Can correct knowledge ease people's anxiety about radiation effects on the next generations after the FDNPP accident?

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Abstract.
This exploratory study examined the relationship between radiation anxiety and knowledge. It focused on the effect of radiation on human health by using an existing mail survey asking inhabitants living in Fukushima in 2016 regarding "information and health." We found that some extent of the relationship between anxiety and the availability of knowledge is directly connected to the object, that is, anxiety. The effect of knowledge status on anxiety seems to be stronger than that of personal attributes except for the living area.

KEYWORDS: radiation anxiety; knowledge; Fukushima; media; questionary survey.

1 INTRODUCTION

Residents of Fukushima feel anxiety about the radiation effects following the Fukushima Daiichi Nuclear Power Plant accident in 2011. Several studies [1-3] have pointed this out by using the word "anxiety" directly, and the Fukushima Health Management Survey conducted every three years after the accident revealed psychological distress among the Fukushima prefecture residents [4-6]. Anxiety is an emotional status concerning something uncertain in our lives, which is closely connected to psychological distress. To eliminate public anxiety, many efforts have been made to clarify the mechanism of anxiety, and the relationship between risk perception and risk communication has been studied [7,8].

In this context, Yasumura et al. [3,9] conducted a mail survey in Fukushima to investigate the information and health. They sent questionnaires to 2,000 people in Fukushima prefecture in 2016, and 861 inhabitants sent back their responses. Information that people were exposed in their daily lives was surveyed because it has an impact on the establishment of their risk perception. Further, this survey asked about and attempted to reveal the relationships between anxieties derived from radiation accidents and other factors, especially information sources such as authorities and media that residents usually use to search for information and techniques to reduce concerns [3,9]. The questionnaire also included questions about health status; lifestyle habits such as drinking, smoking, and sleeping hours; age; sex; educational background; knowledge; and personal level of trust in information sources. Responses to the questionnaire seem to indicate a loose connection between the respondents' object of anxiety and the content of their knowledge .

Thus, in this study, we attempted to summarize the complicated relationship between knowledge and anxiety based on confounding factors. Specifically, we concentrated on anxiety about the radiation effects on the next generation, which may remain for a long time as radiation-related anxiety.

2 METHOD

2.1 Mail survey on information and health

For analysis, we used the responses to the mail survey mentioned above. This mail survey was approved by the Ethics Committee of Fukushima Medical University (approval number: 2699). Kuroda et al. [9] and Nakayama et al. [3] published articles based on the same dataset.

The survey targeted 2,000 residents in all areas of Fukushima prefecture, aged 20 to 79 years. Fukushima prefecture was culturally and geographically divided into three areas. In this survey, 500 inhabitants were selected from each of the three areas and the evacuation area. There were 961 responses to the fundamental factors, age, and sex.

2.2 Questionnaire

This study analyzed the questionnaire responses to understand the intricate relationship between knowledge and anxiety. Table 1 shows the questions we focused on in this study. Five knowledge questions asked about radiation from various perspectives, such as biology, epidemiology, protection, and national standards used in practice. Seven questions about anxiety were related to the respondents' health now and in the future, descendants' health, the nuclear power plant accident itself, discrimination, and effects on family relationships.

Table 1: Questions about radiation knowledge and radiation-related anxiety in the mail survey.

Topics	#	Questions
Knowledge	1	Once you are exposed to radiation, that radiation stays in your body forever.
	2	International standards have adopted the concept that the higher the dose of radiation exposure, the higher the probability of dying from cancer.
	3	Studies on the health effects of the second and third generations of the atomic bomb survivors in Hiroshima and Nagasaki have shown no genetic effects.
	4	Once a cell's DNA (the main body of genes) is damaged by radiation, it cannot be repaired.
	5	The government's standard value for radioactive materials is set at no more than 100 becquerels per kilogram for general foods.
Anxiety	1	I am worried that I will get a severe disease in the future due to radiation.
	2	Every time I get sick, I worry that it is because I was exposed to radiation.
	3	I am worried that the effects of radiation will be passed on to my children, grandchildren, and other future generations.
	4	The news reports on the nuclear accident make me feel very uneasy.
	5	I am worried that my children and I will be discriminated against (treated unfairly) by other people because we lived in an area where radiation levels are high.
	6	I try to avoid telling people that I am a resident of the area.
	7	I have had conflicting opinions and disputes with my family about the effects of radiation on my health.

