

Characteristics of anxiety and the factors associated with presence or absence of each anxiety among radiation decontamination workers in Fukushima

Takeyasu KAKAMU^{1*}, Tomoo HIDAKA¹, Tomohiro KUMAGAI¹,
Takanobu JINNOUCHI¹, Sei SATO¹, Yusuke MASUISHI¹, Shota ENDO¹,
Shinichi NAKANO², Kikuo KOYAMA³ and Tetsuhito FUKUSHIMA¹

¹Department of Hygiene and Preventive Medicine, Fukushima Medical University School of Medicine, Japan

²Nakano Clinic, Japan

³Fukushima Occupational Health Promotion Center, Japan

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Abstract: The aims of the present study were to investigate what kind of anxiety radiation decontamination workers have, and to analyze what factors are associated to presence or absence of their anxieties. A self-administered questionnaire was conducted, which included 10 anxiety items. A logistic regression model was then used to determine what factors were related to increased anxiety. Of 531 workers who completed the questionnaire, 477 (91.6%) complained of at least one of the 8 anxiety items. The most common anxiety item was job security (41.8%), and the least common item was working hours (6.0%). The logistic regression analysis revealed that the most common causes of related to presence of anxiety was heat illness and the most common causes of related to absence of anxiety was having someone available for consultation. The current study revealed the kinds of anxiety, and the factors associated with presence or absence of each anxiety among radiation decontamination workers. These results provide important implications for the improvement of educational content and occupational health management for radiation decontamination workers in the future.

Key words: Radiation decontamination workers, Anxiety, Work environments, Occupational health and safety management system, Psychosocial stress

Introduction

On March 11, 2011, the Great East Japan Earthquake struck just off the Pacific coast of northeast Japan and, along with the resulting tsunami, caused the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident. This led

to the release of large amounts of radioactive materials, and the environmental radiation dose rate was thus elevated in Fukushima Prefecture^{1, 2)}. The Japanese government designated an area within a 20-km radius of the nuclear plant as a “high-alert zone”. An evacuation order was put into place on April 22, 2011, and anyone other than emergency workers was prohibited to enter the zone³⁾. The government also designated a “planned evacuation zone” for areas that were outside the 20-km radius, which had an estimated cumulative radiation dose of 20 mSv/yr. After July 2012, these evacuation areas were divided into three

*To whom correspondence should be addressed.

E-mail: bamboo@fmu.ac.jp

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categories: “areas in which evacuation orders are ready to be lifted”; “areas in which residents are not permitted to live”; and “areas where it is expected that residents will face difficulties in returning for the foreseeable future”⁴). After the FDNPP accident, approximately 80,000 residents who had been living in the high-alert and planned evacuation zones were evacuated, and those who did not evacuate continued to live with concern over the potential health effects caused by radiation exposure⁵).

Because the reduction of the environmental radiation dose rate was expected to take a long time in the natural environment⁶, the Japanese government decided to begin decontamination work in November 2011⁷). The Ministry of the Environment published decontamination guidelines to provide concrete descriptions of each process of the decontamination work, including removal of soil, cut grass and fallen leaves, as well as washing of houses and roads^{8,9}).

As the radiation decontamination work is still expanding, many more workers are coming to Fukushima Prefecture. Therefore, it may be safe to assume that an increasing number of inexperienced workers are being employed to carry out the work, which is conducted by companies engaged in manual labor such as construction. We suspected that these workers in particular may have concerns regarding their inexperience and living environment.

The decontamination work is not only conducted inside the evacuation areas, but also outside, in areas that are not considered to be high-exposure areas. Taking into account that residents who live outside the evacuation zone have anxiety over radiation exposure^{10,11}), it may be reasonable to consider that even radiation decontamination workers working in such areas have the same anxiety. In addition to radiation exposure, we hypothesized that these workers also have various anxieties over their daily life, as well as their work, due to placement in a new environment. We previously reported that radiation decontamination workers have anxiety about living in company dormitories or shared rooms¹⁰). The media have reported the unpleasant living conditions experienced by radiation decontamination workers on numerous occasions, thus suggesting that this may also be the cause of anxiety.

