have exclusivity [22]. Furthermore, those who tried to comply with public health rules were more likely to act exclusively in their decision-making [23]. This result also represented an aspect of the desire for survival, and did not conflict with PTG, which included importance of life and death as a component. Existing research [40] also reported a positive association between PTG and exclusiveness to out-groups. However, the association with factor 2 was slightly weaker than that with other factors, which probably

235 reflected that ethical aspects were likely to create differences in thinking among
236 individuals.

237 Overall, this study highlighted the powerful role of PTG in response to a subsequent
238 pandemic or disaster. Providing support to increase PTG in after a disaster may lead to
239 further appropriate behaviours, such as adherence to infection control measures. This
240 study also revealed that stronger social networks and higher e-health literacy were
241 associated with PTG. Therefore, promoting a stronger social networks or e-health literacy
242 can be key factors for enhancing PTG and eventually increasing health-preventive
243 behaviours during another future disaster.

244 This study had some limitations. First, owing to the cross-sectional design, causal
245 relationships could not be identified. Second, since the participants were limited to youths,
246 the findings may not be applicable to other generations. Third, this study focused on the
247 GEJE and COVID-19 outbreak. Natural disasters, nuclear disasters, and pandemics were
248 different types of disasters; while COVID-19 divided people to avoid infection, GEJE
249 had united people to rebuild their communities. Generalization and application of these
250 findings to different types of disasters should be done with caution. Fourth, the low
251 response rate may have caused selection bias. However, this value was better than that of
252 previous studies conducted after the GEJE [41]. Respondents may have had better mental

health than non-respondents [42]. Thus, the PTG scores in our study may have been overestimated. However, we assessed the association between PTG and COVID-19 responses after adjusting for covariates to mitigate the effects of selection bias. Further findings should be obtained by targeting all age groups and collecting responses via other methods.

Despite these limitations, this study was the first to reveal that post-GEJE PTG was associated with COVID-19 responses. This study highlighted the significance of providing support, such as enhancement of social networks and e-health literacy, to increase PTG after a disaster.

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Authorship Contributions

M.K.: Conceptualization, Methodology, Formal analysis, Writing - Original Draft.

M.M: Conceptualization, Methodology, Funding acquisition, Writing - Review & Editing.

T.K.: Formal analysis, Writing - Review & Editing.

Y.T.: Methodology, Funding acquisition, Writing - Review & Editing.

M.T.: Writing - Review & Editing.

T.Y.: Funding acquisition, Writing - Review & Editing.

T.T.: Funding acquisition, Writing - Review & Editing.

Notes

Preliminary results of this study were presented at the 34th Annual Conference of the Society of Risk Analysis in Japan [43].

Statement

During the preparation of this manuscript, the authors used DeepL to improve expressions in the English language. Subsequently, the authors reviewed and edited the content. Furthermore, the manuscript was carefully reviewed by professional scientific editors whose first language is English. The authors take full responsibility for the content of the publication.

References

[1] N. Salari, A. Hosseinian-Far, R. Jalali, A. Vaisi-Raygani, S. Rasoulpoor, M. Mohammadi, S. Rasoulpoor, B. Khaledi-Paveh, Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis, Global Health. 16 (2020) 57.

[2] J.P. Rogers, E. Chesney, D. Oliver, T.A. Pollak, P. McGuire, P. Fusar-Poli, M.S. Zandi, G. Lewis, A.S. David, Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis with comparison to the COVID-19 pandemic, Lancet Psychiatry. 7 (2020) 611–627.

[3] Y. Okumura, T. Higuchi, Cost of depression among adults in Japan, Prim Care Companion CNS Disord. 13 (2011).

[4] COVID-19 Mental Disorders Collaborators, Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic, Lancet. 398 (2021) 1700–1712.

[5] R.D. Christopher, L. Welling, C. Clearfield, How one Seattle health system is managing the COVID-19 crisis, Harvard Business Review. (2020).