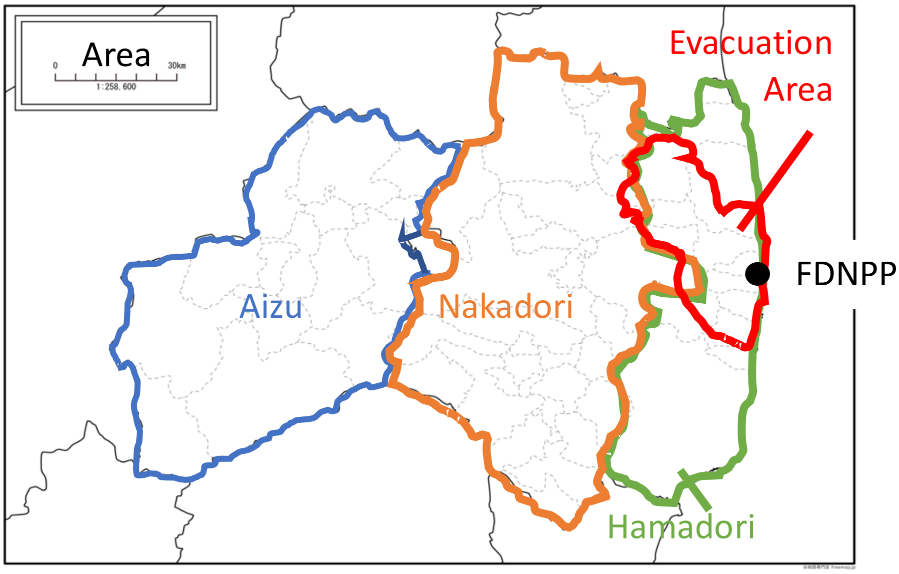
Note: We would like to modify the expression of the third knowledge question, as there is no epidemiological study about the third generation of atomic bomb survivors.

For the knowledge questions, respondents chose alternatives from the following options: 1. *right*, 2. *wrong*, and 3. *I do not know*. For questions about the extent of anxiety, respondents replied on a four-point scale: 1. *I do not think so*, 2. *I do not think so much*, 3. *I think so a little*, and 4. *I think so strongly*.

In this questionnaire, we also asked what media they used as their usual source of information. Multiple answers were allowed from the following categories: 1. *local newspapers*, 2. *nationwide newspapers*, 3. *Japan Broadcasting Corporation*, 4. *local television*, 5. *nationwide commercial television*, 6. *radio*, 7. *online news*, 8. *blogs and websites*, 9. *social networking services*, 10. *books and magazines*, 11. *local government public relations*, 12. *word of mouth*, and 13. *other*.

Moreover, personal characteristics, such as sex, age, educational background, and residential area, were collected. Regarding educational background, we categorized respondents into four groups: graduates from junior high school, high school, technical college, and university. For residential areas, we set four categories: Hamadori, Nakadori, and Aizu, and the evacuation area, as shown in Fig. 1.

Figure 1: Map of Fukushima prefecture and the four categories of residential areas.



Note: FDNPP=Fukushima Daiichi Nuclear Power Plant.

2.3 Statistical Analysis

2.3.1 Exploratory analysis for the relationship between anxiety and knowledge

To determine the kind of knowledge that affects anxiety, we performed a multiple regression analysis. The response to the question asking about anxiety was given on a rank-order scale. We regarded it as a rating scale, and the degree of anxiety was quantified. Additionally, we transformed it into an interval scale using sigma scaling. The degree of anxiety for each content was used as an objective variable.

The response status for each knowledge question, *correct*, *incorrect*, and *unsure*, was expressed by two dummy variables. We defined dummy variables for all knowledge questions as explanatory variables in the multiple regression analysis. Personal characteristics, such as sex, age, educational background, and residential area, may affect anxiety. To adjust for these parameters, we added dummy variables to these characteristics.

