

OPINION

A brief overview of the registration system of radiation exposure doses for decontamination workers and their occupational health management

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Abstract

Following the Fukushima nuclear accident in March 2011, decontamination and related works have been carried out over a wide area, mainly in Fukushima Prefecture. In November 2013, the Radiation Dose Registration and Management System for Decontamination Workers was established to manage the occupational exposure doses of workers engaged in such work. The Radiation Effects Association mainly operates the registration system. This paper summarizes existing reports on this system and occupational health issues among decontamination workers. We collected previous reports and related regulatory laws on occupational health management for decontamination workers working in Fukushima Prefecture, summarized the outline of the radiation dose registration and management system for these decontamination workers, and discussed future issues related to their health management. Approximately 100 000 decontamination workers were registered in the system as of 2020, but none showed radiation doses that exceeded the dose limit. To our knowledge, there have been no reports of decontamination workers presenting physical symptoms suspected to be related to radiation exposure. On the other hand, heatstroke countermeasures and anxiety about radiation exposure have been reported as possible issues in the occupational health management of decontamination workers. Although decontamination workers are unlikely to experience biological effects from radiation exposure, epidemiological studies are needed to examine this evidence. Further analysis is also needed on non-radiation effects, which pose occupational health concerns for decontamination workers. The registration system would allow for tracking decontamination workers, providing data for analyzing radiological and non-radiological effects.

KEYWORDS

decontamination, Fukushima Daiichi Nuclear Power Station, nuclear disaster, occupational health management, radiation protection, registration system

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1 | INTRODUCTION

After the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) following the Great East Japan Earthquake and the colossal tsunami in March 2011, radioactive contamination was discharged into the air and ocean, raising concerns about the risk of physical and mental health problems due to environmental radiation exposure for local residents. This nuclear accident was classified as “Level 7 (severe accident)” on the International Nuclear and Radiological Event Scale. The Japanese government took emergency measures to protect local residents by forcibly evacuating them from areas where relatively high air dose rates were measured and banning the distribution of food products that were contaminated above existing limits.¹ As a result, although there were no deaths directly attributed to radiation exposure, more than 2000 disaster-related deaths occurred due to the forced evacuation of local residents, especially among residents aged 66 years and older in Fukushima Prefecture.² In addition, to quickly reduce the impact of radioactive contamination on human health and the living environment and significantly reduce local residents' anxiety, decontamination and related works have been carried out in a wide range of areas, including Fukushima Prefecture. These measures work to decontaminate soil, collect waste materials, and create interim storage facilities. Decontamination in almost all the residential areas in Fukushima Prefecture could result in a long-term reduction of external radiation doses for residents.³

For decontamination workers, controlling exposure doses is essential. When carrying out decontamination procedures at work sites where the average air dose rate exceeds 2.5 $\mu\text{Sv/h}$ (equivalent to 5 mSv/year at 40 h per week for 52 weeks), workers are required to measure external doses using personal dosimeters and internal doses according to the work content and the concentration of radioactive materials in contaminated soil, air, and other sources. When performing decontamination work in settings where the radiation dose rate is 2.5 $\mu\text{Sv/h}$ or lower, workers are required to measure external exposure doses either by using personal dosimeters, multiplying the average air dose rate by the daily working hours of each person, or by measuring the exposure of a representative with an expected average external exposure dose from the decontamination work. In addition to this dose control, various other occupational health measures are required of decontamination workers.⁴

The Japanese System of Registration and Management of Radiation Exposure Doses for Decontamination and Related Work (hereinafter referred to as the “decontamination registration system”) is administered by the Radiation Effects Association, along with participation

by prime contractors who perform decontamination and related works. By enabling decontamination workers to be tracked, this system has the potential to provide a variety of epidemiological insights into occupational health. In this paper, we focus on this decontamination registration system and clarify future issues in occupational health management including the assessment of radiation exposure risk. We also summarize the dose data of decontamination workers and the literature on occupational health issues reported so far and discuss the future of radiation exposure risk assessment and health management.

2 | DOSE REGISTRATION AND MANAGEMENT SYSTEM FOR DECONTAMINATION WORKERS

In 2011, the ordinances from the Japanese Ministry of Health, Labor, and Welfare (No. 152, 2011), required that decontamination operators take safety measures to control radiation exposure and keep radiation dose records. The ordinance of the Ministry of Labour (Ordinance No. 41 of 1972) and the Act on the Protection of the Environment (Act No. 114 of 1950) also supports this directive. However, decontamination workers often moved between companies, and there was possibility that if decontamination workers reported incorrect values for past doses, accumulated doses might not be adequately managed.⁵ Thus, it was necessary to centrally manage the exposure doses recorded by each company in a single organization.

Based on such a request, in August 2013, decontamination service providers established a study group to examine a method to centrally manage the exposure doses of decontamination workers. They agreed to implement a system equivalent to the “radiation passbook system” and “nuclear radiation worker exposure dose registration management system” (from now on referred to as the “nuclear registration system”) implemented for nuclear power plant workers. Then, prime contractors with decontamination projects voluntarily launch the decontamination registration system in November 2013 to register and manage the radiation dose of each worker. Furthermore, they designate the Radiation Effects Association, as the central registration agency. Thus, the Radiation Dose Registration Centre (RADREC) of the association serves as a delivery organization for “radiation dose management records” about decontamination workers based on laws and regulations.⁶ The RADREC receives these records from decontamination contractors participating in the decontamination registration system and stores them for long periods of time.