We previously reported that 52.8% of radiation decontamination workers have experienced heat illness symptoms¹²). As workers with high job strain are at higher risk of occupational injury, employers need to reduce the strain on their employees¹³). Although the government has called for attention to be paid to occupational health risks, such as heat illness during radiation decontamination work, no advice or suggestions for the mental health care of the

workers has yet been provided. We previously reported that some factors, such as having a written contract and a person to consult, significantly reduce anxiety over radiation exposure¹⁴). The aims of the present study were to investigate what kind of anxiety radiation decontamination workers have, and to analyze what factors are associated to presence or absence of their anxieties in order to reduce their psychological distress.

Methods

Study subjects

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 in Fukushima Prefecture, Japan^{12,14}). Fukushima Occupational Health Promotion Center obtained information of companies engaged in radiation decontamination via the Fukushima Labor Bureau. In total, information was obtained from 213 companies. We asked each company to participate in our research, and to select approximately 10 on-site regular employees to complete self-administered questionnaires. The questionnaires were sent to 1,505 radiation decontamination workers in August 2013, and were returned anonymously by mail. By the end of October 2013, 651 workers (628 men and 23 women) returned completed questionnaires. Among them, 531 men, who answered all questions, were included in the statistical analysis because the number of women were very small. The response and effective response rates were 42.5% and 35.3%, respectively.

The subjects were made aware that the questionnaire was for research purposes, and that all responses were optional and anonymous. The subjects also understood that they were deemed to have consented to the use of their responses once they were sent to us.

Ethics approval

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

Questionnaire

The questionnaire included age, sex, education (training sessions for radiation decontamination work and knowledge of radiation exposure, physical condition check, and self-study with materials for radiation decontamination

work), management of radiation exposure (self-monitoring of environmental radiation dose rate, personal radiation exposure dose rate, wearing a mask, and possession of a radiation passbook), consultation (having someone available for consultation and knowledge of public assistance), working status (coming to Fukushima Prefecture for work, duration of decontamination work experience, and working as a new employee), occupational management (having heat illness experience and possession of a written contract), and items regarding anxiety. The anxiety items consisted of radiation exposure, health problems during work, job security, human relationships in the workplace, wages, future health, working hours, separation from family, personal time, and privacy. These items were presented in a list, with the respondents able to select multiple items.

Statistical analysis

We used the statistical software package R, version 3.5.1 (The R Foundation for Statistical Computing, Vienna, Austria).

Mean and standard deviation (SD) were calculated for age. The median number and 25–75 percentile of anxiety were calculated. Working durations were categorized into two groups; “less than 6 months” and “6 months or longer” because the median of the working duration was six. A logistic regression model was conducted to determine the factors that were related to each anxiety. The adjusted odds ratios (ORs) for presence or absence of anxiety, and their 95% confidence intervals (95% CI), were calculated.

Results

We described the characteristics of the subject in Table 1. The mean subject age was 46.3 yr (SD: 13.2, range: 18–77). Of the 531 workers, 181 (34.1%) came to Fukushima Prefecture for the radiation decontamination work and two hundred thirty-nine (45.0) were working as new employee. The median duration of engagement in radiation decontamination work was 7 months (range: 0–30) and about the half of the subjects (49.0%) engaged less than 6 months.

The characteristics of each anxiety is shown in Fig. 1. The most common anxiety item was job security (41.8%), and the least common item was working hours (6.0%). Anxiety over both privacy and personal time was relatively low, at 16.8% and 14.3%, respectively.