The equation is shown as follows:

$$y_i = \beta_0 + \sum_{j=1}^{5}(\beta_{jc} d_{jc} + \beta_{jw} d_{jw}) + \beta_s s + \sum_{age=1}^{5} \beta_{age} d_{age} + \sum_{edu=1}^{3} \beta_{edu} d_{edu} + \sum_{res=1}^{3} \beta_{res} d_{res}, \quad (1)$$

where y_i is the anxiety level on the *i*th question asking about anxiety, d_{jc} is the dummy value for the correct status, and d_{jw} is the dummy value for the wrong status on the *j*th knowledge question. β with subscripted letters represents the coefficients of the variables. β_s is that for sex, expressed as s. The variable s is 1 when the respondent's sex is male. For the expression of age in decades, we introduced five dummy variables. For respondents who were in their 20s, all variables were 0: (d_1,d_2,d_3,d_4,d_5)=(0,0,0,0,0). For those in their 30s, only d_1 was 1, and the others were 0. For the those in their 40s, 50s, 60s, and 70s, only d_2, d_3, d_4, and d_5 were 1, and the others were 0. We treated the age of the respondents as categorical data because the age effect was sometimes not linear. The dummy variables were also defined for the educational background: junior high school graduate, high school graduate, vocational school graduate, college graduate, and above. If the respondent's highest qualification was graduate from a junior high school, all three dummy variables were set to 0. For other educational background categories, the corresponding dummy variable was set to 0. Similarly, we introduced dummy variables expressing respondents' residential areas: evacuation area, Hamadori, Nakadori, and Aizu. For respondents from the evacuation area, we assigned 0 to all three dummy variables.

2.3.2 Possible confounders in the relationship between personal characteristics and knowledge

When looking at the relationship between anxiety and knowledge, both anxiety and knowledge are possibly related to age, gender, education, and residential area; therefore, these factors may be confounding factors. Accordingly, we conducted a multiple regression analysis to determine whether these factors could be used to predict the extent of knowledge. To evaluate the amount of knowledge, we used scores calculated as 1 for correct answers, 0 for "I do not know," and -1 for incorrect answers. Dummy variables were used for gender, educational background, and residential area. A normal distribution was assumed for the distribution of the family of residuals.

The equation used in the multiple regression analysis is given as follows:

$$sc = \beta_0 + \sum_{age=1}^{5} \beta_{age} d_{age} + \beta_s s + \sum_{edu=1}^{3} \beta_{edu} d_{edu} + \sum_{res=1}^{3} \beta_{res} d_{res}, \tag{2}$$

where *sc* is the score for the amount of knowledge, and the other dummy factors for personal characteristics are the same as in Eq. (1).

Additionally, a logistic analysis was conducted to examine the relationship between these variables and the probability of correct or incorrect answers for each knowledge question, with the dependent variable being the correct or incorrect answer. The equation for this analysis is given as follows:

$$l_{cj}(or\ l_{wj}) = \beta_0 + \sum_{age=1}^{5} \beta_{age} d_{age} + \beta_s s + \sum_{edu=1}^{3} \beta_{edu} d_{edu} + \sum_{res=1}^{3} \beta_{res} d_{res}, \tag{3}$$

where l_{cj} and l_{wj} express the logit transformation of the probability of answering correctly and incorrectly in the *j*th knowledge question, respectively. The other dummy variables are the same as in Eq. (1).

2.3.3 Search for the relationship with the media

Because people need media to obtain information, including knowledge related to radiation, we also suspected a relationship between anxiety, knowledge, and media.

We performed a multiple regression analysis by applying dummy variables to each media type to identify the relationships between media and knowledge. We tried both cases in which knowledge scores as in Eq. (2) were set as the objective variable and each answer status was set as the objective variable. We also conducted cluster analysis using the Ward method and the Jaccard similarity coefficient to characterize the media. Then, the respondents were categorized into five groups based on the similarity of their media choices. We tried to use these categories to explain the status of knowledge based on multiple regression analysis.
Further, we categorized the media into three groups by the same type of cluster analysis and used these categories instead of each media type in the multiple regression analysis above.

