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Effect of age and social connection on perceived anxiety over radiation exposure among decontamination workers in Fukushima Prefecture, Japan

Tomoo Hidaka¹, Takeyasu Kakamu¹, Takehito Hayakawa¹, Tomohiro Kumagai¹, Takanobu Jinnouchi¹, Sei Sato¹, Masayoshi Tsuji², Shinichi Nakano³, Kikuo Koyama⁴ and Tetsuhito Fukushima¹

¹Department of Hygiene and Preventive Medicine, Fukushima Medical University School of Medicine, ²Department of Preventive Medicine and Public Health, Fukuoka University Faculty of Medicine, ³Nakano Clinic and ⁴Fukushima Occupational Health Promotion Center

Abstract: Objectives: To reveal the effect of age and other factors on perceived anxiety over radiation exposure among decontamination workers in Fukushima Prefecture, Japan. **Methods:** A survey questionnaire was sent to 1505 workers, with questions regarding age, presence of a written employment contract, previous residence, radiation passbook ownership, presence of close persons for consultation, knowledge of how to access public assistance, and a four-point scale of radiation-related anxiety (1="Very much," 2="Somewhat," 3="A little bit," and 4="None"). The relationships between the degree of anxiety and variables were analyzed using the chi-square test and residual analysis. **Results:** In all, 512 participants responded to the questionnaire. The mean age of participants was 46.2 years (SD: 13.1, range: 18-77). Of them, 50, 233, 168, and 61 workers chose "Very much," "Somewhat," "A little bit," and "None," respectively, on the anxiety scale. Chi-square test showed that participants aged 61 years and over had higher degrees of anxiety ($p < 0.001$). Ordinal logistic regression showed that the degree of anxiety increased if they did not have a written contract ($p = 0.042$) or persons to consult ($p = 0.034$) and if they routinely checked the dose rate ($p = 0.046$). **Conclusions:** Decontamination workers who do not have a written contract or who are in socially isolated situations have greater anxiety over radiation exposure. Thus, it is important to both create supportive human relationships for consultation and en-

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Introduction

Following the Great East Japan Earthquake and its subsequent tsunami on March 11, 2011, the Fukushima Daiichi Nuclear Power Plant accident occurred, and radiation dispersed due to explosions and the opening of nuclear reactor containment vessel pressure valves^{1,2}. Because the half-lives of radionuclides emitted by the nuclear power plant are long (2 years and 30.2 years for cesium-134 and cesium-137, respectively), pollution of the natural environment and health problems became issues of concern. The Japanese government designated three evacuation zone types, in order to create priorities for radiation decontamination work, according to intensity of radiation contamination: the "difficult-to-return zone" with radiation levels of 50 mSv/year or more (the return of this area's residents to their homes cannot be completed within five years); "no-residence zones" between 20 and 50 mSv/year (the evacuation of residents is ongoing); and "zones being prepared for lifting of evacuation order," with 20 mSv/year or less.

The Japanese government made laws and guidelines to start working on radiation decontamination. A basic numerical goal of decontamination was set on August 26, 2011³, and since December 28, 2011, "special decontami-

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Correspondence to: T. Hidaka, Department of Hygiene and Preventive Medicine, Fukushima Medical University School of Medicine, Hikarigaoka 1, Fukushima, 960-1295, Japan (e-mail: thidaka@fmu.ac.jp)

nation” and “intensive contamination survey” areas have been designated sequentially based on the need for decontamination⁴⁾. Special decontamination areas are highly contaminated areas, including “difficult-to-return zones,” “no-residence zones,” and “zones being prepared for lifting of evacuation order,” where decontamination work is conducted by the government of Japan. Intensive contamination survey areas are areas with a radiation dose rate of more than 1 mSv/year. In such areas, municipal governments organize the decontamination work. Furthermore, a holistic plan of recovery and reconstruction, including decontamination work, was formulated on December 26, 2011⁵⁾. To date, radiation decontamination work has been conducted in many areas in Fukushima Prefecture, including habitable areas with no contamination in order to reduce people’s concerns over radiation.

As the decontamination work progresses, increasing attention is being paid to the occupational health management of radiation decontamination workers. The Japanese government established the basic principle of decontamination work⁶⁾ and also created a prevention guideline⁷⁾ to protect the decontamination workers from radiation exposure. Past studies have pointed out that the decontamination workers are at risk of radiation exposure, heat illness, and stress⁸⁾. They have also indicated the need for appropriate measures to be taken and equipment to be used to effectively prevent internal/external radiation exposure⁹⁾.