The median number of anxiety items selected was two. Four hundred forty-eight workers (84.4%) selected at least one anxiety item, and four workers selected all 8 anxiety

Table 1. Characteristics of the study participants

Age (yr)	
<30	83 (12.9)
30–39	109 (16.9)
40–49	126 (19.5)
50–59	183 (28.4)
60≤	144 (22.3)
Education provided by the company	
Training sessions	494 (93.0)
Physical condition check	341 (64.2)
Self-study with materials	311 (58.6)
Management of radiation exposure	
Self-checking of environmental radiation dose rate	285 (53.7)
Personal radiation exposure dose rate	358 (67.4)
Wearing a mask	511 (96.2)
Possession of a radiation passbook	279 (52.5)
Consultation	
Having someone available for consultation	407 (76.6)
Knowledge of public assistance	254 (47.8)
Working status	
Coming to Fukushima Prefecture for work	181 (34.1)
Working as a new employee	239 (45.0)
Duration of decontamination work (month)	
0–<6	260 (49.0)
6–<12	163 (30.7)
12–<24	87 (16.4)
24≤	21 (4.0)
Occupational management	
Having experienced heat illness	307 (57.8)
Possession of a written contract	477 (89.8)

N (%).

items (Fig. 2).

The results of the logistic regression analysis are shown in Table 2. Items that were significantly related to many kinds of anxieties were experience of heat illness (job security, human relationship, wage, separate from family, personal time, and privacy for presence), coming to Fukushima (separate from family, personal time, and privacy for presence, working hours for absence), possession of radiation passbook (separate from family and privacy for presence, human relationship for absence), and working as a new employee (job security and personal time for presence, separate from family for absence). Training session, self-study with materials, wearing mask, and written contract were not significantly related to any anxiety.

Discussion

We investigated various types of anxiety and their

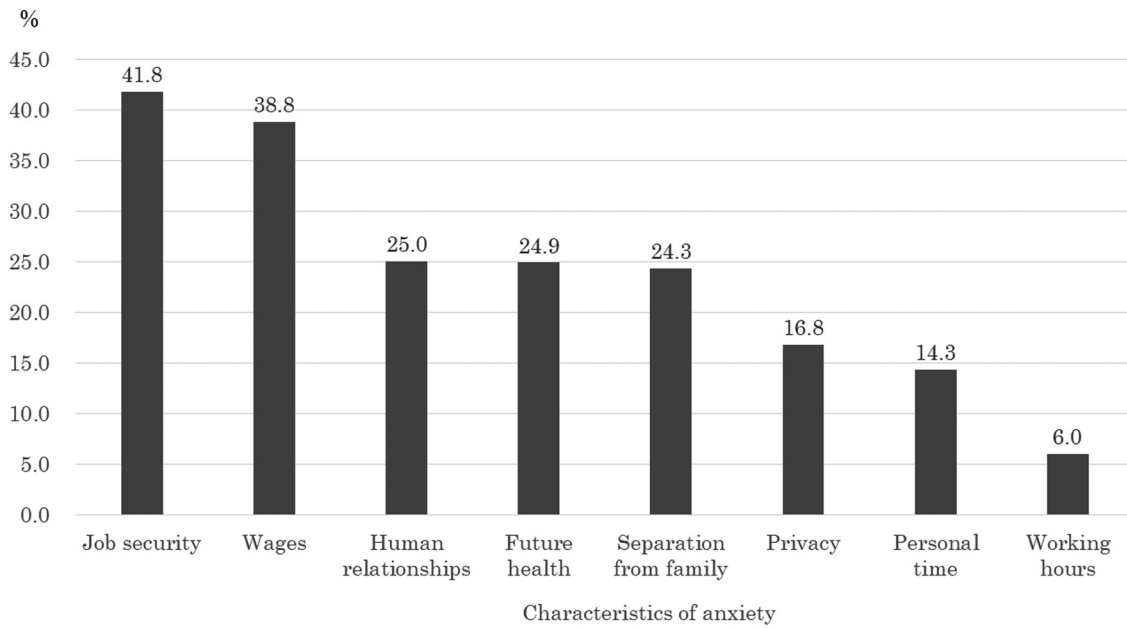


Fig. 1. Characteristics of anxiety over work and daily living.
Rate of each anxiety among workers (n=531).

