

Radiation-related Anxiety among Public Health Nurses in the Fukushima Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station

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Manuscripts

1 Radiation-related Anxiety among Public Health Nurses in the Fukushima
2 Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station

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4 Koji Yoshida^{1,2*}, Makiko Orita³, Aya Goto⁴, Atsushi Kumagai², Kiyotaka Yasui², Akira
5 Ohtsuru⁵, Naomi Hayashida⁶, Takashi Kudo⁷, Shunichi Yamashita⁸, Noboru Takamura³
6

7 1 Department of Health Sciences, Nagasaki University Graduate School of Biomedical
8 Sciences, Nagasaki, Japan

9 2 Education Center for Disaster Medicine, Fukushima Medical University, Fukushima,
10 Japan

11 3 Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute,
12 Nagasaki University, Nagasaki, Japan

13 4 Center for Integrated Science and Humanities, Fukushima Medical University,
14 Fukushima, Japan

15 5 Department of Radiation Health Management, Fukushima Medical University School
16 of Medicine, Fukushima, Japan

17 6 Division of Promotion of Collaborative Research on Radiation and Environment
18 Health Effects, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

19 7 Department of Radioisotope Medicine, Atomic Bomb Disease Institute, Nagasaki
20 University, Nagasaki, Japan

21 8 Department of, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

22

23 *Corresponding author

24 Koji Yoshida, R.N, Ph.D.

25 Department of Health Sciences, Nagasaki University Graduate School of Biomedical

26 Sciences, Nagasaki, Japan

27 1-7-1 Sakamoto, Nagasaki 850-8520, Japan

28 Email: koujiy@nagasaki-u.ac.jp (KY)

29 TEL: +81-95-819-7195

30

Abstract

Objective: In Japan, public health nurses (PHNs) play important roles in managing the health of local residents, especially after a disaster. In this study, we assessed radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS).

Methods: We conducted a questionnaire survey among the PHNs (n=430) in July of 2015 via mail by post. The questions included demographic factors (sex, age, and employment position), knowledge about radiation, degree of anxiety about radiation at the time of the FDNPS accident (and at present), when answering the questions about radiation, and the Sense of Coherence-13 (SOC-13). We classified the low and high levels of anxiety when answering questions about radiation, and compared the anxiety-negative (-) group with the anxiety-positive (+) group.

Results: Of the PHNs, 269 (62.6%) were classified in the anxiety (-) group and 161 (37.4%) were in the anxiety (+) group. When the multivariate logistic regression analysis was conducted, the PHNs at the time of the accident (OR: 2.37, p=0.007), current general anxieties about radiation (OR: 3.56, p<0.001), current possession of materials to obtain knowledge about radiation (OR: 2.11, p=0.006), and knowledge of the childhood thyroid cancer increase after the Chernobyl accident (OR: 1.69, p=0.035) were significantly associated with anxiety after the FDNPS accident. The mean SOC-13 was 43.0 ± 7.7 , with no significant difference between anxiety (-) group and anxiety (+) group (p=0.47).

Conclusions: Our study suggested that anxiety about radiation was associated with materials and knowledge about radiation in the PHNs of Fukushima Prefecture four years after the FDNPS accident. It is important for PHNs to obtain knowledge and teaching materials about radiation, and radiation education programs for PHNs must be established in areas that have nuclear power stations and other nuclear facilities.

Keywords: public health nurse, anxiety, radiation, Fukushima Daiichi Nuclear Power Station, Sense of Coherence-13

Strengths and limitations of this study

- We could assess radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the FDNPS.
- We believe that this study regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS disaster will be very important in the provision of future support.
- We could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and other information.

71 **Introduction**

72 On March 11, 2011, the Great East Japan Earthquake struck the east coast of
73 Japan. This large earthquake and tsunami caused immense damage, including that to the
74 Fukushima Daiichi Nuclear Power Station (FDNPS) [1-4]. After the accident at the
75 FDNPS, the Fukushima prefectural government immediately issued instructions for the
76 evacuation of those areas within a 20 km radius of the FDNPS, and they also instructed
77 sheltering in the areas between 20 km and 30 km from the FDNPS. Beyond the 30 km
78 radius, additional areas were designated “deliberate evacuation areas” if there was
79 concern that the cumulative doses of radiation might reach 20 mSv per year in those
80 areas [2]. Despite the low estimated and measured external and internal exposure doses
81 just after the accident, many residents of the Fukushima Prefecture evacuated inside or
82 outside the prefecture [5-8].

83 In the report by the World Health Organization (WHO) on the health impacts 20
84 years after the Chernobyl accident, mental health was described as the most serious
85 public health problem resulting from that nuclear accident [9-11]. Based on the lessons
86 learned from the Chernobyl accident, the Fukushima Health Management Survey
87 (FHMS) was initiated to assess the health impacts, including mental health, of the
88 residents by the Fukushima prefectural government and the Fukushima Medical
89 University [12, 13]. According to the results of this survey, the residents of the
90 Fukushima Prefecture were exposed to a higher risk of not only physical problems, such
91 as diabetes and obesity, but also mental problems (including the risk perception of the

health effects of radiation) [14, 15].

In Japan, public health nurses (PHNs) play important roles in managing the health of local residents, especially after this disaster. While they were themselves victims of the radiation disaster, they had to respond to the residents' anxieties about radiation exposure, despite their lack of professional knowledge on this topic.

In this study, we conducted a survey to clarify the radiation anxiety and stress processing capacity of the PHNs in the Fukushima Prefecture, after the nuclear accident at the FDNPS.

100

101 **Materials and Methods**

102 *Study population and data collection*

We conducted a questionnaire survey among the PHNs in the Fukushima Prefecture located in Northeastern Japan, which was severely affected by the earthquake, tsunami, and FDNPS accident following the Great East Japan Earthquake in 2011. The survey was conducted in July of 2015 via mail by post, and contained questions about the demographic factors (sex, age, activity area, and employment position) and knowledge of the PHNs about radiation before and after the accident at the FDNPS, as well as their degree of anxiety about radiation at the time of the FDNPS accident (and at present), and their mental health status. The degree of anxiety was rated on a 10-point Likert scale ranging from no anxiety to having a lot of anxiety; we defined 1-5 as "anxiety (-)" and 6-10 as "anxiety (+)."

113 To measure the PHNs' stress management capability, we used the Japanese
114 version of the Sense of Coherence-13 (SOC-13). The SOC-13 consists of three
115 dimensions (comprehensibility, manageability, and meaningfulness) that are equally
116 weighted to create an overall (total) score. The score ranges from 7-91, with a higher
117 score representing a stronger sense of coherence [16].

119 ***Statistical analysis***

120 We classified the low and high levels of anxiety when answering the questions
121 about radiation, and compared the anxiety (-) group and anxiety (+) group by using the
122 chi-square test and t-test as univariate analyses. A multiple logistic regression analysis
123 was then used to calculate the odds ratio (OR), and its 95% confidence interval (95%
124 CI) was used to identify the factors independently associated with the anxiety level. A
125 p-value of less than 0.05 was considered to be significant, and the statistical analysis
126 was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

128 ***Ethics statement***

129 This study was approved by the ethics committee of the Fukushima Medical
130 University (No. 2251), and conducted in accordance with the guidelines specified in the
131 Declaration of Helsinki.

Results

A total of 458 PHNs responded to the survey, and 430 of those PHNs (93.9%) completed all of the questions. The number of women was 416 (96.7%), and 153 (35.6%) were 50 years old or older. The number of PHNs with less than 10 years of working experience was 124 (22.8%), and 306 (71.2%) had ten years or more. There were 119 participants (27.7%) with managerial positions. At the time of the accident, 330 (76.8%) worked as PHNs and 62 (14.4%) were still in training. The number of those in Hamadori, which became the evacuation area of the FDNPS accident, was 83 (19.3%) (Table 1).

Table 1. Basic characteristics of the study participants.

| Variable | Number (%) |
|----------------------------------------|----------------------------------------------|
| Gender | Women 416(96.7) |
| | Men 14(3.3) |
| Age | 20-29 years old 92(21.4) |
| | 30-39 years old 72(16.7) |
| | 40-49 years old 113(26.3) |
| | ≥50 years old 153(35.6) |
| Tenure as a public health nurse | <10 years 124(28.8) |
| | ≥10 years 306(71.2) |
| Nursing experience in a hospital | Yes 149(34.7) |
| | No 281(65.3) |
| Activity area | Hamadori 83(19.3) |
| | Other area (Nakadori, Aizu et al.) 347(80.7) |
| Position in the workplace | Manager (director, chief) 119(27.7) |
| | Staff 311(72.3) |
| Occupation at the time of the accident | Public health nurse 330(76.8) |
| | Other occupations (mostly nurses) 38(8.8) |
| | Students 62(14.4) |

Of the PHNs, 269 were classified in the anxiety (-) group and 161 were in the anxiety (+) group (Table 2). A significantly higher ratio of PHNs younger than 40 years old was observed in the anxiety (+) group ($p<0.001$, Table 2). Likewise, higher ratios of PHNs with less than 10 years of working experience, staff positions, and nursing licenses were observed in the anxiety (+) group ($p<0.001$, respectively, Table 2). On the other hand, no significant differences were observed between the two groups in the activity area, education curriculum, and seminars before or after the accident ($p=0.62$, $p=0.16$, $p=0.60$, and $p=0.13$, respectively, Table 2). In addition, there was no significant difference in the mean points in the SOC-13 observed between the two groups ($p=0.47$, Table 2).

