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

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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 Prefecture1, 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

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ANXIETY AMONG RADIATION DECONTAMINATION WORKERS

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”. 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 exposure.

Because the reduction of the environmental radiation dose rate was expected to take a long time in the natural environment, the Japanese government decided to begin decontamination work in November 2011. 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.

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, 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 rooms. 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 symptoms. As workers with high job strain are at higher risk of occupational injury, employers need to reduce the strain on their employees. 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 exposure. 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. 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 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
prevalence in radiation decontamination workers using a questionnaire, and determined the factors that were associated with a presence or absence of each anxiety item. 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 accident\(^{15}\). 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 employee\(^{16}\) 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
|                      | Job security | Human relationships in the workplace | Wages | Future health | Working hours | Separation from family | Personal time | Privacy |
|----------------------|--------------|--------------------------------------|-------|--------------|--------------|------------------------|---------------|---------|
| Age                  | 1.017 (1.002–1.033) | 0.991 (0.975–1.007) | **0.980 (0.966–0.994)** | 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 | 2.322 (1.409–3.878) | 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) | 2.366 (1.355–4.212) |
| 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) | 0.423 (0.247–0.723) |
| 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) | 0.69 (0.185–3.126) | 0.766 (0.241–2.969) |
| Possession of a radiation passbook | 1.453 (0.959–2.211) | **0.638 (0.407–0.995)** | 0.714 (0.476–1.069) | 0.743 (0.477–1.154) | 0.724 (0.312–1.627) | **2.170 (1.327–3.594)** | 1.548 (0.889–2.727) | 1.928 (1.130–3.339) |
| Having someone available for consultation | 0.691 (0.426–1.121) | **0.405 (0.247–0.660)** | 0.633 (0.397–1.009) | **0.552 (0.342–0.892)** | 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) | **1.681 (1.028–2.763)** | 0.463 (0.252–0.833) | 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) | 0.381 (0.132–0.946) | **2.060 (1.283–3.328)** | **2.170 (1.258–3.752)** | **2.763 (1.666–4.611)** |
| Working as a new employee | 3.022 (1.983–4.665) | 1.519 (0.973–2.375) | 1.223 (0.817–1.832) | 1.102 (0.710–1.709) | 1.410 (0.644–3.135) | 0.378 (0.224–0.625) | 1.882 (1.070–3.349) | 1.624 (0.948–2.799) |
| Having decontamination work experience of less than 6 months | 1.648 (1.120–2.419) | 0.979 (0.642–1.490) | 1.301 (0.894–1.896) | 0.977 (0.644–1.483) | 0.745 (0.340–1.589) | **2.115 (1.352–3.338)** | 1.189 (0.701–2.024) | 1.353 (0.819–2.248) |
| Having experienced heat illness | 2.500 (1.687–3.737) | 2.188 (1.409–3.452) | **1.840 (1.254–2.715)** | 1.291 (0.845–1.986) | 2.151 (0.946–5.388) | **2.285 (1.428–3.719)** | **2.167 (1.239–3.716)** | **1.754 (1.051–2.984)** |
| 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. Ra-
diation decontamination companies are required to record
and store data on workers’ personal working hours17).

Heat illness is a typical occupational injury among con-
struction 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 imple-
mentation of preventive measures against heat illness9).
Our results show that experience of heat illness was as-
associated with 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 ac-
commodation12). 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. Previ-
ous studies have indicated that social support and having
someone to consult can reduce job stress in general22, 23).
On the other hand, in the present study, knowledge of pub-
lic 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 be-
cause 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 train-
ing 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 reduc-
tion of anxiety found in the current study, this issue needs
to be urgently addressed. The radiation decontamination
guidelines outline the necessary education and fundamen-
tal working conditions such as working hours, working
process, rest time, and clothing17). These countermeasures
may be useful to prevent occupational injury but insuffi-
cient to relieve workers’ anxiety.

The present study has some limitations. First, we inves-
tigated 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 anx-
xiety among radiation decontamination workers. The work-
ers 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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