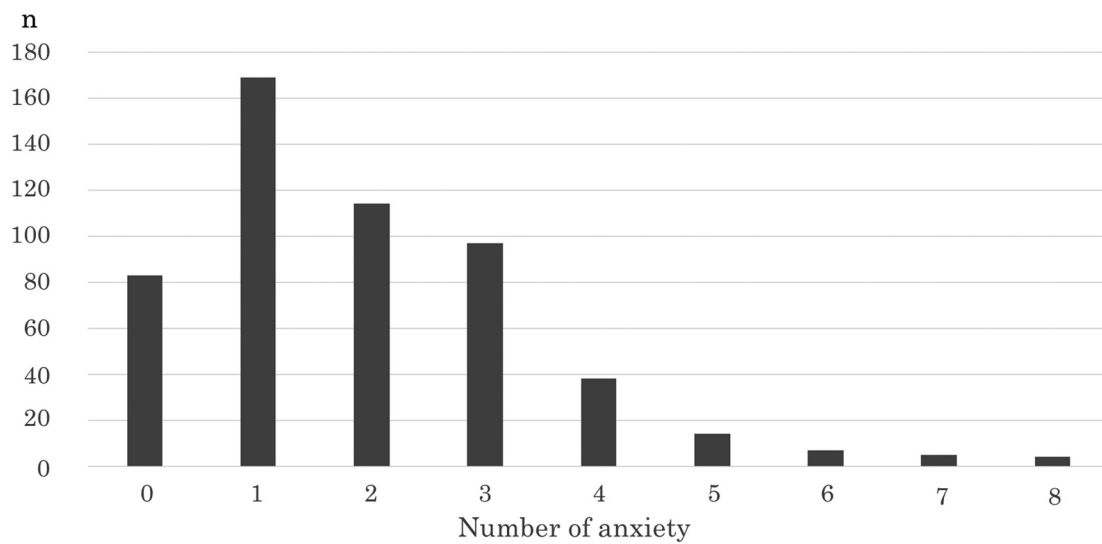


Fig. 2. Total number of anxieties among workers.

prevalence in radiation decontamination workers using a questionnaire, and determined the factors that were associated with a presence or absence of each anxiety items. Most workers in the present study selected at least one anxiety item. Mental health care, such as relieving anxiety, is important for preventing occupational accidents in such workers. Swaen *et al.* reported that emotional job demands increase the risk of being injured in an occupational accident¹⁵. To decrease the risk of occupational accidents, all

employers should try to decrease the emotional demands on their employees, as well as decrease the amount of decontamination work required of each employee.

Usually, anxiety about job security occurs in non-standard employee¹⁶) but this study showed that job security was the most commonly selected anxiety item. This result occurred from that decontamination work was considered as a temporary project in the beginning of radiation decontamination. Precarious project can make worker their