[6] J. Henssler, F. Stock, J. van Bohemen, H. Walter, A. Heinz, L. Brandt, Mental health effects of infection containment strategies: quarantine and isolation-a systematic

307 review and meta-analysis, Eur Arch Psychiatry Clin Neurosci. 271 (2021) 223–234.

308 [7] World Bank Group, Global Economic Prospects: June 2020. (accessed 13 March

309 2023)

310 [8] J. Pirkis, D. Gunnell, S. Shin, M. Del Pozo-Banos, V. Arya, P.A. Aguilar, et al.

311 Spittal, Suicide numbers during the first 9-15 months of the COVID-19 pandemic

312 compared with pre-existing trends: an interrupted time series analysis in 33 countries,

313 EClinicalMedicine. 51 (2022) 101573.

314 [9] X. Wu, A.C. Kaminga, W. Dai, J. Deng, Z. Wang, X. Pan, A. Liu, The prevalence

315 of moderate-to-high posttraumatic growth: a systematic review and meta-analysis, J

316 Affect Disord. 243 (2019) 408–415.

317 [10] N.E. Bush, N.A. Skopp, R. McCann, D.D. Luxton, Posttraumatic growth as

318 protection against suicidal ideation after deployment and combat exposure, Mil Med. 176

319 (2011) 1215–1222.

320 [11] Y. Jin, J. Xu, D. Liu, The relationship between post traumatic stress disorder and

321 post traumatic growth: gender differences in PTG and PTSD subgroups, Soc Psychiatry

322 Psychiatr Epidemiol. 49 (2014) 1903–1910.

323 [12] A. Casellas-Grau, E.C. Sumalla, M. Lleras, J. Vives, A. Sirgo, C. Leon et al, The

324 role of posttraumatic stress and posttraumatic growth on online information use in breast

cancer survivors, Psychooncology 27 (2018) 1971–1978.

[13] C.L. Katz, N. Gluck, A. Maurizio, L.E. DeLisi, The medical student experience with disasters and disaster response, CNS Spectrums. 7 (2002) 604–610.

[14] S. Chen, G.A. Bonanno, Psychological adjustment during the global outbreak of COVID-19: a resilience perspective, Psychol Trauma. 12 (2020) S51–S54.

[15] D. Anderson, P. Prioleau, K. Taku, Y. Naruse, H. Sekine, M. Maeda et al, Post-traumatic stress and growth among medical student volunteers after the March 2011 disaster in Fukushima, Japan: implications for student involvement with future disasters, Psychiatr Q. 87 (2016) 241–251.

[16] K. Taku, A. Cann, R.G. Tedeschi, L.G. Calhoun, Core beliefs shaken by an earthquake correlate with posttraumatic growth, Psychol Trauma. 7 (2015) 563–569.

[17] K.S. Kanako Taku, Handbook of Post-Traumatic Growth: What Excruciating Experiences Can Do to the Human Mind, Igakushoin. Tokyo, 2014.

[18] Gender Equality Bureau Cabinet Office, Section 1: Situation Concerning Education. https://www.gender.go.jp/about_danjo/whitepaper/r03/zentai/html/honpen/b1_s05_01.html. (accessed 26 June 2023).