However, the support for mental health—especially, perceived anxiety over radiation exposure—among decontamination workers is insufficient compared with the support for physical health. As Kakamu et al. reported, many more workers are engaged in the decontamination work in places with relatively lower dose rates than there are in places with higher dose rates; therefore, the risk of physical health problems from radiation exposure is low¹⁰⁾. Moreover, prior to starting their work, the workers are educated on safety management and decontamination methods, using a text made by the Japanese government¹¹⁾. Although these documents state countermeasures to cope with physical health problems caused by radiation exposure, they do not cover mental health problems. With regards to the association between radiation and psychological problems, a study on the Chernobyl accident reported that people may experience anxiety disorders, depression, and other symptoms “as a result of perceived, not actual, radiation exposure”¹²⁾. Furthermore, a previous study reported that many residents have evacuated from Fukushima Prefecture on account of anxiety over radiation exposure¹³⁾. From the perspective of mental health, the association between anxiety over radiation exposure and other relevant factors has yet to be clarified, while past studies on radiation protection of general workers in Fukushima Prefecture indicated an association between the workers’ behavioral aspects and the age groups of their children^{14,15)}.

We posit three hypotheses as follows. First, younger workers have greater anxiety over radiation exposure because of future health problems that may arise due to having a longer life expectancy. In addition, their high information-gathering capacity may expose them to much more information on the effects of low-level radiation exposure on their health. Second, the workers have greater anxiety over radiation exposure if they do not have adequate social connections. Supportive relationships bring better mental health for workers generally, as Kuper et al. indicated¹⁶⁾. The absence of such relationships may contribute also to increased anxiety over radiation exposure. Finally, workers without adequate working conditions or employee education have greater anxiety over radiation exposure. Accompanied by an increasing number of decontamination workers, poor management or violation of labor laws by employers has been reported¹⁷⁾. There is a high possibility that decontamination workers have problems in terms of working conditions and employee education, and that they therefore have greater anxiety over radiation exposure.

The purpose of this study was to investigate the effect of age, social connection, working conditions, and employee education on the perceived anxiety over radiation exposure among decontamination workers. In addition, the decontamination work has not been operated in the “difficult-to-return zone”, but only in areas with relatively low dose rates, such as the “no-residence zones” and “zones being prepared for lifting of evacuation order.” Thus, the study of anxiety over radiation exposure among decontamination workers is more significant than the study of physical problems caused by radiation.

Subjects and Methods

Study Participants

Participants’ data were obtained from our previous study designed to investigate associations of behavioral, social, mental, and environmental factors with occupational health among radiation decontamination workers in Fukushima Prefecture, Japan¹⁰⁾. We asked all 213 companies, who were involved in radiation decontamination in Fukushima Prefecture and attended a training program against radiation exposure held by the Fukushima Occupational Health Promotion Center from April to July 2013, to select approximately 10 workers to complete the questionnaires for the present study. Then, in August 2013, self-administered questionnaires were sent to the companies to distribute among a total of 1,505 decontamination workers. By the end of October 2013, 651 workers (628 men and 23 women) returned the questionnaires anonymously by mail. Almost all of the respondents were male, and as a result, 512 males who completed the questionnaires were included in the analysis as participants in this study. The response rate was 43.3%,

and the effective rate was 34.0%.

Measures

Degree of perceived anxiety over radiation exposure: The degree of perceived anxiety over radiation exposure was assessed by the question, “How much anxiety do you have over radiation exposure?” The answers were then measured on a four-point scale (1=“Very much,” 2=“Somewhat,” 3=“A little bit,” and 4=“None”).

Working conditions and social connection: Questions regarding working conditions and social connection included “Written contract with the current company regarding vacation, wages, and perquisite” (“Present” or “Absent”), “Previous residence before starting the current job” (“Fukushima Prefecture” or “Others”), “Radiation passbook” (“Own” or “Do not own”), “Close persons for consultation” (“Present” or “Absent”), and “Knowledge of how to access public assistance” (“Have” or “Do not have”). A radiation passbook is a documented history of exposure, including dose records and locations. It is used by radiation decontamination workers and workers of radiation-related institutions in Japan. Ownership of the passbook by workers, as well as its management and storage by employers, is required by law^{18,19}. The passbook is the most essential item for managing occupational health among workers involved in radiation-related positions, and it was thus included in the questionnaire.