Table 2. Associated factors for presence or absence of each anxiety

	Job security	Human relationships in the workplace	Wages	Future health	Working hours	Separation from family	Personal time	Privacy
Age	<u>1.017 (1.002–1.033)</u>	0.991 (0.975–1.007)	<u>0.980 (0.966–0.994)</u>	0.991 (0.975–1.007)	0.996 (0.969–1.023)	1.014 (0.996–1.032)	0.984 (0.965–1.004)	1.019 (0.999–1.040)
Training sessions	0.678 (0.315–1.485)	0.692 (0.322–1.550)	0.589 (0.281–1.239)	1.745 (0.757–4.559)	3.032 (0.559–56.911)	1.319 (0.504–4.151)	0.574 (0.240–1.492)	1.123 (0.449–3.226)
Physical condition check	<u>2.322 (1.409–3.878)</u>	1.669 (0.991–2.842)	1.460 (0.908–2.359)	0.841 (0.506–1.396)	0.589 (0.243–1.413)	1.040 (0.571–1.904)	0.747 (0.383–1.451)	0.828 (0.443–1.548)
Self-study with materials	1.032 (0.637–1.672)	0.782 (0.470–1.300)	1.356 (0.853–2.166)	1.300 (0.785–2.171)	1.213 (0.495–2.991)	1.348 (0.761–2.409)	1.850 (0.962–3.639)	0.935 (0.509–1.730)
Self-monitoring of environmental radiation dose rate	1.312 (0.851–2.029)	1.056 (0.664–1.685)	0.842 (0.551–1.285)	0.996 (0.631–1.577)	0.651 (0.280–1.474)	0.922 (0.550–1.541)	1.534 (0.858–2.777)	<u>2.366 (1.355–4.212)</u>
Personal radiation exposure dose rate	1.462 (0.936–2.299)	0.846 (0.530–1.359)	1.536 (0.992–2.401)	1.097 (0.692–1.755)	1.122 (0.493–2.667)	0.861 (0.504–1.479)	0.801 (0.453–1.428)	<u>0.423 (0.247–0.723)</u>
Wearing a mask	1.167 (0.422–3.457)	1.378 (0.446–5.270)	1.929 (0.627–7.327)	1.055 (0.352–3.919)	999.999<(0.000–999.999)<	1.336 (0.394–6.185)	0.659 (0.185–3.126)	0.766 (0.241–2.969)
Possession of a radiation passbook	1.453 (0.959–2.211)	<u>0.638 (0.407–0.995)</u>	0.714 (0.476–1.069)	0.743 (0.477–1.154)	0.724 (0.312–1.627)	<u>2.170 (1.327–3.594)</u>	1.548 (0.889–2.727)	<u>1.928 (1.130–3.339)</u>
Having someone available for consultation	0.691 (0.426–1.121)	<u>0.405 (0.247–0.660)</u>	0.633 (0.397–1.009)	<u>0.552 (0.342–0.892)</u>	0.532 (0.237–1.228)	1.195 (0.659–2.218)	0.672 (0.374–1.224)	1.245 (0.694–2.290)
Knowledge of public assistance	1.366 (0.889–2.103)	1.314 (0.822–2.113)	0.963 (0.635–1.463)	0.653 (0.411–1.032)	0.745 (0.298–1.770)	<u>1.681 (1.028–2.763)</u>	<u>0.463 (0.252–0.833)</u>	0.629 (0.359–1.093)
Coming to Fukushima Prefecture for work	0.846 (0.557–1.279)	1.385 (0.885–2.160)	0.793 (0.524–1.193)	1.217 (0.778–1.894)	<u>0.381 (0.132–0.946)</u>	<u>2.060 (1.283–3.328)</u>	<u>2.170 (1.258–3.752)</u>	<u>2.763 (1.666–4.611)</u>
Working as a new employee	<u>3.022 (1.983–4.665)</u>	1.519 (0.973–2.375)	1.223 (0.817–1.832)	1.102 (0.710–1.709)	1.410 (0.644–3.135)	<u>0.378 (0.224–0.625)</u>	<u>1.882 (1.070–3.349)</u>	1.624 (0.948–2.799)
Having decontamination work experience of less than 6 months	<u>1.643 (1.120–2.419)</u>	0.979 (0.642–1.490)	1.301 (0.894–1.896)	0.977 (0.644–1.483)	0.745 (0.340–1.589)	<u>2.115 (1.352–3.338)</u>	1.189 (0.701–2.024)	1.353 (0.819–2.248)
Having experienced heat illness	<u>2.500 (1.687–3.737)</u>	<u>2.188 (1.409–3.452)</u>	<u>1.840 (1.254–2.715)</u>	1.291 (0.845–1.986)	2.151 (0.946–5.388)	<u>2.285 (1.428–3.719)</u>	<u>2.167 (1.239–3.916)</u>	<u>1.754 (1.051–2.984)</u>
Possession of a written contract	0.742 (0.382–1.449)	0.928 (0.465–1.927)	0.591 (0.314–1.109)	0.602 (0.317–1.165)	1.735 (0.527–7.974)	2.175 (0.837–6.833)	0.662 (0.297–1.568)	0.855 (0.378–2.073)

Odds Ratio (95% confidence interval). Underline indicates $p < 0.05$.

precarious future prospects. We think it is important to give them more detailed information of the prospects of the projects. On the other hand, in the current study we found that the number of workers with anxiety regarding working hours was low. We consider this to be because decontamination working hours are highly restricted. Radiation decontamination companies are required to record and store data on workers' personal working hours¹⁷).