3 RESULTS AND DISCUSSIONS

3.1 Exploratory analysis for the relationship between anxiety and knowledge

Table 2 shows the results of the multiple regression analysis using Eq. (1). The coefficients in boldface with a dark-gray background have values that are significantly non-zero. For the seven anxiety items shown in Table 1, the coefficients β_{ic} and β_{iw} indicate how much the anxiety level changed when the respondent answered an ith knowledge question in Table 1 correctly and incorrectly. The coefficient β_0 indicates the average anxiety level of a woman in her 20s, who lives in the evacuation area, graduated from junior high school, and answers "I do not know" for all knowledge questions.

Table 2: Best-fit value based on the multiple regression analysis using Eq. (1).

	β_0	β_{1c}	β_{2c}	β_{3c}	β_{4c}	β_{5c}	β_{1w}	β_{2w}	β_{3w}	β_{4w}	β_{5w}	
Q1	**2.72**	**-0.30**	0.22	-0.14	-0.03	0.02	-0.02	-0.09	0.21	0.12	0.07	
Q2	**2.20**	**-0.33**	0.15	-0.11	0.05	0.07	-0.08	-0.13	0.09	0.08	0.19	
Q3	**2.67**	-0.25	0.19	**-0.32**	0.06	-0.05	0.07	-0.21	0.19	0.16	-0.04	
Q4	**2.72**	-0.09	0.06	-0.09	-0.08	-0.06	0.14	**-0.41**	0.24	0.07	0.07	
Q5	**2.23**	-0.10	0.06	-0.07	-0.03	0.14	0.10	-0.16	0.18	0.14	0.08	
Q6	**2.59**	-0.10	0.03	-0.13	0.09	-0.01	-0.08	-0.11	-0.03	**0.26**	0.16	
Q7	**1.82**	-0.15	0.13	-0.00	0.05	-0.00	-0.02	-0.19	0.11	0.02	0.09	
	β_s	$\beta_{age=1}$ (30's)	$\beta_{age=2}$ (40's)	$\beta_{age=3}$ (50's)	$\beta_{age=4}$ (60's)	$\beta_{age=5}$ (70's)	$\beta_{edu=1}$ high school	$\beta_{edu=2}$ tech college	$\beta_{edu=3}$ univ.	$\beta_{res=1}$ Hamadori	$\beta_{res=2}$ Nakadori	$\beta_{res=3}$ Aizu
Q1	-0.00	0.13	-0.07	-0.15	-0.20	-0.33	-0.15	-0.05	-0.26	0.00	-0.12	**-0.36**
Q2	-0.03	0.06	0.01	0.07	0.08	-0.01	-0.14	-0.22	-0.24	-0.17	-0.19	**-0.45**
Q3	-0.08	0.27	-0.00	-0.03	-0.04	0.02	-0.04	0.01	-0.18	-0.06	-0.08	**-0.35**
Q4	-0.08	0.12	0.08	0.13	0.27	0.33	0.03	0.17	0.09	0.04	-0.10	-0.11
Q5	0.05	0.32	0.19	0.10	0.09	-0.09	0.16	0.34	0.15	-0.27	-0.26	**-0.43**
Q6	0.10	0.24	0.03	-0.11	-0.14	-0.22	0.02	0.03	-0.16	**-0.68**	**-0.81**	**-0.94**
Q7	0.13	0.15	0.15	0.04	0.07	0.01	0.07	0.24	0.11	-0.23	**-0.32**	**-0.62**

Note: Q1 to Q7 correspond to questions asking about anxiety, as shown in Table 1. The boldfaced numbers in the darkest gray cells indicate that the p-value of the coefficient is under 0.001. The medium-gray and light-gray cells express that the p-value is less than 0.01 and 0.05, respectively.

According to Table 2, some knowledge questions seem to be related to some types of anxiety. Except for the second knowledge question, having the correct knowledge corresponds with a reduction in anxiety levels, and having incorrect knowledge corresponds with an increase in anxiety levels.