Employee education: Questions pertaining to how the workers were educated by their employers on the risk and working methods of their decontamination work were included in the questionnaire, based on the guidelines for decontamination work⁷. The answer options were as follows: “Training session (Studied work method, safety management, and protection from radiation exposure)”; “Watching a video (Watched a video about work method, safety management, and protection from radiation exposure)”; “Physical condition check (Checked physical condition daily before work)”; “Self-study with materials (Materials for work method, safety management, and protection from radiation exposure were given for self-study)”; and “Self-study without materials (Materials were not given for self-study).”

Preventive behaviors: Questions regarding preventive behaviors against radiation exposure were quoted from the guidelines⁷. These included “Checking the dose rate and keeping out of high dose areas (Checking the dose rate of working areas and keeping out of high dose areas),” “Monitoring external exposure (Monitoring the total amount of daily external dosage by portable indicator),” “Wearing a mask,” and “Wearing a radiation protection suit”⁷.

Sociodemographics: Sociodemographic characteristics included age, gender, and duration of engagement in radiation decontamination work (months). In addition, age was classified into five groups (≤ 30 , 31-40, 41-50, 51-60,

and ≥ 61 years).

Statistical Analysis

Statistical analyses were performed using SPSS statistics version 17 (IBM Corp., Armonk, NY, USA). Participants’ characteristics, based on sociodemographic data, were examined using descriptive statistics. The Mantel-Haenszel test was used to analyze and compare trends in age and degree of anxiety with other factors in the questionnaire. The relationship between the degree of anxiety and other factors in the questionnaire was analyzed by the chi-square test, and then the statistical significance of cells in the tables was examined using residual analysis. The cells were considered to have significantly more people than expected when the adjusted standardized residual values were greater than 1.96, whereas the cells were considered to have significantly fewer people than expected when the values were lower than -1.96 .

We used ordinal logistic regression to examine whether age, social connection, working conditions, and education are predictors of degrees of anxiety regarding radiation exposure. All covariates were included in the adjusted model after verification of multicollinearity, irrespective of their *p* values, and 95% confidence intervals (95%CI) were calculated.

Ethics

This study was approved by the Research Ethics Committees of the Japan Labour Health and Welfare Organization (Announcement No. 3) and the Ethics Committees of Fukushima Medical University (Application No. 1728).

Results

The mean age of participants ($n=512$, all male) was 46.2 years (SD: 13.1, range: 18-77), and the number of participants in the ≤ 30 , 31-40, 41-50, 51-60, and ≥ 61 age groups were 74 (14.5%), 105 (20.5%), 120 (23.4%), 142 (27.7%), and 71 (13.9%), respectively. The mean duration of engagement in radiation decontamination work was 7.6 months (SD: 5.9, range: 0-30). The numbers of workers who chose “Very much,” “Somewhat,” “A little bit,” and “None” on the scale of anxiety over radiation exposure were 50 (9.8%), 233 (45.5%), 168 (32.8%), and 61 (11.9%), respectively.

The chi-square test revealed that the degree of perceived anxiety over radiation exposure was significantly associated with age ($p=0.001$). Residual analysis revealed that a significantly low number of participants in the ≤ 30 age group chose “A little bit” on the anxiety scale, and a significantly high number of participants in the 41-50 age group chose “Somewhat.” In the 51-60 age group, a significantly high number of participants chose “A little bit” and a few chose “Somewhat.” Finally, the number of par-

Table 1. Association between degree of perceived anxiety over radiation exposure and age

	Degree of perceived anxiety over radiation exposure				<i>p</i> value
	Very much	Somewhat	A little bit	None	
Age group (%)					<i>0.001</i>
≤30	7 (9.5)	39 (52.7)	<u>16 (21.6)</u>	12 (16.2)	
31-40	8 (7.6)	56 (53.3)	31 (29.5)	10 (9.5)	
41-50	9 (7.5)	67 (55.8)	33 (27.5)	11 (9.2)	
51-60	13 (9.2)	<u>43 (30.3)</u>	66 (46.5)	20 (14.1)	
≥61	13 (18.3)	28 (39.4)	22 (31.0)	8 (11.3)	

Note: Italicized *p* values indicate significant chi-square test; Underlined numbers indicate adjusted standardized residual <-1.96; Bold numbers indicate adjusted standardized residual >1.96.