Table 2. Participant’s demographic factors, educational history, and mental health via anxiety with regard to questions about radiation after the FNPS accident.

| Variable | Unit | Anxiety (-) | Anxiety (+) | p-values |
|---------------------------------------------|---------------------------|-------------|-------------|----------|
| | | (n=269) (%) | (n=161) (%) | |
| Gender | Women/ | 262(97.4)/ | 154(95.7)/ | 0.32 |
| | Men | 7(2.6) | 7(4.3) | |
| Age | <40 years old/ | 77(28.6)/ | 87(54.0)/ | <0.001 |
| | ≥40 years old | 192(71.4) | 74(46.0) | |
| Working experience as a public health nurse | <10 years/ | 53(19.7)/ | 71(44.1)/ | <0.001 |
| | ≥10 years | 216(80.3) | 90(55.9) | |
| Activity area | Hamadori/ | 54(20.1)/ | 29(18.0)/ | 0.62 |
| | Other area | 215(79.9) | 132(72.0) | |
| Position in the workplace | Manager/ | 88(32.7)/ | 31(19.3)/ | 0.003 |
| | Staff | 181(67.3) | 130(80.7) | |
| Occupation at the time of the accident | PHNs/ | 230(85.5)/ | 100(62.1)/ | <0.001 |
| | Others (nurses, students) | 39(14.5) | 61(37.9) | |

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|------------------------------------------------------------------------|-----------------|------------------------|-----------------------|------|
| Did you have children ≤ 15 years old at the time of the accident? | Yes | 110(40.9) | 59(36.6) | 0.42 |
| Education history in curriculum | Yes | 114(42.4) | 80(49.7) | 0.16 |
| Education history in seminar before the accident | Yes | 25(9.3) | 12(7.5) | 0.60 |
| Education history in seminar after the accident | Yes | 247(91.8) | 140(87.0) | 0.13 |
| Frequency of participation in seminars | Once/ Plural | 47(19.0)/ 200(81.0) | 42(29.6)/ 98(70.4) | 0.02 |
| SOC-13 total points | Mean | 44.0 | 41.4 | 0.47 |

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159 In the anxiety (+) group, the ratio of those having current anxiety about radiation
 160 was significantly higher than that in the anxiety (-) group ($p < 0.001$, Table 3). On the
 161 other hand, in the anxiety (-) group, the ratios with difficulty answering the questions
 162 about radiation, currently having the materials to obtain knowledge about radiation, and
 163 having knowledge about childhood thyroid cancer increases after the Chernobyl
 164 accident were significantly higher than in the anxiety (+) group ($p < 0.05$, $p < 0.01$, and
 165 $p < 0.05$, respectively, Table 3). However, there were no significant changes between the
 166 two groups in the anxiety about radiation at the time of the accident and the recognition
 167 of health effects (such as late effects and genetic effects) due to radiation exposure
 168 ($p = 0.68$, $p = 0.79$, and $p = 0.20$, respectively, Table 3).

169

170 **Table 3. Participants' anxiety, recognition, and knowledge about radiation via**
 171 **anxiety with regard to answering the questions about radiation after the FDNPS**
 172 **accident.**

| Question | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------|----------------------------|----------|
| Degree of anxiety about radiation at the time of the FDNPS accident | anxiety (-)/ anxiety (+) | 99(36.8)/ 170(63.2) | 56(34.8)/ 105(65.2) | 0.68 |
| Degree of anxiety about radiation currently | anxiety (-)/ anxiety (+) | 251(93.3)/ 18(6.7) | 130(80.7)/ 31(19.3) | <0.001 |
| Do you think that delayed effects such as malignancies occur due to radiation exposure following the Fukushima accident? | Yes | 37(13.8) | 33(20.5) | 0.79 |
| Do you think that genetic effects in offspring occur due to radiation exposure following the Fukushima accident? | Yes | 33(12.3) | 27(16.8) | 0.20 |
| Did you have a difficult time answering the questions about radiation? | Yes | 216(80.3) | 115(71.4) | 0.04 |
| Did you have the materials to obtain knowledge about radiation at the time of the accident? | Yes | 87(32.3) | 40(24.8) | 0.10 |
| Do you currently have the materials to obtain knowledge about radiation? | Yes | 233(86.6) | 118(73.3) | 0.01 |
| Did you know about the three principles of radiation protection? | Yes | 64(23.8) | 42(26.1) | 0.64 |
| Did you know about the annual dose limit for the general public? | Yes | 20(12.4) | 11(6.8) | 0.99 |
| Did you know about the half-life of radioactive substances? | Yes | 129(48.0) | 77(47.8) | 0.99 |
| Did you know about childhood thyroid cancer increases after the Chernobyl accident? | Yes | 213(79.2) | 109(67.7) | 0.01 |

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174 When the logistic regression analysis was conducted, following the adjustment

175 for confounding factors, being a PHN at the time of the accident (OR: 2.37, p<0.01),

176 current general anxieties about radiation (OR: 3.56, p<0.001), currently having the

177 materials to obtain knowledge about radiation (OR: 2.11, p<0.01), and having

knowledge about childhood thyroid cancer increases after the Chernobyl accident (OR: 1.69, $p=0.04$) were all significantly associated with anxiety after the FDNPS accident (Table 4).

Table 4. Odds ratios and 95% confidence intervals of the study variables for anxiety (+) when answering questions about radiation, as assessed by the logistic regression analysis.

| Variable | Unit | Odds ratio | 95% confidence interval | p-value |
|--------------------------------------------------------------------------------|---------------------|------------|-------------------------|---------|
| Age | ≥ 40 years old | 0.64 | 0.36-1.15 | 0.13 |
| Manager in the workplace | No | 1.14 | 0.65-2.00 | 0.66 |
| Public health nurse at the time of the accident | No | 2.37 | 1.27-4.42 | <0.01 |
| Current degree of anxiety about radiation | anxiety (+) | 3.56 | 1.82-6.96 | <0.001 |
| Difficulty answering radiation questions in the past | No | 1.27 | 0.76-2.12 | 0.37 |
| Currently have materials to obtain knowledge about radiation | No | 2.11 | 1.248-3.60 | <0.01 |
| Knowledge about childhood thyroid cancer increase after the Chernobyl accident | No | 1.69 | 1.04-2.75 | 0.04 |

186 **Discussion**

187 This study was conducted four years after the FDNPS disaster to provide
188 educational support for PHNs who receive many consultations from residents. In
189 univariate analysis, younger and inexperienced PHNs had higher anxiety with regard to
190 communicating with residents about radiation. When adjusting for other variables, those
191 PHNs who were students at the time of the accident had higher anxiety when
192 communicating with residents about radiation. Our results suggested that experience as
193 a professional during the FDNPS accident is important. Although many of the PHNs
194 had knowledge about the Chernobyl accident, they could not properly communicate the
195 health effects of radiation with the residents, which caused anxiety in the residents after
196 the accident at the FDNPS. In addition, our results showed that having the materials to
197 obtain knowledge about radiation was independently associated with anxiety about the
198 FDNPS accident.

199 These results suggest that continuous effort is necessary to provided education
200 and materials among the PHNs in the Fukushima Prefecture for them to gain knowledge
201 about radiation, including the health effects caused by radiation exposure [17]. Some
202 education initiatives have been undertaken in the prefecture after the nuclear accident,
203 which includes Fukushima Medical University's disaster education for undergraduates
204 and health literacy training for public health nurses for field practitioners [18, 19].
205 Appropriate and sustainable allocation of financial and human resources is needed to
206 continue and expand such activities.

207 The SOC-13 was employed to estimate the stress management capability of the

PHNs in this study. There was no significant difference in the mean points in the SOC-13 observed between the anxiety (-) group and anxiety (+) group. This result, as well as other study, may suggest that factor of lifestyle related [20]. On the other hand, Eriksson et al. showed that individuals with high scores in the SOC-13 are better able to cope with chronic stress than those with low scores [21]. In other studies, the average points of the nursing students at two Japanese universities were 50.2 ± 7.7 and 53.8 ± 10.7 , respectively [22, 23], and the average score of elderly individuals in the Nagasaki Prefecture in Japan was 45.0 [24]. In this study, the average score (43.0 ± 7.7) was lower than those in other studies, and it was substantially lower when compared to those of nursing students. Accordingly, there is a need for planning of stress management capacity improvement for the PHNs in Fukushima Prefecture with low SOC score.

The correspondence of the disaster affected the stress management capability, and might cause a worsening of chronic stress. According to the FHMS, which includes monitoring the mental health and daily lives of Fukushima residents and providing proper care for them, the mental health status of the residents in the Fukushima Prefecture was very poor [13]. Thus, the mental health of the residents was greatly affected by the disaster, and a similar impact could be expected from the PHNs who work in the Fukushima Prefecture. Therefore, mental support is important for the PHNs, as well as for the residents of the Fukushima Prefecture.

The present study has several limitations. For example, we could not obtain sufficient information on the anxiety-related factors, such as detailed consultation

229 contents and other information. However, we believe that this study regarding the PHNs'
230 situation in the Fukushima Prefecture four years after the FDNPS disaster will be very
231 important in the provision of future support.

232 In conclusion, we conducted a survey of the radiation anxiety and stress
233 processing capacity of PHNs in the Fukushima Prefecture four years after the nuclear
234 accident at the FDNPS, and determined that it is important for PHNs to obtain
235 knowledge and teaching materials about radiation. In addition to Fukushima, radiation
236 education programs for PHNs must be established in areas that have nuclear power
237 stations and other nuclear facilities.

238

239 **Footnotes**

240 ***Contributorship statement***

241 • Koji Yoshida conceived and designed the experiments, analyzed the data, wrote the
242 paper, prepared Tables.

243 • Makiko Orita, Akira Ohtsuru, Aya Goto, Atsushi Kumagai and Kiyotaka Yasui
244 contributed materials, reviewed drafts of the paper.

245 • Naomi Hayashida, Takashi Kudo, and Shunichi Yamashita designed the experiments,
246 reviewed drafts of the paper.

247 • Noboru Takamura conceived and designed the experiments, wrote the paper,
248 reviewed drafts of the paper.

249

250 ***Competing interests***

251 There are no competing interests

252

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255

256 ***Data sharing statement***

257 No additional data are available.

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Radiation-related Anxiety among Public Health Nurses in the Fukushima Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station

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Manuscripts

1 Radiation-related Anxiety among Public Health Nurses in the Fukushima
2 Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station

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4 Koji Yoshida^{1,2*}, Makiko Orita³, Aya Goto⁴, Atsushi Kumagai², Kiyotaka Yasui², Akira
5 Ohtsuru⁵, Naomi Hayashida⁶, Takashi Kudo⁷, Shunichi Yamashita⁸, Noboru Takamura³

6
7 1 Department of Health Sciences, Nagasaki University Graduate School of Biomedical
8 Sciences, Nagasaki, Japan

9 2 Education Center for Disaster Medicine, Fukushima Medical University, Fukushima,
10 Japan

11 3 Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute,
12 Nagasaki University, Nagasaki, Japan

13 4 Center for Integrated Science and Humanities, Fukushima Medical University,
14 Fukushima, Japan

15 5 Department of Radiation Health Management, Fukushima Medical University School
16 of Medicine, Fukushima, Japan

17 6 Division of Promotion of Collaborative Research on Radiation and Environment
18 Health Effects, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

19 7 Department of Radioisotope Medicine, Atomic Bomb Disease Institute, Nagasaki
20 University, Nagasaki, Japan

21 8 Department of, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

22

23 *Corresponding author

24 Koji Yoshida, R.N, Ph.D.

25 Department of Health Sciences, Nagasaki University Graduate School of Biomedical

26 Sciences, Nagasaki, Japan

27 1-7-1 Sakamoto, Nagasaki 850-8520, Japan

28 Email: koujiy@nagasaki-u.ac.jp (KY)

29 TEL: +81-95-819-7195

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Abstract

Objective: In Japan, public health nurses (PHNs) play important roles in managing the health of local residents, especially after a disaster. In this study, we assessed radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS).