Heat illness is a typical occupational injury among construction workers who carry out decontamination work¹⁸). The Fukushima Labor Association sent a letter of attention to the Ministry of the Environment, and the municipalities engaged in radiation decontamination urging the implementation of preventive measures against heat illness¹⁹). Our results show that experience of heat illness was associated to presence of the workers' anxiety. Therefore, decreasing such occupational injuries might be effective to decrease the workers' anxiety.

Radiation decontamination workers requires many workers so many workers were coming to Fukushima for radiation decontamination work. We previously reported that the housing for decontamination workers coming to Fukushima Prefecture was typically either company dormitories or hotel rooms, both of which were shared accommodation¹²). So, workers coming to Fukushima tended to have anxieties of separate from family, personal time, and privacy. Construction workers tend to move between various areas for each work assignment; thus, they may have gotten used to living in shared accommodation.

We found that limited experience (new employee and short working duration) was associated with a presence of some anxiety. In addition, the current study shows that the workers who regularly checked the radiation dose rate of their workplace selected more anxiety items than those who did not make such regular checks. Before engaging radiation decontamination work, all workers are required to be educated on radiation exposure and its prevention for a legally-required amount of time¹⁷). However, few relationship was observed between education provided by employers and anxiety. In 2015, the Japanese government issued a management and education manual for unskilled workers²⁰). The contents of this manual may need to be updated in light of the present findings.

In Japan, co-workers, friends, and family members are consulted when a worker is under stress²¹). The results of the current study revealed that having someone available for consultation decreased some kinds of anxiety. Previous studies have indicated that social support and having someone to consult can reduce job stress in general^{22, 23}).

On the other hand, in the present study, knowledge of public assistance that provides support for job stress-related problems was not associated with anxiety. Hidaka *et al.* reported that not knowing how to access public assistance is associated with increased anxiety over radiation exposure¹⁴). These results indicate that decontamination workers may not use public assistance even when they are aware that such assistance is available. This may be because while the workers are aware of the support available to them, they are not aware of how to receive it, or how easy it is.

Our results indicate that appropriate working conditions may decrease anxiety in workers, and mental health care for those with less experience is needed. The guidelines laid out by the Ministry of Health, Labour and Welfare state that all workers should wear a mask and attend training sessions¹⁷). Employers are legally obliged to provide employees with a written contract but the present study found that this was not fully implemented. There may have been a recall bias; however, considering the contribution of presence of a written employment contract to the reduction of anxiety found in the current study, this issue needs to be urgently addressed. The radiation decontamination guidelines outline the necessary education and fundamental working conditions such as working hours, working process, rest time, and clothing¹⁷). These countermeasures may be useful to prevent occupational injury but insufficient to relieve workers' anxiety.

The present study has some limitations. First, we investigated workers' anxieties, but did not investigate their past medical history or mental health status. As a past study reported that occupational stress was strongly associated with psychological health status²⁴), further investigation is required. Second, we did not ask the details of their work. Radiation decontamination work is conducted by construction company but the details of work includes various processes such as remove soil, wash wall and roof, transportation of contaminated materials. These issues remain to be elucidated in future studies. Despite these limitations, the findings of this study are useful because most of the factors that increase anxiety can be applied to the entire population.

Conclusion

The current study revealed the kinds of anxiety, and the factors associated with presence or absence of each anxiety among radiation decontamination workers. The workers experienced several kinds of anxiety both regarding

their working environment and occupational management. We investigated the prevalence of anxieties regarding human relationships, separation from family, privacy, and personal time. These are factors that can be addressed by employers and occupational professionals. Furthermore, our results may be useful for occupational health management. To reduce anxiety in recently employed workers, not only is continuous training required, but so is a development framework that includes mental health care. Radiation decontamination work is expected to continue over a long period; thus, development of worker education and occupational health management is necessary. Our results highlight important implications for the improvement of future educational content and the occupational health management of radiation decontamination workers.

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Conflict of Interest

The authors declare that they have no competing interests.

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