Table 2. Association of age with working conditions and social connection

	Age group (%)					<i>p</i> value
	≤30	31-40	41-50	51-60	≥61	
Written contract ^a						
Trend						0.060
χ^2 test						0.050
Present	67 (90.5)	97 (92.4)	110 (91.7)	131 (92.3)	57 (80.3)	
Absent	7 (9.5)	8 (7.6)	10 (8.3)	11 (7.7)	14 (19.7)	
Previous residence ^b						
Trend						<i>0.010</i>
χ^2 test						0.144
Fukushima Pref.	56 (75.7)	72 (68.6)	77 (64.2)	87 (61.3)	41 (57.7)	
Others	18 (24.3)	33 (31.4)	43 (35.8)	55 (38.7)	30 (42.3)	
Radiation passbook						
Trend						<i>0.017</i>
χ^2 test						0.166
Own	44 (59.5)	58 (55.2)	66 (55.0)	70 (49.3)	29 (40.8)	
Do not own	30 (40.5)	47 (44.8)	54 (45.0)	72 (50.7)	42 (59.2)	
Persons to consult ^c						
Trend						0.099
χ^2 test						0.070
Present	55 (74.3)	91 (86.7)	93 (77.5)	107 (75.4)	49 (69.0)	
Absent	19 (25.7)	14 (13.3)	27 (22.5)	35 (24.6)	22 (31.0)	
Public assistance ^d						
Trend						0.822
χ^2 test						<i>0.012</i>
Have	29 (39.2)	55 (52.4)	54 (45.0)	81 (57.0)	<u>25 (35.2)</u>	
Do not have	45 (60.8)	50 (47.6)	66 (55.0)	<u>61 (43.0)</u>	46 (64.8)	

Note: Italicized *p* values indicate significant chi-square test or Mantel-Haenszel test; Underlined numbers indicate adjusted standardized residual <-1.96; Bold numbers indicate adjusted standardized residual >1.96.

^aWritten contract with current company regarding vacation, wages, and perquisite

^bPrevious residence before starting the current job

^cClose persons for consultation

^dKnowledge of how to access public assistance

Table 3. Association of degree of perceived anxiety over radiation exposure with working conditions and social connection

	Total (%)	Degree of perceived anxiety over radiation exposure				<i>p</i> value
		Very much	Somewhat	A little bit	None	
Written contract^a						
Trend						0.060
χ^2 test						0.144
Present	462 (90.2)	41 (8.9)	209 (45.2)	156 (33.8)	56 (12.1)	
Absent	50 (9.8)	9 (18.0)	24 (48.0)	12 (24.0)	5 (10.0)	
Previous residence^b						
Trend						0.814
χ^2 test						0.330
Fukushima	333 (65.0)	31 (9.3)	159 (47.7)	101 (30.3)	42 (12.6)	
Others	179 (35.0)	19 (10.6)	74 (41.3)	67 (37.4)	19 (10.6)	
Radiation passbook						
Trend						0.072
χ^2 test						0.154
Own	267 (52.1)	19 (7.1)	123 (46.1)	89 (33.3)	36 (13.5)	
Do not own	245 (47.9)	31 (12.7)	110 (44.9)	79 (32.2)	25 (10.2)	
Persons to consult^c						
Trend						<i>0.044</i>
χ^2 test						<i>0.003</i>
Present	395 (77.1)	<u>28 (7.1)</u>	186 (47.1)	133 (33.7)	48 (12.2)	
Absent	117 (22.9)	22 (18.8)	47 (40.2)	35 (29.9)	13 (11.1)	
Public assistance^d						
Trend						0.779
χ^2 test						<i>0.012</i>
Have	244 (47.7)	<u>15 (6.1)</u>	120 (49.2)	86 (35.2)	23 (9.4)	
Do not have	268 (52.3)	35 (13.1)	113 (42.2)	82 (30.6)	38 (14.2)	

Note: Italicized *p* values indicate significant chi-square test or Mantel-Haenszel test; Underlined numbers indicate adjusted standardized residual < -1.96; Bold numbers indicate adjusted standardized residual > 1.96.