It seems crucial to obtain correct knowledge related to the radiation effect on people and their children to reduce the concern about human health induced by radiation exposure, as asked by the first, second, and third questions about anxiety. On the other hand, for other types of anxiety, such as vague anxiety recalled by news about radiation accidents and concern about discrimination and conflict between families, having the correct knowledge does not affect anxiety. However, misunderstanding increases such types of anxiety.

Among anxiety related to health, a correlation can be seen with knowledge directly connected to the targeted concern. For example, anxiety related to the effects on the next generation was reduced by knowing that there is no evidence to indicate that there are health effects on the children of atomic bomb survivors.

Among the knowledge questions, Q5 in Table 2 did not significantly affect all types of anxiety. Although the health effects of internal radiation exposure are one factor to be considered when setting the reference values for food, knowing the reference values used in Japan is not the same as understanding the health effects of internal radiation exposure.

We should note the peculiarity of the second knowledge question. This question asked whether the respondent understands that the global standard for radiation protection adopts the concept that the higher the radiation dose, the higher the cancer risk. For this question, the effect on health concern was opposite to that of other knowledge questions. With this knowledge, people who answered correctly felt more unease than people who misunderstood this knowledge. This phenomenon may be related to the possibility that the linear no-threshold hypothesis may be more unsettling to the desire for zero risks, but this needs to be tested in more detail.

3.2 Possible confounders in the relationship between concern and knowledge

Table 3: Best-fit value based on the multiple regression analysis using Eq. (2).

β_s	$\beta_{age=1}$ (30's)	$\beta_{age=2}$ (40's)	$\beta_{age=3}$ (50's)	$\beta_{age=4}$ (60's)	$\beta_{age=5}$ (70's)	$\beta_{edu=1}$ high school	$\beta_{edu=2}$ tech college	$\beta_{edu=3}$ univ.	$\beta_{res=1}$ Hamadori	$\beta_{res=2}$ Nakadori	$\beta_{res=3}$ Aizu
0.23	0.58	**1.02**	0.87	**0.96**	0.84	-0.08	-0.00	0.43	-0.12	-0.06	-0.34

Note: The bold characters in the darkest-gray cells indicate that the p-value of the coefficient is under 0.001. The medium-gray and light-gray cells express that the p-value is less than 0.01 and 0.05, respectively.

As shown in Table 3, only age significantly affected the amount of knowledge. For those aged higher than their 40s, knowledge increases compared to those in their the 20s. The same but weaker tendency can be seen for those in their 30s: the score increases by 0.58, and its p-value is 0.07. Those who were male and had graduated from university also showed a weak tendency to increase the score; their p-value was 0.05 and 0.08, respectively. Moreover, living in Aizu tended to decrease the score, with a p-value of 0.04.

Table 4: Best-fit value based on the logistic regression analysis using Equ. (4).

	β_s	$\beta_{age=1}$ (30's)	$\beta_{age=2}$ (40's)	$\beta_{age=3}$ (50's)	$\beta_{age=4}$ (60's)	$\beta_{age=5}$ (70's)	$\beta_{edu=1}$ high school	$\beta_{edu=2}$ tech college	$\beta_{edu=3}$ univ.	$\beta_{res=1}$ Hamadori	$\beta_{res=2}$ Nakadori	$\beta_{res=3}$ Aizu
C1	0.17	0.68	1.22	0.89	0.80	0.05	-0.13	0.26	0.62	-0.16	-0.02	-0.23
C2	0.46	0.47	0.12	0.26	0.78	0.96	0.62	0.59	1.00	-0.06	0.04	0.05
C3	0.34	-0.00	0.20	0.39	0.41	0.23	0.14	0.24	0.34	0.27	0.18	0.37
C4	0.32	-0.12	0.63	0.16	0.29	0.44	-0.47	-0.34	0.44	0.02	-0.12	-0.32
C5	0.37	-0.44	0.55	0.38	0.48	0.82	0.08	0.32	0.15	-0.33	-0.19	**-0.76**
W1	-0.04	-0.36	-1.06	0.74	-0.73	-0.42	0.16	-0.02	-0.41	0.29	0.08	-0.36
W2	-0.36	-1.01	0.03	-0.34	-0.79	1.01	0.02	0.38	0.11	0.13	-0.01	0.14
W3	0.15	-0.65	-0.70	-0.81	-0.48	-0.19	0.19	0.18	0.26	-0.19	-0.07	-0.11
W4	0.24	0.13	0.15	0.13	0.16	0.11	0.45	0.69	0.59	0.02	0.02	0.15
W5	0.45	-1.02	-0.83	-0.54	-0.46	-1.03	-0.07	0.32	-0.15	0.14	0.28	0.64