Methods: We conducted a questionnaire survey among the PHNs (n=430) in July of 2015 via mail by post. The questions included demographic factors (sex, age, and employment position), knowledge about radiation, degree of anxiety about radiation at the time of the FDNPS accident (and at present), by asking them to answer questions about radiation, and the Sense of Coherence-13 (SOC-13). We classified the low and high levels of anxiety by asking them to answer questions about radiation, and compared the anxiety-negative (-) group with the anxiety-positive (+) group.

Results: Of the PHNs, 269 (62.6%) were classified in the anxiety (-) group and 161 (37.4%) were in the anxiety (+) group. When the multivariate logistic regression analysis was conducted, the PHNs at the time of the accident (OR: 2.37, p=0.007), current general anxieties about radiation (OR: 3.56, p<0.001), current possession of materials to obtain knowledge about radiation (OR: 2.11, p=0.006), and knowledge of the childhood thyroid cancer increase after the Chernobyl accident (OR: 1.69, p=0.035) were significantly associated with anxiety after the FDNPS accident. The mean SOC-13 was 43.0±7.7, with no significant difference between anxiety (-) group and anxiety (+) group (p=0.47).

Conclusions: Our study suggested that anxiety about radiation was associated with materials and knowledge about radiation in the PHNs of Fukushima Prefecture four years after the FDNPS accident. It is important for PHNs to obtain knowledge and teaching materials about radiation, and radiation education programs for PHNs must be established in areas that have nuclear facilities.

Keywords: public health nurse, anxiety, radiation, Fukushima Daiichi Nuclear Power Station, Sense of Coherence-13

Strengths and limitations of this study

- We could assess radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the FDNPS.
- We believe that this study regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS disaster will be very important in the provision of future support.
- We could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and other information.
- We were not able to gather sufficient information on stress management factors, such as family issues and marital status.

Introduction

On March 11, 2011, the Great East Japan Earthquake struck the east coast of Japan. This large earthquake and tsunami caused immense damage, including that to the Fukushima Daiichi Nuclear Power Station (FDNPS) [1-4]. After the accident at the FDNPS, the Fukushima prefectural government immediately issued instructions for the evacuation of those areas within a 20 km radius of the FDNPS, and they also instructed sheltering in the areas between 20 km and 30 km from the FDNPS. Beyond the 30 km radius, additional areas were designated “deliberate evacuation areas” if there was concern that the cumulative doses of radiation might reach 20 mSv per year in those areas [2]. Despite the low estimated and measured external and internal exposure doses just after the accident, many residents of the Fukushima Prefecture evacuated inside or outside the prefecture [5-8].

In the report by the World Health Organization (WHO) on the health impacts 20 years after the Chernobyl accident, mental health was described as the most serious public health problem resulting from that nuclear accident [9-11]. Based on the lessons learned from the Chernobyl accident, the Fukushima Health Management Survey (FHMS) was initiated to assess the health impacts, including mental health, of the residents by the Fukushima prefectural government and the Fukushima Medical University [12, 13]. According to the results of this survey, the residents of the Fukushima Prefecture were exposed to a higher risk of not only physical problems, such as diabetes and obesity, but also mental problems (including the risk perception of the

health effects of radiation) [14, 15].

In Japan, public health nurses (PHNs) hold a national license, and many PHNs work for prefectural and municipal bodies, enabling them to provide community health services such as health guidance, home visits, and health education to local residents. In other words, they play important roles in managing the health of local residents, including the time after this disaster. While they were themselves victims of the radiation disaster, they had to respond to the residents' anxieties about radiation exposure, despite their lack of professional knowledge on this topic.

In this study, we conducted a survey to clarify the radiation anxiety and stress processing capacity of the PHNs in the Fukushima Prefecture, after the nuclear accident at the FDNPS.

Materials and Methods

Study population and data collection

We conducted a questionnaire survey among the PHNs in the Fukushima Prefecture located in Northeastern Japan, which was severely affected by the earthquake, tsunami, and FDNPS accident following the Great East Japan Earthquake in 2011. The survey was conducted in July of 2015 via mail by post, and contained questions about the demographic factors (sex, age, activity area, and employment position) and knowledge of the PHNs about radiation before and after the accident at the FDNPS, and their mental health status. In addition, we examined their degree of anxiety about

114 radiation at the time of the FDNPS accident, and at present, by asking them to answer
115 questions about radiation at present. The degree of anxiety was rated on a 10-point
116 Likert scale ranging from no anxiety to having a lot of anxiety; we defined 1-5 as
117 “anxiety (-)” and 6-10 as “anxiety (+).”

118 To measure the PHNs’ stress management capability, we used the Japanese
119 version of the Sense of Coherence-13 (SOC-13). The SOC-13 consists of three
120 dimensions (comprehensibility, manageability, and meaningfulness) that are equally
121 weighted to create an overall (total) score. The score ranges from 7-91, with a higher
122 score representing a stronger sense of coherence [16].

124 *Statistical analysis*

125 We classified the low and high levels of anxiety by asking them to answer
126 questions about radiation, and compared the anxiety (-) group and anxiety (+) group by
127 using the chi-square test and t-test as univariate analyses. A multiple logistic regression
128 analysis was then used to calculate the odds ratio (OR), and its 95% confidence interval
129 (95% CI) was used to identify the factors independently associated with the anxiety
130 level. A p-value of less than 0.05 was considered to be significant, and the statistical
131 analysis was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

133 *Ethics statement*

134 This study was approved by the ethics committee of the Fukushima Medical

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6 135 University (No. 2251), and conducted in accordance with the guidelines specified in the

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8 136 Declaration of Helsinki.

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138 **Results**

139 A total of 458 PHNs responded to the survey, and 430 of those PHNs (93.9%)
140 completed all of the questions. The number of women was 416 (96.7%), and 153
141 (35.6%) were 50 years old or older. The number of PHNs with less than 10 years of
142 working experience was 124 (22.8%), and 306 (71.2%) had ten years or more. There
143 were 119 participants (27.7%) with managerial positions. At the time of the accident,
144 330 (76.8%) worked as PHNs and 62 (14.4%) were still in training. The number of
145 those in Hamadori, which became the evacuation area of the FDNPS accident, was 83
146 (19.3%) (Table 1).

147

148 **Table 1. Basic characteristics of the study participants.**

| Variable | | Number (%) |
|----------------------------------------|------------------------------------|------------|
| Gender | Women | 416(96.7) |
| | Men | 14(3.3) |
| Age | 20-29 years old | 92(21.4) |
| | 30-39 years old | 72(16.7) |
| | 40-49 years old | 113(26.3) |
| | ≥50 years old | 153(35.6) |
| Tenure as a public health nurse | <10 years | 124(28.8) |
| | ≥10 years | 306(71.2) |
| Nursing experience in a hospital | Yes | 149(34.7) |
| | No | 281(65.3) |
| Activity area | Hamadori | 83(19.3) |
| | Other area (Nakadori, Aizu et al.) | 347(80.7) |
| Position in the workplace | Manager (director, chief) | 119(27.7) |
| | Staff | 311(72.3) |
| Occupation at the time of the accident | Public health nurse | 330(76.8) |
| | Other occupations (mostly nurses) | 38(8.8) |
| | Students | 62(14.4) |

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Of the PHNs, 269 were classified in the anxiety (-) group and 161 were in the anxiety (+) group (Table 2). A significantly higher ratio of PHNs younger than 40 years old was observed in the anxiety (+) group ($p<0.001$, Table 2). Likewise, higher ratios of PHNs with less than 10 years of working experience, staff positions, and nursing licenses were observed in the anxiety (+) group ($p<0.001$, respectively, Table 2). On the other hand, no significant differences were observed between the two groups in the activity area, education curriculum, and seminars before or after the accident ($p=0.62$, $p=0.16$, $p=0.60$, and $p=0.13$, respectively, Table 2). In addition, there was no significant difference in the mean points in the SOC-13 observed between the two groups ($p=0.47$, Table 2).

Table 2. Participant's demographic factors, educational history, and mental health via anxiety with regard to questions about radiation after the FNPS accident.

| Variable | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|---------------------------------------------|------------------------------------|----------------------------|----------------------------|----------|
| Gender | Women/ Men | 262(97.4)/ 7(2.6) | 154(95.7)/ 7(4.3) | 0.32 |
| Age | <40 years old/ ≥40 years old | 77(28.6)/ 192(71.4) | 87(54.0)/ 74(46.0) | <0.001 |
| Working experience as a public health nurse | <10 years/ ≥10 years | 53(19.7)/ 216(80.3) | 71(44.1)/ 90(55.9) | <0.001 |
| Activity area | Hamadori/ Other area | 54(20.1)/ 215(79.9) | 29(18.0)/ 132(72.0) | 0.62 |
| Position in the workplace | Manager/ Staff | 88(32.7)/ 181(67.3) | 31(19.3)/ 130(80.7) | 0.003 |
| Occupation at the time of the accident | PHNs/ Others (nurses, students) | 230(85.5)/ 39(14.5) | 100(62.1)/ 61(37.9) | <0.001 |

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|------------------------------------------------------------------|-----------------|------------------------|-----------------------|------|
| Did you have children ≤15 years old at the time of the accident? | Yes | 110(40.9) | 59(36.6) | 0.42 |
| Education history in curriculum | Yes | 114(42.4) | 80(49.7) | 0.16 |
| Education history in seminar before the accident | Yes | 25(9.3) | 12(7.5) | 0.60 |
| Education history in seminar after the accident | Yes | 247(91.8) | 140(87.0) | 0.13 |
| Frequency of participation in seminars | Once/ Plural | 47(19.0)/ 200(81.0) | 42(29.6)/ 98(70.4) | 0.02 |
| SOC-13 total points | Mean | 44.0 | 41.4 | 0.47 |

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164 In the anxiety (+) group, the ratio of those having current anxiety about radiation

165 was significantly higher than that in the anxiety (-) group ($p<0.001$, Table 3). On the

166 other hand, in the anxiety (-) group, the ratios with difficulty answering the questions

167 about radiation, currently having the materials to obtain knowledge about radiation, and

168 having knowledge about childhood thyroid cancer increases after the Chernobyl

169 accident were significantly higher than in the anxiety (+) group ($p<0.05$, $p<0.01$, and

170 $p<0.05$, respectively, Table 3). However, there were no significant changes between the

171 two groups in the anxiety about radiation at the time of the accident and the recognition

172 of health effects (such as late effects and genetic effects) due to radiation exposure

173 ($p=0.68$, $p=0.79$, and $p=0.20$, respectively, Table 3).