^aWritten contract with current company regarding vacation, wages, and perquisite

^bPrevious residence before starting the current job

^cClose persons for consultation

^dKnowledge of how to access public assistance

ticipants in the ≥ 61 age group who chose “Very much” was significantly high (Table 1).

The associations among age, working conditions, and social connection are shown in Table 2. The presence of a written contract was common in all age groups (80.3–92.4%). Fifty-six (75.7%) participants in the ≤ 30 age group and 41 (57.7%) in the ≥ 61 age group answered that their previous residence was in Fukushima Prefecture. More than half of the participants in the ≤ 30 , 31–40, and 41–50 age groups owned a radiation passbook, whereas less than half in the 51–60 and ≥ 61 age groups owned one. The presence of “Persons to consult” was most common in the 31–40 age group (86.7%) and least common in the ≥ 61 age group (69.0%). The 51–60 age group had the

highest percentage of participants who knew how to access public assistance (57.0%), and the ≥ 61 age group had the lowest percentage (35.2%). The Mantel-Haenszel test revealed that there were significant correlations between age and the number of participants who answered that their previous residence was Fukushima Prefecture ($p=0.010$) and those who owned a radiation passbook ($p=0.017$). The chi-square test revealed that age was significantly associated with “Public assistance” ($p=0.012$). Residual analysis revealed that significantly more participants in the 51–60 age group had knowledge of how to access public assistance, whereas significantly fewer participants in the ≥ 61 age group had such knowledge.

The associations of the degree of perceived anxiety

Table 4. Association between degree of perceived anxiety over radiation exposure and education provided by employers (multiple answers allowed)

	Total (%)	Degree of perceived anxiety over radiation exposure				<i>p</i> value
		Very much	Somewhat	A little bit	None	
Training sessions^a						
Trend						0.782
χ^2 test						0.826
Yes	475 (92.8)	45 (9.5)	218 (45.9)	155 (32.6)	57 (12.0)	
No	37 (7.2)	5 (13.5)	15 (40.5)	13 (35.1)	4 (10.8)	
Watching a video^b						
Trend						0.835
χ^2 test						0.206
Yes	307 (60.0)	25 (8.1)	147 (47.9)	103 (33.6)	32 (10.4)	
No	205 (40.0)	25 (12.2)	86 (42.0)	65 (31.7)	29 (14.1)	
Physical condition check^c						
Trend						0.439
χ^2 test						0.094
Yes	333 (65.0)	26 (7.8)	154 (46.2)	117 (35.1)	36 (10.8)	
No	179 (35.0)	24 (13.4)	79 (44.1)	51 (28.5)	25 (14.0)	
Self-study with materials^d						
Trend						0.347
χ^2 test						0.122
Yes	298 (58.2)	26 (8.7)	143 (48.0)	101 (33.9)	28 (9.4)	
No	214 (41.8)	24 (11.2)	90 (42.1)	67 (31.3)	33 (15.4)	
Self-study without materials^e						
Trend						0.282
χ^2 test						0.354
Yes	16 (3.1)	2 (12.5)	10 (62.5)	2 (12.5)	2 (12.5)	
No	496 (96.9)	48 (9.7)	223 (45.0)	166 (33.5)	59 (11.9)	

^aStudied about work method, safety management, and protection from radiation exposure, during training

^bWatched a video about work method, safety management, and protection from radiation exposure, during training

^cChecked the physical condition daily before work

^dMaterials for work method, safety management, and protection from radiation exposure were given for self-study

^eMaterials were not given for self-study

over radiation exposure with working conditions and social connection are shown in Table 3. The presence of a written contract of employment was common (90.2%). About two thirds of the participants answered that their previous residence was Fukushima Prefecture (65.0%). Approximately half of the participants owned a radiation passbook (52.1%). The presence of persons for consultation was also common (77.1%); however, less than half of the participants knew how to access public assistance (47.7%). The Mantel-Haenszel test revealed that there were significant trends in the degree of anxiety with “Persons to consult” ($p=0.044$). A chi-square test revealed that

the degree of anxiety was significantly associated with presence of persons for consultation ($p=0.003$) and knowledge of public assistance ($p=0.012$). Residual analysis revealed that the number of participants who chose “Very much” on the anxiety scale significantly increased if close persons for consultation were “Absent,” and if they did not know how to access public assistance.