Note: C1 corresponds to the probability to answer the first knowledge question correctly. W1 corresponds to the wrong answer. The number after C and W indicates the number of knowledge questions in Table 1. The bold characters in the darkest-gray cells indicate that the p-value of the coefficient is under 0.001. The medium-gray and light-gray cells express that the p-value is less than 0.01 and 0.05, respectively.

Table 4 is consistent with the results in Table 3. For instance, the probability of the right answer increases for males for all questions as a best-fit value. Simultaneously, when we focused on the wrong answer, the probability increases in males in three questions, too. Considering that we saw the weak tendency that being males was a factor of high score in Table 3, the incorrect answer's effect could not cancel the summation of the correct answer's effect. Even if the effects in Table 4 were not significant but sometimes made a tendency in the score shown in Table 3 by combining all this information. Similar results were observed for the age categories. More people aged higher than their 40s answered all questions correctly than those in their 20s, and they did not misunderstand most of the questions. The significance could be seen only in the first question and in their 40s in Table 4. However, the fact that all coefficients for the correct answer had a plus sign and the more than half of the incorrect answer's coefficient had a minus sign appeared as a significant increase in the score in Table 3. Of course, the same things happened in the situation of graduating from university and living in Aizu.

Sometimes, the same factor increases (or decreases) the probability of both the correct answers and wrong answers, which means that the probability of the answer “I do not know” decreases (or increases). People who belong to the categories with increasing probability of having the correct knowledge, such as graduating from university, male, or elderly, might have confidence in their knowledge even if they have misunderstood. The probability of correct answers increases for all questions, but the probability of wrong answers also increases for some questions. On the other hand, in the case of a decrease in both the correct answers and wrong answers, the respondents might not have confidence in their knowledge.

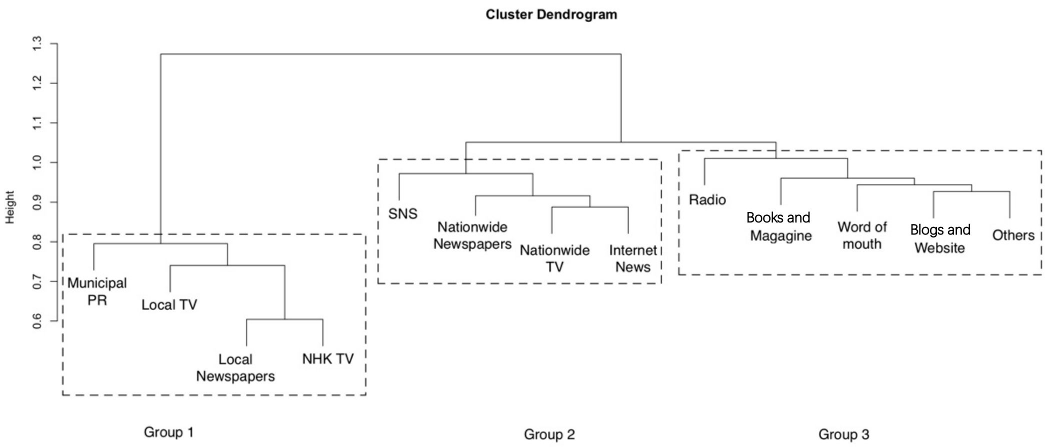
Age, sex, and the residential area had some relationship with knowledge status, but not with anxiety except for the residential area in Table 2, although anxiety is correlated with knowledge status.

3.3 Search for the structure between anxiety, knowledge, and media

We found no overt relationship in the multiple regression analysis that examined each anxiety level and each knowledge availability, based on whether or not each media was selected as an explanatory variable. In addition, when respondents were clustered and grouped according to the type of media they chose, no relationship with the degree of anxiety or knowledge was found.