174

175 **Table 3. Participants' anxiety, recognition, and knowledge about radiation via**

176 **anxiety with regard to answering the questions about radiation after the FDNPS**

177 **accident.**

| Question | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------|----------------------------|----------|
| Degree of anxiety about radiation at the time of the FDNPS accident | anxiety (-)/ anxiety (+) | 99(36.8)/ 170(63.2) | 56(34.8)/ 105(65.2) | 0.68 |
| Degree of anxiety about radiation currently | anxiety (-)/ anxiety (+) | 251(93.3)/ 18(6.7) | 130(80.7)/ 31(19.3) | <0.001 |
| Do you think that delayed effects such as malignancies occur due to radiation exposure following the Fukushima accident? | Yes | 37(13.8) | 33(20.5) | 0.79 |
| Do you think that genetic effects in offspring occur due to radiation exposure following the Fukushima accident? | Yes | 33(12.3) | 27(16.8) | 0.20 |
| Did you have a difficult time answering the questions about radiation? | Yes | 216(80.3) | 115(71.4) | 0.04 |
| Did you have the materials to obtain knowledge about radiation at the time of the accident? | Yes | 87(32.3) | 40(24.8) | 0.10 |
| Do you currently have the materials to obtain knowledge about radiation? | Yes | 233(86.6) | 118(73.3) | 0.01 |
| Did you know about the three principles of radiation protection? | Yes | 64(23.8) | 42(26.1) | 0.64 |
| Did you know about the annual dose limit for the general public? | Yes | 20(12.4) | 11(6.8) | 0.99 |
| Did you know about the half-life of radioactive substances? | Yes | 129(48.0) | 77(47.8) | 0.99 |
| Did you know about childhood thyroid cancer increases after the Chernobyl accident? | Yes | 213(79.2) | 109(67.7) | 0.01 |

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179 When the logistic regression analysis was conducted, following the adjustment
 180 for confounding factors, being a PHN at the time of the accident (OR: 2.37, $p<0.01$),
 181 current general anxieties about radiation (OR: 3.56, $p<0.001$), currently having the
 182 materials to obtain knowledge about radiation (OR: 2.11, $p<0.01$), and having

183 knowledge about childhood thyroid cancer increases after the Chernobyl accident (OR:
184 1.69, p=0.04) were all significantly associated with anxiety after the FDNPS accident
185 (Table 4).

186
187 **Table 4. Odds ratios and 95% confidence intervals of the study variables for**
188 **anxiety (+) by asking them to answer questions about radiation, as assessed by the**
189 **logistic regression analysis.**

| Variable | Unit | Odds ratio | 95% confidence interval | p-value |
|--------------------------------------------------------------------------------|---------------|------------|-------------------------|---------|
| Age | ≥40 years old | 0.64 | 0.36-1.15 | 0.13 |
| Manager in the workplace | No | 1.14 | 0.65-2.00 | 0.66 |
| Public health nurse at the time of the accident | No | 2.37 | 1.27-4.42 | <0.01 |
| Current degree of anxiety about radiation | anxiety (+) | 3.56 | 1.82-6.96 | <0.001 |
| Difficulty answering radiation questions in the past | No | 1.27 | 0.76-2.12 | 0.37 |
| Currently have materials to obtain knowledge about radiation | No | 2.11 | 1.248-3.60 | <0.01 |
| Knowledge about childhood thyroid cancer increase after the Chernobyl accident | No | 1.69 | 1.04-2.75 | 0.04 |

191 Discussion

192 This study was conducted four years after the FDNPS disaster to provide
193 educational support for PHNs who receive many consultations from residents. In
194 univariate analysis, younger and inexperienced PHNs had higher anxiety with regard to
195 communicating with residents about radiation. When adjusting for other variables, those
196 PHNs who were students at the time of the accident had higher anxiety when
197 communicating with residents about radiation. Our results suggested that experience as
198 a professional during the FDNPS accident is important. Although many of the PHNs
199 had knowledge about the Chernobyl accident, they could not properly communicate the
200 health effects of radiation with the residents, which caused anxiety in the residents after
201 the accident at the FDNPS. In addition, our results showed that having the materials to
202 obtain knowledge about radiation was independently associated with anxiety about the
203 FDNPS accident.

204 These results suggest that continuous effort is necessary to provided education
205 and materials among the PHNs in the Fukushima Prefecture for them to gain knowledge
206 about radiation, including the health effects caused by radiation exposure [17]. Some
207 education initiatives have been undertaken in the prefecture after the nuclear accident,
208 which includes Fukushima Medical University's disaster education for undergraduates
209 and health literacy training for public health nurses for field practitioners [18, 19].
210 Appropriate and sustainable allocation of financial and human resources is needed to
211 continue and expand such activities.

212 The SOC-13 was employed to estimate the stress management capability of the

PHNs in this study. There was no significant difference in the mean points in the SOC-13 observed between the anxiety (-) group and anxiety (+) group. This result, as well as other study, may suggest that factor of lifestyle related [20]. On the other hand, Eriksson et al. showed that individuals with high scores in the SOC-13 are better able to cope with chronic stress than those with low scores [21]. In other studies, the average points of the nursing students at two Japanese universities were 50.2 ± 7.7 and 53.8 ± 10.7 , respectively [22, 23], and the average score of elderly individuals in the Nagasaki Prefecture in Japan was 45.0 [24]. In this study, the average score (43.0 ± 7.7) was lower than those in other studies, and it was substantially lower when compared to those of nursing students. Accordingly, there is a need for planning of stress management capacity improvement for the PHNs in Fukushima Prefecture with low SOC score.

The correspondence of the disaster affected the stress management capability, and might cause a worsening of chronic stress. According to the FHMS, which includes monitoring the mental health and daily lives of Fukushima residents and providing proper care for them, the mental health status of the residents in the Fukushima Prefecture was very poor [13]. Thus, the mental health of the residents was greatly affected by the disaster, and a similar impact could be expected from the PHNs who work in the Fukushima Prefecture. Therefore, mental support is important for the PHNs, as well as for the residents of the Fukushima Prefecture.

The present study has several limitations. First, we could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and

other information. Second, we were not able to gather sufficient information on stress management factors, such as family issues and marital status. However, we believe that this study regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS disaster will be very important in the provision of future support.

In conclusion, we conducted a survey of the radiation anxiety and stress processing capacity of PHNs in the Fukushima Prefecture four years after the nuclear accident at the FDNPS, and determined that it is important for PHNs to obtain knowledge and teaching materials about radiation. In order to develop workers' capabilities that can correspond to the timing of radiation disasters in the future, radiation education programs for PHNs and nursing students must be established in areas that have nuclear power stations and other nuclear facilities.

Footnotes

Contributorship statement

• Koji Yoshida conceived and designed the experiments, analyzed the data, wrote the paper, prepared Tables.

• Makiko Orita, Akira Ohtsuru, Aya Goto, Atsushi Kumagai and Kiyotaka Yasui contributed materials, reviewed drafts of the paper.

• Naomi Hayashida, Takashi Kudo, and Shunichi Yamashita designed the experiments, reviewed drafts of the paper.

• Noboru Takamura conceived and designed the experiments, wrote the paper,

255 reviewed drafts of the paper.

256

257 ***Competing interests***

258 There are no competing interests

259

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263 ***Data sharing statement***

264 No additional data are available.

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Radiation-related Anxiety among Public Health Nurses in the Fukushima Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station : a cross-sectional study.



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Manuscripts

1 Radiation-related Anxiety among Public Health Nurses in the Fukushima
2 Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station: a
3 cross-sectional study.

4
5 Koji Yoshida^{1,2*}, Makiko Orita³, Aya Goto⁴, Atsushi Kumagai², Kiyotaka Yasui², Akira
6 Ohtsuru⁵, Naomi Hayashida⁶, Takashi Kudo⁷, Shunichi Yamashita⁸, Noboru Takamura³

7
8 1 Department of Health Sciences, Nagasaki University Graduate School of Biomedical
9 Sciences, Nagasaki, Japan

10 2 Education Center for Disaster Medicine, Fukushima Medical University, Fukushima,
11 Japan

12 3 Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute,
13 Nagasaki University, Nagasaki, Japan

14 4 Center for Integrated Science and Humanities, Fukushima Medical University,
15 Fukushima, Japan

16 5 Department of Radiation Health Management, Fukushima Medical University School
17 of Medicine, Fukushima, Japan

18 6 Division of Promotion of Collaborative Research on Radiation and Environment
19 Health Effects, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

20 7 Department of Radioisotope Medicine, Atomic Bomb Disease Institute, Nagasaki
21 University, Nagasaki, Japan

22 8 Department of, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

23

24 *Corresponding author

25 Koji Yoshida, R.N, Ph.D.

26 Department of Health Sciences, Nagasaki University Graduate School of Biomedical

27 Sciences, Nagasaki, Japan

28 1-7-1 Sakamoto, Nagasaki 850-8520, Japan

29 Email: koujiy@nagasaki-u.ac.jp (KY)

30 TEL: +81-95-819-7195

31

Abstract

Objective: In Japan, public health nurses (PHNs) play important roles in managing the health of local residents, especially after a disaster. In this study, we assessed radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS).

Methods: We conducted a questionnaire survey among the PHNs (n=430) in July of 2015 via mail by post. The questions included demographic factors (sex, age, and employment position), knowledge about radiation, degree of anxiety about radiation at the time of the FDNPS accident (and at present), by asking them to answer questions about radiation, and the Sense of Coherence-13 (SOC-13). We classified the low and high levels of anxiety by asking them to answer questions about radiation, and compared the anxiety-negative (-) group with the anxiety-positive (+) group.

Results: Of the PHNs, 269 (62.6%) were classified in the anxiety (-) group and 161 (37.4%) were in the anxiety (+) group. When the multivariate logistic regression analysis was conducted, the PHNs at the time of the accident (OR: 2.37, p=0.007), current general anxieties about radiation (OR: 3.56, p<0.001), current possession of materials to obtain knowledge about radiation (OR: 2.11, p=0.006), and knowledge of the childhood thyroid cancer increase after the Chernobyl accident (OR: 1.69, p=0.035) were significantly associated with anxiety after the FDNPS accident. The mean SOC-13 was 43.0±7.7, with no significant difference between anxiety (-) group and anxiety (+) group (p=0.47).

Conclusions: Our study suggested that anxiety about radiation was associated with materials and knowledge about radiation in the PHNs of Fukushima Prefecture four years after the FDNPS accident. It is important for PHNs to obtain knowledge and teaching materials about radiation, and radiation education programs for PHNs must be established in areas that have nuclear facilities.

Keywords: public health nurse, anxiety, radiation, Fukushima Daiichi Nuclear Power Station, Sense of Coherence-13

Strengths and limitations of this study

- We could assess radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the FDNPS.
- We believe that this study regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS disaster will be very important in the provision of future support.
- We could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and other information.
- We were not able to gather sufficient information on stress management factors, such as family issues and marital status.