Results concerning the association between anxiety and education provided by employers are shown in Table 4. “Training sessions” was the most common answer (92.8%), while “Watching a video” (60%), “Physical condition check” (65%), and “Self-study with materials”

Table 5. Association between degree of perceived anxiety over radiation exposure and preventive behaviors (multiple answers allowed)

	Total (%)	Degree of perceived anxiety over radiation exposure				p value
		Very much	Somewhat	A little bit	None	
Checking the dose rate and keeping out of high dose areas^a						
Trend						0.337
χ^2 test						0.293
Yes	273 (53.3)	24 (8.8)	134 (49.1)	87 (31.9)	28 (10.3)	
No	239 (46.7)	26 (10.9)	99 (41.4)	81 (33.9)	33 (13.8)	
Monitoring external exposure^b						
Trend						0.946
χ^2 test						0.998
Yes	349 (68.2)	34 (9.7)	159 (45.6)	115 (33.0)	41 (11.7)	
No	163 (31.8)	16 (9.8)	74 (45.4)	53 (32.5)	20 (12.3)	
Wearing a mask						
Trend						0.744
χ^2 test						0.336
Yes	497 (97.1)	47 (9.5)	227 (45.7)	165 (33.2)	58 (11.7)	
No	15 (2.9)	3 (20.0)	6 (40.0)	3 (20.0)	3 (20.0)	
Wearing a radiation protection suit						
Trend						0.627
χ^2 test						0.393
Yes	12 (2.3)	2 (16.7)	4 (33.3)	3 (25.0)	3 (25.0)	
No	500 (97.7)	48 (9.6)	229 (45.8)	165 (33.0)	58 (11.6)	

^aChecking dose rate of working areas and keeping out of high-dose areas

^bMonitoring the total amount of daily external dosage by portable indicator

(58.2%) were also chosen by more than half of the participants. "Self-study without materials" was rarely chosen (3.1%). There were no significant associations between the degrees of anxiety and the methods of education.

The association between anxiety and preventive behaviors against radiation exposure are shown in Table 5. "Wearing a mask" was the most common (97.1%). "Checking the dose rate and keeping out of high dose areas" (53.3%) and "Monitoring external exposure" (68.2%) were also chosen by more than half of the participants. "Wearing a radiation protection suit" was rarely chosen (2.3%). There were no significant associations between the degrees of anxiety and preventive behaviors against radiation exposure.

The ordinal logistic regression model for associations between the degree of anxiety over radiation exposure and covariates is shown in Table 6. The degree of anxiety significantly decreased if a written contract or persons to consult were present ($p=0.042$ and $p=0.034$, respectively), whereas it increased in workers who routinely checked the dose rates of working areas and kept out of high-dose

areas ($p=0.046$).

Discussion

In the present study, we examined the effect of age and related factors on the degree of perceived anxiety over radiation exposure. Contrary to expectations, our study revealed that age was not significantly associated with the degree of anxiety. The degree of anxiety decreased if the workers had persons to consult or a written contract, whereas it increased if they routinely checked the dose rate of working areas and kept out of high-dose areas.

The absence of persons to consult represented a socially isolated situation among workers in our study. A past study indicated that environments that facilitate mutual support among coworkers may buffer against physical and mental health stressors¹⁶). The absence of close persons, such as colleagues, for consultation was related to deep anxiety in the present study.

Regarding working conditions, the presence of a written contract contributed to decreased anxiety. A previous study reported that employees with informal contracts

Table 6 Ordinal logistic regression model for association between the degree of anxiety over radiation exposure and covariates

Variables	Coefficient (95% CI)	SE	<i>p</i> value
Age	-0.009 (-0.022, 0.003)	0.007	0.151
Written contract ^a	-0.605 (-1.188, -0.021)	0.298	<i>0.042</i>
Previous residence ^b	0.058 (-0.297, 0.414)	0.181	0.747
Radiation passbook	-0.356 (-0.720, 0.008)	0.186	0.055
Persons to consult ^c	-0.454 (-0.873, -0.034)	0.214	<i>0.034</i>
Public assistance ^d	0.072 (-0.294, 0.438)	0.187	0.700
Training sessions ^e	-0.046 (-0.699, 0.607)	0.333	0.890
Watching a video ^f	0.149 (-0.257, 0.555)	0.207	0.472
Physical condition check ^g	-0.331 (-0.761, 0.100)	0.220	0.132
Self-study with materials ^h	0.206 (-0.203, 0.615)	0.209	0.323
Self-study without materials ⁱ	0.533 (-0.438, 1.505)	0.496	0.282
Checking the dose rate and keeping out of high dose areas ^j	0.375 (0.006, 0.744)	0.188	<i>0.046</i>
Monitoring external exposure ^k	0.109 (-0.269, 0.487)	0.193	0.573
Wearing a mask	-0.496 (-1.507, 0.515)	0.516	0.336
Wearing a radiation protection suit	-0.166 (-1.246, 0.915)	0.551	0.764