[19] R.G. Tedeschi, A. Cann, K. Taku, E. Senol-Durak, L.G. Calhoun, The

343 Posttraumatic Growth Inventory: a revision integrating existential and spiritual change, J
344 Trauma Stress. 30 (2017) 11–18.
345 [20] K. Muto, I. Yamamoto, M. Nagasu, M. Tanaka, K. Wada, Japanese citizens'
346 behavioral changes and preparedness against COVID-19: an online survey during the
347 early phase of the pandemic, PLoS One. 15 (2020) e0234292.
348 [21] M. Murakami, S. Nomura, Annual prevalence of non-communicable diseases
349 and identification of vulnerable populations following the Fukushima disaster and
350 COVID-19 pandemic, Int J Disaster Risk Reduct. 84 (2023) 103471.
351 [22] M. Yamagata, T. Teraguchi, A. Miura, Effects of pathogen-avoidance tendency
352 on infection-prevention behaviors and exclusionary attitudes toward foreigners: a
353 longitudinal study of the COVID-19 outbreak in Japan, Jpn Psychol Res. 65 (2023) 158-
354 172.
355 [23] S. Tomczyk, M. Rahn, S. Schmidt, Social distancing and stigma: association
356 between compliance with behavioral recommendations, risk perception, and stigmatizing
357 attitudes during the COVID-19 outbreak, Front Psychol. 11 (2020) 1821.
358 [24] J.E. Lubben, Assessing social networks among elderly populations, Fam
359 Community Health. 11 (1988) 42–52.
360 [25] M. Murakami, J. Nakatani, T. Oki, Evaluation of risk perception and risk-

361 comparison information regarding dietary radionuclides after the 2011 Fukushima
362 Nuclear Power Plant Accident, PLoS One 11 (2016) e0165594.
363 [26] S. Mitsutake, A. Shibata, K. Ishii, K. Okazaki, K. Oka, [Developing Japanese
364 version of the eHealth Literacy Scale (eHEALS)], Nihon Koshu Eisei Zasshi. 58 (2011)
365 361–371. (in Japanese)
366 [27] Y. Suzuki, Y. Takebayashi, S. Yasumura, M. Murakami, M. Harigane, H. Yabe,
367 T. Ohira, A. Ohtsuru, S. Nakajima, M. Maeda, Changes in risk perception of the health
368 effects of radiation and mental health status: The Fukushima Health Management Survey,
369 Int J Environ Res Public Health 15 (2018) 1219.
370 [28] Y. Suzuki, H. Yabe, S. Yasumura, T. Ohira, S. Niwa, A. Ohtsuru, H. Mashiko, M.
371 Maeda, M. Abe, s, Mental Health Group of the Fukushima health management,
372 Psychological distress and the perception of radiation risks: the Fukushima health
373 management survey, Bull. World Health Organ. 93 (2015) 598–605.
374 [29] K. Hori, Parallel analysis. http://www.ec.kagawa-
375 u.ac.jp/~hori/delphistat/index.html#pa., 2001 (accessed 29 Nov 2022).
376 [30] K. Taku, L.G. Calhoun, R.G. Tedeschi, V. Gil-Rivas, R.P. Kilmer, A. Cann,
377 Examining posttraumatic growth among Japanese university students, Anxiety Stress
378 Coping. 20 (2007) 353–367.

[31] J. Guo, C. Liu, D. Kong, P. Solomon, M. Fu, The relationship between PTSD and suicidality among Wenchuan earthquake survivors: the role of PTG and social support, J Affect Disord. 235 (2018) 90–95.

[32] P.I. Jewett, R.I. Vogel, P. Galchutt, S.A. Everson-Rose, D. Teoh, M. Radomski, A.H. Blaes, Associations between a sense of connection and existential and psychosocial outcomes in gynecologic and breast cancer survivors, Support Care Cancer. 30 (2022) 3329–3336.

[33] A. Laufer, Z. Solomon, Posttraumatic symptoms and posttraumatic growth among Israeli youth exposed to terror incidents, J Soc Clin Psychol. 25 (2006) 429–-447.

[34] C.S. Tang, C.Y. Wong, An outbreak of the severe acute respiratory syndrome: predictors of health behaviors and effect of community prevention measures in Hong Kong, China, Am J Public Health. 93 (2003) 1887–1888.

[35] K. Batra, Y. Urankar, R. Batra, A.F. Gomes, M. S, P. Kaurani, Knowledge, protective behaviors and risk perception of COVID-19 among dental students in india: a cross-sectional analysis, Healthcare. 9 (2021) 574.

