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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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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.

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) 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.

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, 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 (+)."

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. The score ranges from 7-91, with a higher score representing a stronger sense of coherence [16].

Statistical analysis

We classified the low and high levels of anxiety when answering the 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 then used to calculate the odds ratio (OR), and its 95% confidence interval (95% CI) was used to identify the factors independently associated with the anxiety level. A p-value of less than 0.05 was considered to be significant, and the statistical analysis was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

Ethics statement

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

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

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

When the logistic regression analysis was conducted, following the adjustment for confounding factors, being a PHN at the time of the accident (OR: 2.37, p<0.01), current general anxieties about radiation (OR: 3.56, p<0.001), currently having the 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

Discussion

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

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

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

contents and other information. 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 addition to Fukushima, radiation education programs for PHNs 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, 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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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

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. The score ranges from 7-91, with a higher score representing a stronger sense of coherence [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 then used to calculate the odds ratio (OR), and its 95% confidence interval (95% CI) was used to identify the factors independently associated with the anxiety level. A p-value of less than 0.05 was considered to be significant, and the statistical analysis was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

Ethics statement

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

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

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

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

When the logistic regression analysis was conducted, following the adjustment for confounding factors, being a PHN at the time of the accident (OR: 2.37, p<0.01), current general anxieties about radiation (OR: 3.56, p<0.001), currently having the 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 (+) by asking them to answer 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

Discussion

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

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

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,

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

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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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. The score ranges from 7-91, with a higher score representing a stronger sense of coherence [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 then used to calculate the odds ratio (OR), and its 95% confidence interval (95% CI) was used to identify the factors independently associated with the anxiety level. A p-value of less than 0.05 was considered to be significant, and the statistical analysis was performed using SPSS Statistics 22.0 (IBM Japan, Tokyo, Japan).

Ethics statement

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

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

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

When the logistic regression analysis was conducted, following the adjustment for confounding factors, being a PHN at the time of the accident (OR: 2.37, $p<0.01$), current general anxieties about radiation (OR: 3.56, $p<0.001$), currently having the 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 (+) by asking them to answer 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

Discussion

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

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

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. Third, this study might have caused a recall bias on the study participants. 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, 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 Pages 7-8	✓12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants Pages 6 and 9	✓13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data Pages 6 and 9	✓14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	✓15*	Report numbers of outcome events or summary measures Pages 9-13
Main results Table 4	✓16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	✓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.

BMJ Open

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

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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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,"

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

Ethics statement

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

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

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

When the logistic regression analysis was conducted, following the adjustment for confounding factors, being a PHN at the time of the accident (OR: 2.37, $p<0.01$), current general anxieties about radiation (OR: 3.56, $p<0.001$), currently having the 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 (+) by asking them to answer questions about radiation, as assessed by the 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 the past	No	1.63	1.03-2.57	0.04
Currently have materials to obtain knowledge about radiation	No	2.36	1.44-3.87	<0.001
Knowledge about childhood thyroid cancer increase after the Chernobyl accident	No	1.82	1.17-2.82	0.008

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Discussion

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

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

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.

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. Third, this study might have caused a recall bias on the study participants. Finally, since this study targeted to PHNs only in Fukushima, Japan, there might be a problem about generalizability. 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, reviewed drafts of the paper.

Competing interests

There are no competing interests

Funding

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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 Pages 7-8	✓12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants Pages 6 and 9	✓13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data Pages 6 and 9	✓14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	✓15*	Report numbers of outcome events or summary measures Pages 9-14
Main results Table 4	✓16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	✓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.