Note: Italicized numbers indicate *p* value <0.05.

^aWritten contract with current company regarding vacation, wages, and perquisite

^bPrevious residence before starting the current job

^cClose persons for consultation

^dKnowledge of how to access public assistance

^eStudied about work method, safety management, and protection from radiation exposure, during training

^fWatched a video about work method, safety management, and protection from radiation exposure, during training

^gChecked the physical condition daily before work

^hMaterials for work method, safety management, and protection from radiation exposure were given for self-study

ⁱMaterials were not given for self-study

^jChecking dose rate of working areas and keeping out of high-dose areas

^kMonitoring the total amount of daily external dosage by portable indicator

(oral or no contract) had significantly poorer mental health than those with formal (written) contracts²⁰. Workers with written contracts may work in companies that provide adequate occupational management for their employees; thus, the presence of a written contract may contribute to decreased anxiety over radiation exposure.

Regarding preventive behavior to radiation exposure, “checking dose rate of working areas and keeping out of high-dose areas” was significantly related to increased anxiety. Despite having worked at locations with relatively low dose rates¹⁰, more than half of the workers (53.3%, Table 5) stated that they were concerned about high-dose areas. Workers with a high degree of anxiety over radiation exposure are likely to be highly cautious, and they would therefore routinely check the dose rate of their working areas.

Our ordinal logistic model indicated no association between age and anxiety. Nevertheless, the Mantel-Haenszel test revealed that the proportions of workers who came from places other than Fukushima Prefecture

and those who did not own a radiation passbook tended to be older (Table 2). These results suggest that older workers, in particular aged 61 years and older, may engage in decontamination work in unfamiliar surroundings and inadequate working conditions. Moreover, our analysis revealed that there are biases regarding the degree of anxiety according to age (Table 1). The number of workers who answered “Very much” on the anxiety scale was only significantly increased in the ≥61 group. Thus, older workers, especially 61 years old and older, may be the most vulnerable age group of decontamination workers. Support for decreasing anxiety over radiation exposure, with special consideration given to older people, is required.

A limitation of this study was that the mental support that might have been provided within the company was not considered. In Japan, the responsibilities of industrial physicians include prevention of mental health problems²¹. The number of workers with mental health problems has increased, and it has been recognized as an in-

creasing problem of occupational health requiring immediate action²³). However, although we assumed an association between the absence of knowledge of how to access public assistance and increased anxiety over radiation exposure, our study could not distinguish that the increased anxiety was associated with the lack of general assistance or support from professionals, including industrial physicians. Thus, future studies should be designed to distinguish these factors and focus on more specific information about both the mental health of workers and health care provided by the employer.

Additionally, there were no precise data of the air dose rates at each work site or radiation exposure level for each worker in this study. Thus, we could not examine the association between actual air dose rates and perceived anxiety over radiation exposure.

Furthermore, the sampling of study subjects and companies who participated in our research may be biased. We asked the companies that attended a training program against radiation exposure held by the Fukushima Occupational Health Promotion Center. As a result, it was possible that such companies had relatively better occupational health management among all of the companies engaging in decontamination work. Moreover, data from the present study's participants may be biased because they were individually selected by each company. The sample size was relatively small; therefore, it was not fully representative of the total number of decontamination workers in Fukushima Prefecture.

In conclusion, we revealed that radiation decontamination workers' perceived anxiety over radiation exposure increased if they did not have a written contract or persons to consult. Moreover, workers aged 61 and over tended to have inadequate working conditions, and a low number were in possession of a radiation passbook. These findings show the importance of creating supportive human relationships for consultation and enhancement of labor management in individual companies, with special consideration given to older employees.

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