Introduction

On March 11, 2011, the Great East Japan Earthquake struck the east coast of Japan. This large earthquake and tsunami caused immense damage, including that to the Fukushima Daiichi Nuclear Power Station (FDNPS) [1-4]. After the accident at the FDNPS, the Fukushima prefectural government immediately issued instructions for the evacuation of those areas within a 20 km radius of the FDNPS, and they also instructed sheltering in the areas between 20 km and 30 km from the FDNPS. Beyond the 30 km radius, additional areas were designated “deliberate evacuation areas” if there was concern that the cumulative doses of radiation might reach 20 mSv per year in those areas [2]. Despite the low estimated and measured external and internal exposure doses just after the accident, many residents of the Fukushima Prefecture evacuated inside or outside the prefecture [5-8].

In the report by the World Health Organization (WHO) on the health impacts 20 years after the Chernobyl accident, mental health was described as the most serious public health problem resulting from that nuclear accident [9-11]. Based on the lessons learned from the Chernobyl accident, the Fukushima Health Management Survey (FHMS) was initiated to assess the health impacts, including mental health, of the residents by the Fukushima prefectural government and the Fukushima Medical University [12, 13]. According to the results of this survey, the residents of the Fukushima Prefecture were exposed to a higher risk of not only physical problems, such as diabetes and obesity, but also mental problems (including the risk perception of the

health effects of radiation) [14, 15].

In Japan, public health nurses (PHNs) hold a national license, and many PHNs work for prefectural and municipal bodies, enabling them to provide community health services such as health guidance, home visits, and health education to local residents. In other words, they play important roles in managing the health of local residents, including the time after this disaster. While they were themselves victims of the radiation disaster, they had to respond to the residents' anxieties about radiation exposure, despite their lack of professional knowledge on this topic.

In this study, we conducted a survey to clarify the radiation anxiety and stress processing capacity of the PHNs in the Fukushima Prefecture, after the nuclear accident at the FDNPS.

Materials and Methods

Study population and data collection

We conducted a questionnaire survey among the PHNs in the Fukushima Prefecture located in Northeastern Japan, which was severely affected by the earthquake, tsunami, and FDNPS accident following the Great East Japan Earthquake in 2011. We initially distributed questionnaires to 509 PHNs, and we obtained responses from 458 PHNs (90.0%), after excluding 28 PHNs with insufficient responses. The survey was conducted in July of 2015 via mail by post, and contained questions about the demographic factors (sex, age, activity area, and employment position) and knowledge

115 of the PHNs about radiation before and after the accident at the FDNPS, and their
116 mental health status. In addition, we examined their degree of anxiety about radiation at
117 the time of the FDNPS accident, and at present, by asking them to answer questions
118 about radiation at present. The degree of anxiety was rated on a 10-point Likert scale
119 ranging from no anxiety to having a lot of anxiety; we defined 1-5 as “anxiety (-)” and
120 6-10 as “anxiety (+).”

121 To measure the PHNs’ stress management capability, we used the Japanese
122 version of the Sense of Coherence-13 (SOC-13). The SOC-13 consists of three
123 dimensions (comprehensibility, manageability, and meaningfulness) that are equally
124 weighted to create an overall (total) score. The score ranges from 7-91, with a higher
125 score representing a stronger sense of coherence [16].

127 *Statistical analysis*

128 We classified the low and high levels of anxiety by asking them to answer
129 questions about radiation, and compared the anxiety (-) group and anxiety (+) group by
130 using the chi-square test and t-test as univariate analyses. A multiple logistic regression
131 analysis was then used to calculate the odds ratio (OR), and its 95% confidence interval
132 (95% CI) was used to identify the factors independently associated with the anxiety
133 level. A p-value of less than 0.05 was considered to be significant, and the statistical
134 analysis was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

135

136 ***Ethics statement***

137 This study was approved by the ethics committee of the Fukushima Medical
138 University (No. 2251), and conducted in accordance with the guidelines specified in the
139 Declaration of Helsinki.

140

141 **Results**

142 A total of 458 PHNs responded to the survey, and 430 of those PHNs (93.9%)
143 completed all of the questions. The number of women was 416 (96.7%), and 153
144 (35.6%) were 50 years old or older. The number of PHNs with less than 10 years of
145 working experience was 124 (22.8%), and 306 (71.2%) had ten years or more. There
146 were 119 participants (27.7%) with managerial positions. At the time of the accident,
147 330 (76.8%) worked as PHNs and 62 (14.4%) were still in training. The number of
148 those in Hamadori, which became the evacuation area of the FDNPS accident, was 83
149 (19.3%) (Table 1).

150

151 **Table 1. Basic characteristics of the study participants.**

| Variable | | Number (%) |
|----------------------------------------|------------------------------------|------------|
| Gender | Women | 416(96.7) |
| | Men | 14(3.3) |
| Age | 20-29 years old | 92(21.4) |
| | 30-39 years old | 72(16.7) |
| | 40-49 years old | 113(26.3) |
| | ≥50 years old | 153(35.6) |
| Tenure as a public health nurse | <10 years | 124(28.8) |
| | ≥10 years | 306(71.2) |
| Nursing experience in a hospital | Yes | 149(34.7) |
| | No | 281(65.3) |
| Activity area | Hamadori | 83(19.3) |
| | Other area (Nakadori, Aizu et al.) | 347(80.7) |
| Position in the workplace | Manager (director, chief) | 119(27.7) |
| | Staff | 311(72.3) |
| Occupation at the time of the accident | Public health nurse | 330(76.8) |
| | Other occupations (mostly nurses) | 38(8.8) |
| | Students | 62(14.4) |

152

Of the PHNs, 269 were classified in the anxiety (-) group and 161 were in the anxiety (+) group (Table 2). A significantly higher ratio of PHNs younger than 40 years old was observed in the anxiety (+) group ($p<0.001$, Table 2). Likewise, higher ratios of PHNs with less than 10 years of working experience, staff positions, and nursing licenses were observed in the anxiety (+) group ($p<0.001$, respectively, Table 2). On the other hand, no significant differences were observed between the two groups in the activity area, education curriculum, and seminars before or after the accident ($p=0.62$, $p=0.16$, $p=0.60$, and $p=0.13$, respectively, Table 2). In addition, there was no significant difference in the mean points in the SOC-13 observed between the two groups ($p=0.47$, Table 2).

Table 2. Participant's demographic factors, educational history, and mental health via anxiety with regard to questions about radiation after the FNPS accident.

| Variable | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|---------------------------------------------|------------------------------------|----------------------------|----------------------------|----------|
| Gender | Women/ Men | 262(97.4)/ 7(2.6) | 154(95.7)/ 7(4.3) | 0.32 |
| Age | <40 years old/ ≥40 years old | 77(28.6)/ 192(71.4) | 87(54.0)/ 74(46.0) | <0.001 |
| Working experience as a public health nurse | <10 years/ ≥10 years | 53(19.7)/ 216(80.3) | 71(44.1)/ 90(55.9) | <0.001 |
| Activity area | Hamadori/ Other area | 54(20.1)/ 215(79.9) | 29(18.0)/ 132(72.0) | 0.62 |
| Position in the workplace | Manager/ Staff | 88(32.7)/ 181(67.3) | 31(19.3)/ 130(80.7) | 0.003 |
| Occupation at the time of the accident | PHNs/ Others (nurses, students) | 230(85.5)/ 39(14.5) | 100(62.1)/ 61(37.9) | <0.001 |

| | | | | |
|------------------------------------------------------------------|-----------------|------------------------|-----------------------|------|
| Did you have children ≤15 years old at the time of the accident? | Yes | 110(40.9) | 59(36.6) | 0.42 |
| Education history in curriculum | Yes | 114(42.4) | 80(49.7) | 0.16 |
| Education history in seminar before the accident | Yes | 25(9.3) | 12(7.5) | 0.60 |
| Education history in seminar after the accident | Yes | 247(91.8) | 140(87.0) | 0.13 |
| Frequency of participation in seminars | Once/ Plural | 47(19.0)/ 200(81.0) | 42(29.6)/ 98(70.4) | 0.02 |
| SOC-13 total points | Mean | 44.0 | 41.4 | 0.47 |

166

167 In the anxiety (+) group, the ratio of those having current anxiety about radiation

168 was significantly higher than that in the anxiety (-) group ($p<0.001$, Table 3). On the

169 other hand, in the anxiety (-) group, the ratios with difficulty answering the questions

170 about radiation, currently having the materials to obtain knowledge about radiation, and

171 having knowledge about childhood thyroid cancer increases after the Chernobyl

172 accident were significantly higher than in the anxiety (+) group ($p<0.05$, $p<0.01$, and

173 $p<0.05$, respectively, Table 3). However, there were no significant changes between the

174 two groups in the anxiety about radiation at the time of the accident and the recognition

175 of health effects (such as late effects and genetic effects) due to radiation exposure

176 ($p=0.68$, $p=0.79$, and $p=0.20$, respectively, Table 3).

177

178 **Table 3. Participants' anxiety, recognition, and knowledge about radiation via**

179 **anxiety with regard to answering the questions about radiation after the FDNPS**

180 **accident.**

| Question | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------|----------------------------|----------|
| Degree of anxiety about radiation at the time of the FDNPS accident | anxiety (-)/ anxiety (+) | 99(36.8)/ 170(63.2) | 56(34.8)/ 105(65.2) | 0.68 |
| Degree of anxiety about radiation currently | anxiety (-)/ anxiety (+) | 251(93.3)/ 18(6.7) | 130(80.7)/ 31(19.3) | <0.001 |
| Do you think that delayed effects such as malignancies occur due to radiation exposure following the Fukushima accident? | Yes | 37(13.8) | 33(20.5) | 0.79 |
| Do you think that genetic effects in offspring occur due to radiation exposure following the Fukushima accident? | Yes | 33(12.3) | 27(16.8) | 0.20 |
| Did you have a difficult time answering the questions about radiation? | Yes | 216(80.3) | 115(71.4) | 0.04 |
| Did you have the materials to obtain knowledge about radiation at the time of the accident? | Yes | 87(32.3) | 40(24.8) | 0.10 |
| Do you currently have the materials to obtain knowledge about radiation? | Yes | 233(86.6) | 118(73.3) | 0.01 |
| Did you know about the three principles of radiation protection? | Yes | 64(23.8) | 42(26.1) | 0.64 |
| Did you know about the annual dose limit for the general public? | Yes | 20(12.4) | 11(6.8) | 0.99 |
| Did you know about the half-life of radioactive substances? | Yes | 129(48.0) | 77(47.8) | 0.99 |
| Did you know about childhood thyroid cancer increases after the Chernobyl accident? | Yes | 213(79.2) | 109(67.7) | 0.01 |

181

182 When the logistic regression analysis was conducted, following the adjustment
 183 for confounding factors, being a PHN at the time of the accident (OR: 2.37, $p<0.01$),
 184 current general anxieties about radiation (OR: 3.56, $p<0.001$), currently having the
 185 materials to obtain knowledge about radiation (OR: 2.11, $p<0.01$), and having

186 knowledge about childhood thyroid cancer increases after the Chernobyl accident (OR:
187 1.69, p=0.04) were all significantly associated with anxiety after the FDNPS accident
188 (Table 4).