[36] S. Li, B. Feng, W. Liao, W. Pan, Internet use, risk awareness, and demographic characteristics associated with engagement in preventive behaviors and testing: cross-sectional survey on COVID-19 in the United States, J Med Internet Res. 22 (2020) e19782.

397 [37] K. Nakayama, Y. Yonekura, H. Danya, K. Hagiwara, COVID-19 preventive
398 behaviors and health literacy, information evaluation, and decision-making skills in
399 Japanese adults: cross-sectional survey study, JMIR Form Res. 6 (2022) e34966.
400 [38] J.Y.H. Wong, A.K.C. Wai, S. Zhao, F. Yip, J.J. Lee, C.K.H. Wong, M.P. Wang,
401 T.H. Lam, Association of individual health literacy with preventive behaviours and family
402 well-being during COVID-19 pandemic: mediating role of family information sharing,
403 Int J Environ Res Public Health. 17 (2020) 8838.
404 [39] S. Pfattheicher, L. Nockur, R. Bohm, C. Sassenrath, M.B. Petersen, The
405 emotional path to action: empathy promotes physical distancing and wearing of face
406 masks during the COVID-19 pandemic, Psychol Sci. 31 (2020) 1363-1373.
407 [40] B.J. Hall, S.E. Hobfoll, D. Canetti, R.J. Johnson, S. Galea, The defensive nature
408 of benefit finding during ongoing terrorism: an examination of a national sample of Israeli
409 Jews, J Soc Clin Psychol. 28 (2009) 993–1021.
410 [41] M. Murakami, T. Kobayashi, Y. Oikawa, S. Goto, M. Momoi, Y. Takebayashi, et
411 al, Associations of the COVID-19 pandemic with the economic status and mental health
412 of people affected by the Fukushima disaster using the difference-in-differences method:
413 the Fukushima Health Management Survey, SSM Popul Health. 14 (2021) 100801.
414 [42] N. Horikoshi, H. Iwasa, S. Yasumura, M. Maeda, The characteristics of non-

415 respondents and respondents of a mental health survey among evacuees in a disaster: The
416 Fukushima Health Management Survey, Fukushima J Med. Sci 63 (2017) 152–159.
417 [43] M. Kawashima, M. Murakami, Y. Takebayashi, T. Kobayashi, M. Tsubokura, T.
418 Yasutaka, T. Tamaki, Posttraumatic growth caused by the Great East Japan Earthquake
419 and response to COVID-19, In Proceedings of the SRA - Japan 34th Annual Meeting.
420

421 Table 1. Participants' characteristics (N=582).

	N (%) or *mean (SD)*
Age (years)	*22.57 (1.75)*
Younger	292 (50.2)
Older	290 (49.8)
Gender	
Men	252 (43.3)
Women	328 (56.4)
Other	2 (0.3)
Occupation	
Company employee	299 (51.9)
Self-employed	7 (1.2)
Student	179 (30.8)
Other	91 (15.6)
Place of residence at the time of the Great East Japan Earthquake	
Fukushima	277 (47.6)
Miyagi and Iwate	255 (43.8)
Other	46 (7.9)
Disaster experience	
Earthquake	569 (97.8)
Tsunami	65 (11.2)
Nuclear power plant accident (heard an explosion)	21 (3.6)
None	12 (2.1)
Damage to houses	
No damage / Partially damaged	509 (95.3)
Half or completely destroyed	69 (4.7)
Relocation experience after the Great East Japan Earthquake	
Yes	135 (23.2)
No	446 (76.8)
Trusted information	
TV and radio: Trust	343 (58.9)
TV and radio: Do not trust	239 (41.1)
Newspapers: Trust	221 (38.0)
Newspapers: Do not trust	361 (62.0)
Central government: Trust	284 (48.8)
Central government: Do not trust	298 (51.2)
Direct information from researchers: Trust	187 (32.1)
Direct information from researchers: Do not trust	395 (67.9)
Direct Information from friends: Trust	90 (15.5)
Direct Information from friends: Do not trust	492 (84.5)
On-line information from researchers: Trust	222 (38.1)