When we divided the 13 media into three categories according to the type of people who chose them, we obtained a dendrogram, as shown in Figure 2. However, these media categories did not clearly explain anxiety or knowledge.

Figure 2: Dendrogram for the categorization of media.



Note: This figure was made using the Ward method and the Jaccard similarity coefficient. PR=public relations; TV=television; NHK=Japan Broadcasting Corporation; SNS=social networking service.

Group 1 in Figure 1 shows that most people in Fukushima Prefecture get their information from local newspapers, local commercial broadcasters, Japan Broadcasting Corporation, and local government public relations. More than 90% of the respondents selected three media sources as being most frequently used, and most of them received information from the media in Group 1. Therefore, the differences in the level of anxiety and the state of knowledge seen in this dataset are likely to be due to contributions from sources unrelated to the media used.

4 CONCLUSION

In this study, we described the complicated relationship between radiation anxiety and knowledge. The results suggest a relationship between anxiety about some health effects and knowledge about radiation and living places. However, knowledge status was affected by not only the residential area but also age, sex, and educational background. There was no apparent effect from the media used. The more directly related the knowledge is to the content of the anxiety, the more likely it is that the anxiety can be alleviated by correct knowledge.

However, we should mention the limitations of this study: we conducted only exploratory research to suggest the possibility of a correlation relationship. Moreover, this study used existing cross-sectional data from the questionnaire survey, which made it difficult to analyze the causal relationship between knowledge and anxiety in detail. In the future, we would like to use the results of this study to examine what should be investigated to more directly verify whether knowledge can relieve anxiety and then promote that investigation.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

[1] Rubin, G. James, Amlôt, Richard, Wessely, Simon; Greenberg, Neil. Anxiety, distress and anger among British nationals in Japan following the Fukushima nuclear accident. *The British Journal of Psychiatry*, 2012, 201.5: 400.
[2] Tateno, Saho; Yokoyama, Hiromi M. Public anxiety, trust, and the role of mediators in communicating risk of exposure to low dose radiation after the Fukushima Daiichi Nuclear Plant explosion. *Journal of Science Communication*, 2013, 12.2: A03.
[3] Nakayama, Chihiro, et al. Lingering health-related anxiety about radiation among Fukushima residents as correlated with media information following the accident at Fukushima Daiichi Nuclear Power Plant. *PLOS ONE*, 2019, 14.5: e0217285.
[4] Oe, Misari, et al. Predictors of severe psychological distress trajectory after nuclear disaster: evidence from the Fukushima Health Management Survey. *BMJ Open*, 2016, 6.10: e013400. doi: 10.1136/bmjopen-2016-013400.
[5] Oe, Misari, et al. Three-year trend survey of psychological distress, post-traumatic stress, and problem drinking among residents in the evacuation zone after the Fukushima Daiichi Nuclear Power Plant accident [the Fukushima Health Management Survey]. *Psychiatry and Clinical Neurosciences*, 2016, 70.6: 245.
[6] Maeda, Masaharu; Oe. Misari; SUZUKI, Yuriko. Psychosocial effects of the Fukushima disaster and current tasks. *Journal of the National Institute of Public Health*, 2018, 67.1: 50.
[7] Takebayashi, Yoshitake, Lyamzina, Yuliya, Suzuki, Yuriko; Murakami, Michio. Risk perception and anxiety regarding radiation after the 2011 Fukushima nuclear power plant accident: A systematic qualitative review. *International Journal of Environmental Research and Public Health*, 2017, 14.11.
[8] Kashiwazaki, Yuya, Takebayashi, Yoshitake; Murakami, Michio. Relationships between radiation risk perception and health anxiety, and contribution of mindfulness to alleviating psychological distress after the Fukushima accident: cross-sectional study using a path model. *PLOS ONE*, 2020, 15.7: e0235517.
[9] Kuroda, Yujiro, et al. Association between health literacy and radiation anxiety among residents after a nuclear accident: comparison between evacuated and non-evacuated areas. *International Journal of Environmental Research and Public Health*, 2018, 15.7.