189
190 **Table 4. Odds ratios and 95% confidence intervals of the study variables for**
191 **anxiety (+) by asking them to answer questions about radiation, as assessed by the**
192 **logistic regression analysis.**

| Variable | Unit | Odds ratio | 95% confidence interval | p-value |
|--------------------------------------------------------------------------------|---------------|------------|-------------------------|---------|
| Age | ≥40 years old | 0.64 | 0.36-1.15 | 0.13 |
| Manager in the workplace | No | 1.14 | 0.65-2.00 | 0.66 |
| Public health nurse at the time of the accident | No | 2.37 | 1.27-4.42 | <0.01 |
| Current degree of anxiety about radiation | anxiety (+) | 3.56 | 1.82-6.96 | <0.001 |
| Difficulty answering radiation questions in the past | No | 1.27 | 0.76-2.12 | 0.37 |
| Currently have materials to obtain knowledge about radiation | No | 2.11 | 1.248-3.60 | <0.01 |
| Knowledge about childhood thyroid cancer increase after the Chernobyl accident | No | 1.69 | 1.04-2.75 | 0.04 |

193

194 Discussion

195 This study was conducted four years after the FDNPS disaster to provide
196 educational support for PHNs who receive many consultations from residents. In
197 univariate analysis, younger and inexperienced PHNs had higher anxiety with regard to
198 communicating with residents about radiation. When adjusting for other variables, those
199 PHNs who were students at the time of the accident had higher anxiety when
200 communicating with residents about radiation. Our results suggested that experience as
201 a professional during the FDNPS accident is important. Although many of the PHNs
202 had knowledge about the Chernobyl accident, they could not properly communicate the
203 health effects of radiation with the residents, which caused anxiety in the residents after
204 the accident at the FDNPS. In addition, our results showed that having the materials to
205 obtain knowledge about radiation was independently associated with anxiety about the
206 FDNPS accident.

207 These results suggest that continuous effort is necessary to provided education
208 and materials among the PHNs in the Fukushima Prefecture for them to gain knowledge
209 about radiation, including the health effects caused by radiation exposure [17]. Some
210 education initiatives have been undertaken in the prefecture after the nuclear accident,
211 which includes Fukushima Medical University's disaster education for undergraduates
212 and health literacy training for public health nurses for field practitioners [18, 19].
213 Appropriate and sustainable allocation of financial and human resources is needed to
214 continue and expand such activities.

215 The SOC-13 was employed to estimate the stress management capability of the

PHNs in this study. There was no significant difference in the mean points in the SOC-13 observed between the anxiety (-) group and anxiety (+) group. This result, as well as other study, may suggest that factor of lifestyle related [20]. On the other hand, Eriksson et al. showed that individuals with high scores in the SOC-13 are better able to cope with chronic stress than those with low scores [21]. In other studies, the average points of the nursing students at two Japanese universities were 50.2 ± 7.7 and 53.8 ± 10.7 , respectively [22, 23], and the average score of elderly individuals in the Nagasaki Prefecture in Japan was 45.0 [24]. In this study, the average score (43.0 ± 7.7) was lower than those in other studies, and it was substantially lower when compared to those of nursing students. Accordingly, there is a need for planning of stress management capacity improvement for the PHNs in Fukushima Prefecture with low SOC score.

The correspondence of the disaster affected the stress management capability, and might cause a worsening of chronic stress. According to the FHMS, which includes monitoring the mental health and daily lives of Fukushima residents and providing proper care for them, the mental health status of the residents in the Fukushima Prefecture was very poor [13]. Thus, the mental health of the residents was greatly affected by the disaster, and a similar impact could be expected from the PHNs who work in the Fukushima Prefecture. Therefore, mental support is important for the PHNs, as well as for the residents of the Fukushima Prefecture.

The present study has several limitations. First, we could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and

237 other information. Second, we were not able to gather sufficient information on stress
238 management factors, such as family issues and marital status. Third, this study might
239 have caused a recall bias on the study participants. However, we believe that this study
240 regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS
241 disaster will be very important in the provision of future support.

242 In conclusion, we conducted a survey of the radiation anxiety and stress
243 processing capacity of PHNs in the Fukushima Prefecture four years after the nuclear
244 accident at the FDNPS, and determined that it is important for PHNs to obtain
245 knowledge and teaching materials about radiation. In order to develop workers'
246 capabilities that can correspond to the timing of radiation disasters in the future,
247 radiation education programs for PHNs and nursing students must be established in
248 areas that have nuclear power stations and other nuclear facilities.

250 Footnotes

251 Contributorship statement

252 • Koji Yoshida conceived and designed the experiments, analyzed the data, wrote the
253 paper, prepared Tables.

254 • Makiko Orita, Akira Ohtsuru, Aya Goto, Atsushi Kumagai and Kiyotaka Yasui
255 contributed materials, reviewed drafts of the paper.

256 • Naomi Hayashida, Takashi Kudo, and Shunichi Yamashita designed the experiments,
257 reviewed drafts of the paper.

· Noboru Takamura conceived and designed the experiments, wrote the paper,
reviewed drafts of the paper.

Competing interests

There are no competing interests

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Data sharing statement

No additional data are available.

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| | Item No | Recommendation |
|------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Title and abstract | ✓ 1 | (a) Indicate the study’s design with a commonly used term in the title or the abstract Pages 1 and 3 (b) Provide in the abstract an informative and balanced summary of what was done and what was found Page 3 |
| Introduction | | |
| Background/rationale | ✓ 2 | Explain the scientific background and rationale for the investigation being reported Pages 5-6 |
| Objectives | ✓ 3 | State specific objectives, including any prespecified hypotheses Page 6 |
| Methods | | |
| Study design | ✓ 4 | Present key elements of study design early in the paper Page 6 |
| Setting | ✓ 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 6 |
| Participants | ✓ 6 | (a) Give the eligibility criteria, and the sources and methods of selection of participants Page 6 |
| Variables | ✓ 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pages 7-8 |
| Data sources/ measurement | ✓ 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 Pages 6-7 |
| Bias | ✓ 9 | Describe any efforts to address potential sources of bias Page 16 |
| Study size | ✓ 10 | Explain how the study size was arrived at Page 6 |
| Quantitative variables | ✓ 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pages 7-8 |
| Statistical methods | ✓ 12 | (a) Describe all statistical methods, including those used to control for confounding Pages 7-8 (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses |
| Results | | |
| Participants | ✓ 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 Pages 6 and 9 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram |
| Descriptive data | ✓ 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Pages 6 and 9 (b) Indicate number of participants with missing data for each variable of interest |
| Outcome data | ✓ 15* | Report numbers of outcome events or summary measures Pages 9-13 |
| Main results | ✓ 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 Table 4 (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 | ✓ 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Not applicable |
| Discussion | | |
| Key results | ✓ 18 | Summarise key results with reference to study objectives Page 14 |
| Limitations | ✓ 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Pages 16-17 |
| Interpretation | ✓ 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pages 16-17 |
| Generalisability | ✓ 21 | Discuss the generalisability (external validity) of the study results Page 17 |
| Other information | | |
| Funding | ✓ 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 Page 17 |

*Give information separately for exposed and unexposed groups.

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.

Radiation-related Anxiety among Public Health Nurses in the Fukushima Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station : a cross-sectional study.



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| | |

1 Radiation-related Anxiety among Public Health Nurses in the Fukushima
2 Prefecture after the Accident at the Fukushima Daiichi Nuclear Power Station: a
3 cross-sectional study.

4
5 Koji Yoshida^{1,2*}, Makiko Orita³, Aya Goto⁴, Atsushi Kumagai², Kiyotaka Yasui², Akira
6 Ohtsuru⁵, Naomi Hayashida⁶, Takashi Kudo⁷, Shunichi Yamashita⁸, Noboru Takamura³

7
8 1 Department of Health Sciences, Nagasaki University Graduate School of Biomedical
9 Sciences, Nagasaki, Japan

10 2 Education Center for Disaster Medicine, Fukushima Medical University, Fukushima,
11 Japan

12 3 Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute,
13 Nagasaki University, Nagasaki, Japan

14 4 Center for Integrated Science and Humanities, Fukushima Medical University,
15 Fukushima, Japan

16 5 Department of Radiation Health Management, Fukushima Medical University School
17 of Medicine, Fukushima, Japan

18 6 Division of Promotion of Collaborative Research on Radiation and Environment
19 Health Effects, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

20 7 Department of Radioisotope Medicine, Atomic Bomb Disease Institute, Nagasaki
21 University, Nagasaki, Japan

22 8 Department of, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

23

24 *Corresponding author

25 Koji Yoshida, R.N, Ph.D.

26 Department of Health Sciences, Nagasaki University Graduate School of Biomedical

27 Sciences, Nagasaki, Japan

28 1-7-1 Sakamoto, Nagasaki 850-8520, Japan

29 Email: koujiy@nagasaki-u.ac.jp (KY)

30 TEL: +81-95-819-7195

31

Abstract

Objective: In Japan, public health nurses (PHNs) play important roles in managing the health of local residents, especially after a disaster. In this study, we assessed radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS).

Methods: We conducted a questionnaire survey among the PHNs (n=430) in July of 2015 via mail by post. The questions included demographic factors (sex, age, and employment position), knowledge about radiation, degree of anxiety about radiation at the time of the FDNPS accident (and at present), by asking them to answer questions about radiation, and the Sense of Coherence-13 (SOC-13). We classified the low and high levels of anxiety by asking them to answer questions about radiation, and compared the anxiety-negative (-) group with the anxiety-positive (+) group.

Results: Of the PHNs, 269 (62.6%) were classified in the anxiety (-) group and 161 (37.4%) were in the anxiety (+) group. When the multivariate logistic regression analysis was conducted, the PHNs at the time of the accident (OR: 2.37, p=0.007), current general anxieties about radiation (OR: 3.56, p<0.001), current possession of materials to obtain knowledge about radiation (OR: 2.11, p=0.006), and knowledge of the childhood thyroid cancer increase after the Chernobyl accident (OR: 1.69, p=0.035) were significantly associated with anxiety after the FDNPS accident. The mean SOC-13 was 43.0±7.7, with no significant difference between anxiety (-) group and anxiety (+) group (p=0.47).