On-line information from researchers: Do not trust	360 (61.9)
On-line Information from others: Trust	46 (7.9)
On-line Information from others: Do not trust	536 (92.1)
Trust none of above	52 (8.9)
Trust any of above	530 (91.1)
e-health literacy	
High	233 (40.5)
Low	343 (59.5)
Frequency of searching for information on the Internet	
Once a week or more	550 (95.2)
Less than once a week	28 (4.8)
Social network	
Strong	373 (64.4)
Weak	206 (35.6)

422

423 Table 2. PTG (post-traumatic growth) scores and participants' characteristics.

Participants' Characteristics	Mean of the PTGI-X-J (25 items)[#]	*p*
Overall Average	52.00	
Age		
Younger	54.64	0.018
Older	49.32	
Gender		
Men	51.38	0.583
Women	52.63	
Occupation		
Company employee	52.38	0.035
Self-employed	53.29	
Student	54.83	
Other	44.83	
Place of residence at the time of the Great East Japan Earthquake		0.005
Fukushima	54.35	
Miyagi and Iwate	51.22	
Other	40.83	
Disaster experience		
Experienced earthquake	52.42	0.011
No earthquake experience	32.83	
Tsunami experience	62.86	0.001
No tsunami experience	50.71	
Experiencing a nuclear power plant accident	53.90	0.744
No experience of nuclear accident	51.93	
None of above	32.83	0.011
Any of above	52.42	
Damage to houses		
No damage / Partially damaged	50.97	0.010
Half or completely destroyed	59.97	
Relocation experience after the Great East Japan Earthquake		
Yes	55.08	0.134
No	51.10	
Trusted information		
TV and radio: Trust	53.83	0.052
TV and radio: Do not trust	49.39	
Newspapers: Trust	55.44	0.015
Newspapers: Do not trust	49.82	
Central government: Trust	54.02	0.078
Central government: Do not trust	50.07	
Direct information from researchers: Trust	52.05	0.975
Direct information from researchers: Do not trust	51.98	

Direct Information from friends: Trust	52.60	0.822
Direct Information from friends: Do not trust	51.89	
On-line information from researchers: Trust	52.38	0.789
On-line information from researchers: Do not trust	51.76	
On-line Information from others: Trust	46.33	0.149
On-line Information from others: Do not trust	52.46	
Trust none of above	48.14	0.285
Trust any of above	52.37	
e-health literacy		
High	54.89	0.034
Low	50.01	
Frequency of searching for information on the Internet		
More than once a week	52.37	0.195
Less than once a week	45.71	
Social network		
Strong	57.77	<0.001
Weak	41.47	