Conclusions: Our study suggested that anxiety about radiation was associated with materials and knowledge about radiation in the PHNs of Fukushima Prefecture four years after the FDNPS accident. It is important for PHNs to obtain knowledge and teaching materials about radiation, and radiation education programs for PHNs must be established in areas that have nuclear facilities.

Keywords: public health nurse, anxiety, radiation, Fukushima Daiichi Nuclear Power Station, Sense of Coherence-13

Strengths and limitations of this study

- We could assess radiation anxiety and the stress processing capacity of PHNs in the Fukushima Prefecture in Japan, after the accident at the FDNPS.
- We believe that this study regarding the PHNs' situation in the Fukushima Prefecture four years after the FDNPS disaster will be very important in the provision of future support.
- We could not obtain sufficient information on the anxiety-related factors, such as detailed consultation contents and other information.
- We were not able to gather sufficient information on stress management factors, such as family issues and marital status.

Introduction

On March 11, 2011, the Great East Japan Earthquake struck the east coast of Japan. This large earthquake and tsunami caused immense damage, including that to the Fukushima Daiichi Nuclear Power Station (FDNPS) [1-4]. After the accident at the FDNPS, the Fukushima prefectural government immediately issued instructions for the evacuation of those areas within a 20 km radius of the FDNPS, and they also instructed sheltering in the areas between 20 km and 30 km from the FDNPS. Beyond the 30 km radius, additional areas were designated “deliberate evacuation areas” if there was concern that the cumulative doses of radiation might reach 20 mSv per year in those areas [2]. Despite the low estimated and measured external and internal exposure doses just after the accident, many residents of the Fukushima Prefecture evacuated inside or outside the prefecture [5-8].

In the report by the World Health Organization (WHO) on the health impacts 20 years after the Chernobyl accident, mental health was described as the most serious public health problem resulting from that nuclear accident [9-11]. Based on the lessons learned from the Chernobyl accident, the Fukushima Health Management Survey (FHMS) was initiated to assess the health impacts, including mental health, of the residents by the Fukushima prefectural government and the Fukushima Medical University [12, 13]. According to the results of this survey, the residents of the Fukushima Prefecture were exposed to a higher risk of not only physical problems, such as diabetes and obesity, but also mental problems (including the risk perception of the

health effects of radiation) [14, 15].

In Japan, public health nurses (PHNs) hold a national license, and many PHNs work for prefectural and municipal bodies, enabling them to provide community health services such as health guidance, home visits, and health education to local residents. In other words, they play important roles in managing the health of local residents, including the time after this disaster. While they were themselves victims of the radiation disaster, they had to respond to the residents' anxieties about radiation exposure, despite their lack of professional knowledge on this topic.

In this study, we conducted a survey to clarify the radiation anxiety and stress processing capacity of the PHNs in the Fukushima Prefecture, after the nuclear accident at the FDNPS.

Materials and Methods

Study population and data collection

We conducted a questionnaire survey among the PHNs in the Fukushima Prefecture located in Northeastern Japan, which was severely affected by the earthquake, tsunami, and FDNPS accident following the Great East Japan Earthquake in 2011. We initially distributed questionnaires to 509 PHNs, and we obtained responses from 458 PHNs (90.0%), after excluding 28 PHNs with insufficient responses. The survey was conducted in July of 2015 via mail by post, and contained questions about the demographic factors (sex, age, activity area, and employment position) and knowledge

of the PHNs about radiation before and after the accident at the FDNPS, and their mental health status. In addition, we examined their degree of anxiety about radiation at the time of the FDNPS accident, and at present, by asking them to answer questions about radiation at present. The degree of anxiety was rated on a 10-point Likert scale ranging from no anxiety to having a lot of anxiety; we defined 1-5 as “anxiety (-)” and 6-10 as “anxiety (+).”

To measure the PHNs’ stress management capability, we used the Japanese version of the Sense of Coherence-13 (SOC-13). The SOC-13 consists of three dimensions (comprehensibility, manageability, and meaningfulness) that are equally weighted to create an overall (total) score. Each question was rates on a 5-point Likert scale from one to five, with a higher score representing a stronger sense of coherence (range:13-65) [16].

Statistical analysis

We classified the low and high levels of anxiety by asking them to answer questions about radiation, and compared the anxiety (-) group and anxiety (+) group by using the chi-square test and t-test as univariate analyses. A multiple logistic regression analysis was performed to assess the effects of each variable on the anxiety level adjusted for confounding variables. In this study, the dependent variable was “the anxiety (+) by asking them to answer questions about radiation,” the exposure variables were “Manager in the workplace,” “Public health nurse at the time of the accident,”

136 “Current degree of anxiety about radiation,” “Difficulty answering radiation questions
137 in the past,” “Currently have materials to obtain knowledge about radiation,” and
138 “Knowledge about childhood thyroid cancer increase after the Chernobyl accident” and
139 the confounding variables was “age.” Odds ratio (ORs), and their 95% confidence
140 interval (95% CI) were also calculated. A p-value of less than 0.05 was considered to be
141 significant, and the statistical analysis was performed using SPSS Statistics 22.0 (IBM
142 Japan, Tokyo, Japan).

144 *Ethics statement*

145 This study was approved by the ethics committee of the Fukushima Medical
146 University (No. 2251), and conducted in accordance with the guidelines specified in the
147 Declaration of Helsinki.

149 **Results**

150 A total of 458 PHNs responded to the survey, and 430 of those PHNs (93.9%)
151 completed all of the questions. The number of women was 416 (96.7%), and 153
152 (35.6%) were 50 years old or older. The number of PHNs with less than 10 years of
153 working experience was 124 (22.8%), and 306 (71.2%) had ten years or more. There
154 were 119 participants (27.7%) with managerial positions. At the time of the accident,
155 330 (76.8%) worked as PHNs and 62 (14.4%) were still in training. The number of
156 those in Hamadori, which became the evacuation area of the FDNPS accident, was 83
157 (19.3%) (Table 1).

158

159 **Table 1. Basic characteristics of the study participants.**

| Variable | | Number (%) |
|----------------------------------------|------------------------------------|------------|
| Gender | Women | 416(96.7) |
| | Men | 14(3.3) |
| Age | 20-29 years old | 92(21.4) |
| | 30-39 years old | 72(16.7) |
| | 40-49 years old | 113(26.3) |
| | ≥50 years old | 153(35.6) |
| Tenure as a public health nurse | <10 years | 124(28.8) |
| | ≥10 years | 306(71.2) |
| Nursing experience in a hospital | Yes | 149(34.7) |
| | No | 281(65.3) |
| Activity area | Hamadori | 83(19.3) |
| | Other area (Nakadori, Aizu et al.) | 347(80.7) |
| Position in the workplace | Manager (director, chief) | 119(27.7) |
| | Staff | 311(72.3) |
| Occupation at the time of the accident | Public health nurse | 330(76.8) |
| | Other occupations (mostly nurses) | 38(8.8) |
| | Students | 62(14.4) |

160

Of the PHNs, 269 were classified in the anxiety (-) group and 161 were in the anxiety (+) group (Table 2). A significantly higher ratio of PHNs younger than 40 years old was observed in the anxiety (+) group ($p<0.001$, Table 2). Likewise, higher ratios of PHNs with less than 10 years of working experience, staff positions, and nursing licenses were observed in the anxiety (+) group ($p<0.001$, respectively, Table 2). On the other hand, no significant differences were observed between the two groups in the activity area, education curriculum, and seminars before or after the accident ($p=0.62$, $p=0.16$, $p=0.60$, and $p=0.13$, respectively, Table 2). In addition, there was no significant difference in the mean points in the SOC-13 observed between the two groups ($p=0.47$, Table 2).

Table 2. Participant's demographic factors, educational history, and mental health via anxiety with regard to questions about radiation after the FNPS accident.

| Variable | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|---------------------------------------------|------------------------------------|----------------------------|----------------------------|----------|
| Gender | Women/ Men | 262(97.4)/ 7(2.6) | 154(95.7)/ 7(4.3) | 0.32 |
| Age | <40 years old/ ≥40 years old | 77(28.6)/ 192(71.4) | 87(54.0)/ 74(46.0) | <0.001 |
| Working experience as a public health nurse | <10 years/ ≥10 years | 53(19.7)/ 216(80.3) | 71(44.1)/ 90(55.9) | <0.001 |
| Activity area | Hamadori/ Other area | 54(20.1)/ 215(79.9) | 29(18.0)/ 132(72.0) | 0.62 |
| Position in the workplace | Manager/ Staff | 88(32.7)/ 181(67.3) | 31(19.3)/ 130(80.7) | 0.003 |
| Occupation at the time of the accident | PHNs/ Others (nurses, students) | 230(85.5)/ 39(14.5) | 100(62.1)/ 61(37.9) | <0.001 |

| | | | | |
|------------------------------------------------------------------|-----------------|------------------------|-----------------------|------|
| Did you have children ≤15 years old at the time of the accident? | Yes | 110(40.9) | 59(36.6) | 0.42 |
| Education history in curriculum | Yes | 114(42.4) | 80(49.7) | 0.16 |
| Education history in seminar before the accident | Yes | 25(9.3) | 12(7.5) | 0.60 |
| Education history in seminar after the accident | Yes | 247(91.8) | 140(87.0) | 0.13 |
| Frequency of participation in seminars | Once/ Plural | 47(19.0)/ 200(81.0) | 42(29.6)/ 98(70.4) | 0.02 |
| SOC-13 total points | Mean | 44.0 | 41.4 | 0.47 |

174

175 In the anxiety (+) group, the ratio of those having current anxiety about radiation

176 was significantly higher than that in the anxiety (-) group ($p<0.001$, Table 3). On the

177 other hand, in the anxiety (-) group, the ratios with difficulty answering the questions

178 about radiation, currently having the materials to obtain knowledge about radiation, and

179 having knowledge about childhood thyroid cancer increases after the Chernobyl

180 accident were significantly higher than in the anxiety (+) group ($p<0.05$, $p<0.01$, and

181 $p<0.05$, respectively, Table 3). However, there were no significant changes between the

182 two groups in the anxiety about radiation at the time of the accident and the recognition

183 of health effects (such as late effects and genetic effects) due to radiation exposure

184 ($p=0.68$, $p=0.79$, and $p=0.20$, respectively, Table 3).

185

186 **Table 3. Participants' anxiety, recognition, and knowledge about radiation via**

187 **anxiety with regard to answering the questions about radiation after the FDNPS**

188 **accident.**

| Question | Unit | Anxiety (-) (n=269) (%) | Anxiety (+) (n=161) (%) | p-values |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------|----------------------------|----------|
| Degree of anxiety about radiation at the time of the FDNPS accident | anxiety (-)/ anxiety (+) | 99(36.8)/ 170(63.2) | 56(34.8)/ 105(65.2) | 0.68 |
| Degree of anxiety about radiation currently | anxiety (-)/ anxiety (+) | 251(93.3)/ 18(6.7) | 130(80.7)/ 31(19.3) | <0.001 |
| Do you think that delayed effects such as malignancies occur due to radiation exposure following the Fukushima accident? | Yes | 37(13.8) | 33(20.5) | 0.79 |
| Do you think that genetic effects in offspring occur due to radiation exposure following the Fukushima accident? | Yes | 33(12.3) | 27(16.8) | 0.20 |
| Did you have a difficult time answering the questions about radiation? | Yes | 216(80.3) | 115(71.4) | 0.04 |
| Did you have the materials to obtain knowledge about radiation at the time of the accident? | Yes | 87(32.3) | 40(24.8) | 0.10 |
| Do you currently have the materials to obtain knowledge about radiation? | Yes | 233(86.6) | 118(73.3) | 0.01 |
| Did you know about the three principles of radiation protection? | Yes | 64(23.8) | 42(26.1) | 0.64 |
| Did you know about the annual dose limit for the general public? | Yes | 20(12.4) | 11(6.8) | 0.99 |
| Did you know about the half-life of radioactive substances? | Yes | 129(48.0) | 77(47.8) | 0.99 |
| Did you know about childhood thyroid cancer increases after the Chernobyl accident? | Yes | 213(79.2) | 109(67.7) | 0.01 |

189

190 When the logistic regression analysis was conducted, following the adjustment
 191 for confounding factors, being a PHN at the time of the accident (OR: 2.37, $p<0.01$),
 192 current general anxieties about radiation (OR: 3.56, $p<0.001$), currently having the
 193 materials to obtain knowledge about radiation (OR: 2.11, $p<0.01$), and having

194 knowledge about childhood thyroid cancer increases after the Chernobyl accident (OR:
195 1.69, p=0.04) were all significantly associated with anxiety after the FDNPS accident
196 (Table 4).

197
198 **Table 4. Odds ratios and 95% confidence intervals of the study variables for**
199 **anxiety (+) by asking them to answer questions about radiation, as assessed by the**
200 **logistic regression analysis.**

| Variable | Unit | Odds ratio | 95% confidence interval | p-value |
|--------------------------------------------------------------------------------|---------------|------------|-------------------------|---------|
| Adjusted | | | | |
| Age | ≥40 years old | 0.64 | 0.36-1.15 | 0.13 |
| Manager in the workplace | No | 1.14 | 0.65-2.00 | 0.66 |
| Public health nurse at the time of the accident | No | 2.37 | 1.27-4.42 | 0.007 |
| Current degree of anxiety about radiation | anxiety (+) | 3.56 | 1.82-6.96 | <0.001 |
| Difficulty answering radiation questions in the past | No | 1.27 | 0.76-2.12 | 0.37 |
| Currently have materials to obtain knowledge about radiation | No | 2.11 | 1.25-3.60 | 0.006 |
| Knowledge about childhood thyroid cancer increase after the Chernobyl accident | No | 1.69 | 1.04-2.75 | 0.04 |
| Unadjusted | | | | |
| Age | ≥40 years old | 0.34 | 0.23-0.51 | <0.001 |
| Manager in the workplace | No | 2.04 | 1.28-3.25 | 0.003 |
| Public health nurse at the time of the accident | No | 3.60 | 2.26-5.73 | <0.001 |
| Current degree of anxiety (+) | | 3.33 | 1.79-6.17 | <0.001 |

| | | | | |
|---------------------------|----|------|-----------|--------|
| anxiety about radiation | | | | |
| Difficulty answering | | | | |
| radiation questions in | No | 1.63 | 1.03-2.57 | 0.04 |
| the past | | | | |
| Currently have | | | | |
| materials to obtain | No | 2.36 | 1.44-3.87 | <0.001 |
| knowledge about | | | | |
| radiation | | | | |
| Knowledge about | | | | |
| childhood thyroid | No | 1.82 | 1.17-2.82 | 0.008 |
| cancer increase after the | | | | |
| Chernobyl accident | | | | |

201

202 **Discussion**

203 This study was conducted four years after the FDNPS disaster to provide
204 educational support for PHNs who receive many consultations from residents. In
205 univariate analysis, younger and inexperienced PHNs had higher anxiety with regard to
206 communicating with residents about radiation. When adjusting for other variables, those
207 PHNs who were students at the time of the accident had higher anxiety when
208 communicating with residents about radiation. Our results suggested that experience as
209 a professional during the FDNPS accident is important. Although many of the PHNs
210 had knowledge about the Chernobyl accident, they could not properly communicate the
211 health effects of radiation with the residents, which caused anxiety in the residents after
212 the accident at the FDNPS. In addition, our results showed that having the materials to
213 obtain knowledge about radiation was independently associated with anxiety about the
214 FDNPS accident.

215 These results suggest that continuous effort is necessary to provided education
216 and materials among the PHNs in the Fukushima Prefecture for them to gain knowledge
217 about radiation, including the health effects caused by radiation exposure [17]. Some
218 education initiatives have been undertaken in the prefecture after the nuclear accident,
219 which includes Fukushima Medical University's disaster education for undergraduates
220 and health literacy training for public health nurses for field practitioners [18, 19].
221 Appropriate and sustainable allocation of financial and human resources is needed to
222 continue and expand such activities.

223 The SOC was employed to estimate the stress management capability of the

PHNs in this study. There was no significant difference in the mean points in the SOC observed between the anxiety (-) group and anxiety (+) group. This result, as well as other study, may suggest that factor of lifestyle related [20]. On the other hand, Eriksson et al. showed that individuals with high scores in the SOC are better able to cope with chronic stress than those with low scores [21]. In other studies, the average points of the nurse at two Japanese hospitals were 38.5 ± 6.4 and 39.3 ± 6.3 , respectively [22, 23], and the average score of mothers of children with intellectual disabilities in Japan was 40.0 ± 8.0 [24]. In this study, the average score (43.0 ± 7.7) was higher than those in other studies, and it was substantially higher when compared to those of nurses. We believe that expertise as a public health nurse is one of the factors that increase the SOC. Accordingly, in order to maintain the high scores of in the SOC, there is a need for planning of stress management capacity improvement for the PHNs in Fukushima Prefecture.

The correspondence of the disaster affected the stress management capability, and might cause a worsening of chronic stress. According to the FHMS, which includes monitoring the mental health and daily lives of Fukushima residents and providing proper care for them, the mental health status of the residents in the Fukushima Prefecture was very poor [13]. Thus, the mental health of the residents was greatly affected by the disaster, and a similar impact could be expected from the PHNs who work in the Fukushima Prefecture. Therefore, mental support is important for the PHNs, as well as for the residents of the Fukushima Prefecture.

245 The present study has several limitations. First, we could not obtain sufficient
246 information on the anxiety-related factors, such as detailed consultation contents and
247 other information. Second, we were not able to gather sufficient information on stress
248 management factors, such as family issues and marital status. Third, this study might
249 have caused a recall bias on the study participants. Finally, since this study targeted to
250 PHNs only in Fukushima, Japan, there might be a problem about generalizability.
251 However, we believe that this study regarding the PHNs' situation in the Fukushima
252 Prefecture four years after the FDNPS disaster will be very important in the provision of
253 future support.

254 In conclusion, we conducted a survey of the radiation anxiety and stress
255 processing capacity of PHNs in the Fukushima Prefecture four years after the nuclear
256 accident at the FDNPS, and determined that it is important for PHNs to obtain
257 knowledge and teaching materials about radiation. In order to develop workers'
258 capabilities that can correspond to the timing of radiation disasters in the future,
259 radiation education programs for PHNs and nursing students must be established in
260 areas that have nuclear power stations and other nuclear facilities.

262 **Footnotes**

263 ***Contributorship statement***

264 • Koji Yoshida conceived and designed the experiments, analyzed the data, wrote the
265 paper, prepared Tables.

• Makiko Orita, Akira Ohtsuru, Aya Goto, Atsushi Kumagai and Kiyotaka Yasui contributed materials, reviewed drafts of the paper.

• Naomi Hayashida, Takashi Kudo, and Shunichi Yamashita designed the experiments, reviewed drafts of the paper.

• Noboru Takamura conceived and designed the experiments, wrote the paper, reviewed drafts of the paper.

Competing interests

There are no competing interests

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Data sharing statement

No additional data are available.

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| | Item No | Recommendation |
|------------------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Title and abstract | ✓ 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract Pages 1 and 3-4 |
| | | (b) Provide in the abstract an informative and balanced summary of what was done and what was found Pages 3-4 |
| Introduction | | |
| Background/rationale | ✓ 2 | Explain the scientific background and rationale for the investigation being reported Pages 5-6 |
| Objectives | ✓ 3 | State specific objectives, including any prespecified hypotheses Page 6 |
| Methods | | |
| Study design | ✓ 4 | Present key elements of study design early in the paper Page 6 |
| Setting | ✓ 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 6 |
| Participants | ✓ 6 | (a) Give the eligibility criteria, and the sources and methods of selection of participants Page 6 |
| Variables | ✓ 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pages 7-8 |
| Data sources/ measurement | ✓ 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 Pages 6-7 |
| Bias | ✓ 9 | Describe any efforts to address potential sources of bias Page 17 |
| Study size | ✓ 10 | Explain how the study size was arrived at Page 6 |
| Quantitative variables | ✓ 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pages 7-8 |
| Statistical methods | ✓ 12 | (a) Describe all statistical methods, including those used to control for confounding Pages 7-8 |
| | | (b) Describe any methods used to examine subgroups and interactions |
| | | (c) Explain how missing data were addressed |
| | | (d) If applicable, describe analytical methods taking account of sampling strategy |
| | | (e) Describe any sensitivity analyses |
| Results | | |
| Participants | ✓ 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 Pages 6 and 9 |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | ✓ 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Pages 6 and 9 |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| Outcome data | ✓ 15* | Report numbers of outcome events or summary measures Pages 9-14 |
| Main results | ✓ 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 Table 4 |
| | | (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 | ✓ 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Not applicable |
| Discussion | | |
| Key results | ✓ 18 | Summarise key results with reference to study objectives Page 15 |
| Limitations | ✓ 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 17 |
| Interpretation | ✓ 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pages 15-17 |
| Generalisability | ✓ 21 | Discuss the generalisability (external validity) of the study results Page 17 |
| Other information | | |
| Funding | ✓ 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 Page 18 |

*Give information separately for exposed and unexposed groups.

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.