Note: PTGI-X-J: Expanded Version of the Post-Traumatic Growth Inventory

425 Table 3. Mean, standard deviation (SD), and factor pattern matrix for COVID-19
426 responses.

	Mean (SD)	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
If an individual is infected, it is their own fault (R)	1.64 (1.06)	0.071	0.266	0.053	0.119	-0.060
Have an interest in the COVID-19 pandemic	2.81 (0.92)	0.282	-0.130	0.063	0.077	0.002
Keep distance from foreigners when you see them (R)	1.40 (1.14)	-0.084	**0.502**	0.096	0.067	-0.062
Have actively tried to get involved in some way with people close to you when you could not see them in person	2.19 (1.18)	-0.126	-0.035	0.138	0.313	0.033
Feel uncomfortable when you see out-of-prefecture license plate numbers (R)	1.09 (1.16)	-0.118	**0.635**	0.065	0.034	-0.036
Have stocked up on masks (R)	1.26 (1.31)	0.004	**0.580**	-0.056	-0.082	0.093
Have stocked up on toilet papers (R)	0.63 (0.94)	0.087	**0.644**	-0.051	0.020	0.067
Felt like there was something you could do to help those in need due to COVID-19	1.76 (1.08)	0.010	-0.098	0.234	0.226	-0.017
Think information regarding infected individuals should be disclosed (R)	1.79 (1.21)	0.021	0.361	0.012	-0.083	-0.067
Have exercised to maintain health under the self-restraint	1.90 (1.31)	0.039	-0.008	-0.125	**0.697**	0.036
Have engaged in some kind of activity to reduce stress during the self-restraint	2.10 (1.24)	0.017	0.090	-0.040	**0.735**	-0.037
Feel that there will be a better future after the COVID-19 pandemic is over	2.35 (1.21)	0.033	0.017	-0.016	0.227	0.272
Avoid closed spaces with poor ventilation	1.97 (0.85)	**0.550**	-0.050	0.177	0.083	-0.018
Avoid close contact settings, such as close-range conversations	2.26 (0.91)	**0.610**	-0.029	0.072	0.007	0.025
Avoid crowded places with many people nearby	1.85 (0.86)	**0.920**	0.022	-0.055	-0.056	0.040
Avoid places where items 1–3 above overlap (3 Cs)	1.80 (0.83)	**1.020**	0.049	-0.109	-0.018	-0.040
Do not go to mass gatherings	1.49 (0.77)	**0.426**	0.012	0.214	-0.050	-0.018
Undertake frequent handwashing	1.62 (0.77)	0.131	0.019	**0.558**	0.059	-0.034
Undertake cough etiquette (use handkerchiefs or sleeves instead of hands)	2.01 (1.05)	-0.083	0.034	**0.566**	-0.033	0.003
Avoid going out when you have a cold	1.76 (0.88)	0.120	0.099	**0.542**	-0.013	0.040
Prepare consultation and transportation methods for when you feel ill	2.68 (1.22)	0.050	-0.044	0.306	0.086	0.103
Always wear a surgical-style mask when going out	1.18 (0.48)	0.112	-0.006	**0.417**	-0.128	-0.020
Get sufficient rest and sleep	1.99 (1.03)	0.014	-0.010	-0.042	-0.002	**0.764**
Eat a nutritious diet (R)	2.07 (0.96)	-0.027	-0.018	0.078	-0.003	**0.796**
Interpretation		3 Cs avoidance	No exclusive behavior	Basic infection control	Taking care of oneself under self-restraint	Getting enough rest and nutrition

427 Note: (R) represents a reverse item

Table 4. Regression coefficients of PTG (post-traumatic growth) for COVID-19 responses.

	Factor 1			Factor 2			Factor 3			Factor 4			Factor 5			VIF
	B (95%CI)	β	*p*	B (95%CI)	β	*p*	B (95%CI)	β	*p*	B (95%CI)	β	*p*	B (95%CI)	β	*p*	
PTG	0.009 (0.005 – 0.012)	0.231	<0.001	-0.005 (-0.008 – -0.002)	-0.167	<0.001	0.012 (0.009 – 0.015)	0.364	<0.001	0.011 (0.008 – 0.013)	0.337	<0.001	0.011 (0.008 – 0.014)	0.324	<0.001	1.186
Age (ref = younger)																
Older	0.121 (-0.065 – 0.308)	0.062	0.201	-0.016 (-0.179 – 0.146)	-0.010	0.845	0.105 (-0.052 – 0.263)	0.062	0.190	-0.050 (-0.201 – 0.101)	-0.029	0.516	0.048 (-0.117 – 0.212)	0.027	0.570	1.381
Occupation (ref = student)																
Company employee	-0.160 (-0.370 – 0.049)	-0.082	0.133	-0.104 (-0.287 – 0.078)	-0.063	0.262	0.009 (-0.168 – 0.186)	0.005	0.918	-0.142 (-0.312 – 0.027)	-0.084	0.100	-0.028 (-0.213 – 0.156)	-0.016	0.762	1.743
Self-employed	-0.421 (-1.136 – 0.293)	-0.049	0.247	-0.032 (-0.655 – 0.590)	-0.004	0.919	-0.438 (-1.043 – 0.166)	-0.058	0.155	-0.049 (-0.627 – 0.530)	-0.006	0.869	-0.411 (-1.041 – 0.219)	-0.053	0.200	1.044
Other	-0.054 (-0.321 – 0.213)	-0.020	0.690	-0.002 (-0.235 – 0.230)	-0.001	0.984	0.018 (-0.207 – 0.244)	0.008	0.874	0.120 (-0.096 – 0.337)	0.052	0.274	0.080 (-0.155 – 0.315)	0.033	0.505	1.507
Place of residence at the time of the Great East Japan Earthquake (ref = other)																
Fukushima	-0.212 (-0.540 – 0.116)	-0.108	0.204	-0.346 (-0.632 – -0.060)	-0.208	0.018	-0.132 (-0.410 – 0.145)	-0.077	0.350	-0.048 (-0.314 – 0.218)	-0.028	0.723	-0.051 (-0.341 – 0.238)	-0.029	0.727	4.276
Miyagi and Iwate	-0.401 (-0.731 – -0.070)	-0.204	0.018	-0.217 (-0.505 – 0.071)	-0.129	0.139	-0.236 (-0.515 – 0.044)	-0.137	0.098	0.004 (-0.264 – 0.272)	0.002	0.975	-0.155 (-0.446 – 0.136)	-0.087	0.296	4.291
Disaster experience																
Earthquake (ref= no experience)	0.017 (0.606 – 0.639)	0.002	0.959	-0.076 (-0.619 – 0.467)	-0.012	0.323	-0.340 (-0.867 – 0.187)	-0.054	0.206	-0.467 (-0.971 – 0.038)	-0.074	0.070	-0.693 (-1.242 – -0.144)	0.068	0.013	1.066
Tsunami (ref= no experience)	0.381 (0.118 – 0.645)	0.121	0.005	-0.116 (-0.346 – 0.114)	-0.043	0.323	0.112 (-0.111 – 0.335)	0.041	0.324	0.026 (-0.187 – 0.240)	0.010	0.808	0.194 (-0.039 – 0.426)	0.068	0.102	1.066
Trusted information																
Newspapers (ref = do not trust)	0.171 (0.006 – 0.337)	0.086	0.043	-0.141 (-0.286 – 0.003)	-0.083	0.055	0.152 (0.012 – 0.292)	0.087	0.033	0.194 (0.059 – 0.328)	0.111	0.005	0.100 (-0.046 – 0.246)	0.055	0.179	1.045
e-Health literacy (ref = low)																
High	0.130 (-0.037 – 0.296)	0.065	0.127	0.058 (-0.088 – 0.203)	0.034	0.435	0.118 (-0.023 – 0.259)	0.068	0.100	0.217 (0.082 – 0.352)	0.126	0.002	0.137 (-0.010 – 0.284)	0.076	0.068	1.069
Social network (ref = weak)																
Strong	-0.086 (-0.266 – 0.094)	-0.042	0.347	0.056 (-0.101 – 0.213)	0.032	0.483	-0.055 (-0.207 – 0.098)	-0.031	0.481	0.272 (0.126 – 0.418)	0.154	<0.001	0.109 (-0.049 – 0.268)	0.059	0.177	1.183

Note: B: unstandardized regression coefficient; CI: confidential interval; β: standardized partial regression coefficient. Covariates include age, occupation, place of residence at the time of the Great East Japan Earthquake, earthquake and tsunami experience, trusted information (newspapers), e-Health literacy, and social network.