Since 1977, the Radiation Effects Association has assigned a central registration number to each nuclear worker at nuclear power plants. These workers include reactor installers and nuclear fuel material processors who are members of the Nuclear Registration System and have managed their radiation doses unified.⁷ Given the existence of workers who move between decontamination and nuclear works, the association can be considered a suitable registration organization for the decontamination registration and management system. The RADREC registers the dose data of decontamination workers provided by the decontamination contractors and nuclear power plants, maintains and manages the data, and promotes the system to respond to career inquiries from the workers about the registered data. Such dose monitoring and individual responses to the registrants are essential from the viewpoint of occupational hygiene and radiation protection.

One of the main advantages of the decontamination registration system is that, coupled with the radiation passbook, the operator can reliably ascertain the radiation exposure history of the workers concerned and use this information for health and safety management. The specific use of the system includes the following¹: the system can centrally grasp the exposure doses of decontamination workers who frequently walk around decontamination sites,² the system can grasp the exposure doses of decontamination work and nuclear facilities,³ the Radiation Effects Association can collectively respond to requests for disclosure by decontamination workers themselves, and⁴ the system can prevent the scattering of exposure dose records and other records of decontamination workers. Therefore, such a dose registration and management system is expected to help detect workers engaged in decontamination work with high cumulative exposure doses and to provide critical information such as exposure histories for their health management. Furthermore, it could have the potential to provide useful data for epidemiological analyses of non-radiation effects.

3 | OCCUPATIONAL HEALTH ISSUES FOR DECONTAMINATION WORKERS

Immediately after the Fukushima nuclear accident, the Tokyo Electric Power Company (TEPCO) implemented programs to prevent radiation exposure. However, it had no effective systems for managing other health risks, and few occupational health professionals contributed to the health risk management processes at the FDNPS.⁸ Since the authorities began emphasizing the importance of occupational health after the accident, they have

established emergency response and occupational health systems have been established for workers at the nuclear power plant. Risk management has been implemented for radiation exposure, heat stress, psychological stress, infectious disease outbreaks, and work fitness. Using the lessons learned through these experiences, the Ministry of Health, Labour and Welfare recognized that properly controlling and implementing medical and health care management in response to a similar accident would require sufficient measures and systematic preparation.⁹ Also, new health management procedures were introduced in July 2016 at the TEPCO-operated FDNPS as part of the fitness-for-duty program.¹⁰ Such organizational autonomy and increased responsiveness to changes in the environment are essential to improving occupational health.¹¹

On the other hand, although there have been few reports on decontamination workers, it has been pointed out that the occupational health management of these workers is weaker than that of workers at nuclear power plants.¹² Decontamination and related works mainly involved the removal of radioactive contaminations from the surfaces of soil, grass, trees, and buildings. Recently, the emphasis has shifted to work related to interim storage facilities.^{6,13} Radiation protection equipment for decontamination work is determined according to the radiation concentration of contaminated soil, air dose rate, etc. Although the possibility of acute radiation injury due to decontamination is extremely low, workers may be concerned because the health effects of chronic radiation exposure are unclear. In addition, wearing such protective equipment in the summer may increase the risk of heatstroke.

As shown in Table 1, previous epidemiological studies have suggested that many decontamination workers have health care problems before engaging in decontamination work,¹⁴ and that it is important to deal with heat stroke and anxiety as occupational health issues for decontamination workers.^{15,16} Education is considered a meaningful way to increase knowledge and reduce anxiety about radiation-induced health risks.^{17–19} However, it has been pointed out that decontamination workers' acquisition of such knowledge may reduce physical health risks and increase mental health risks.²⁰ To our knowledge, there are no reports of decontamination workers exhibiting physical symptoms suspected to be related to radiation exposure.

4 | ASSESSMENT OF HEALTH RISK DUE TO THE EXPOSURE TO ENVIRONMENTAL RADIATION

Precise monitoring of radiation doses, including assessment by deposited effective dose, has been conducted

TABLE 1 Summary of occupational health studies on decontamination workers

Study subjects	Approach	Findings	References
113 decontamination workers admitted to a public hospital	Retrospective analysis	57 of 72 hypertensive patients (79.2%), 37 of 45 dyslipidaemic patients (82.2%) and 18 of 27 hyperglycaemic patients (66.7%) had not been treated for their non-communicable diseases before admission to the hospital	Sawano et al. (2016) ¹⁴
528 decontamination workers	Self-administered questionnaire survey	<ul style="list-style-type: none"> • Out of 528 workers, 316 (59.8%) experienced signs of heatstroke • Preventive factors: age, outdoor physical work, adequate sleep, cool vests, and salt intake • Risk factors: living in company dormitories or temporary housing, light clothing, and breakfast consumption 	Kakamu et al. (2015) ¹⁵
531 decontamination workers	Self-administered questionnaire survey	<ul style="list-style-type: none"> • Out of the 531 workers, 477 (91.6%) reported at least one of the eight anxiety items • The most common concern was job stability (41.8%), while the least common concern was working hours (6.0%) • The most common cause related to the presence of anxiety was a heatstroke, while the most common cause associated with the absence of anxiety was having someone to talk to 	Kakamu et al. (2019) ¹⁶

for workers at Fukushima nuclear power stations under the Ministry of Health, Labour, and Welfare.²¹ However, there are still only a few surveys and reports on workers engaged in decontamination and related works.

In 2021, Fukunaga et al. used the decontamination registration system to analyze the dose distribution of workers in 11 municipalities in Fukushima Prefecture (Futaba Town, Iitate Village, Katsurao Village, Kawamata Town, Kawauchi City, Namie Town, Naraha Town, Minamisoma City, Okuma Town, Tamura Town, and Tomioka Town) from 2013 to 2018.⁶ The total number of workers for each year from 2013 to 2018 were 20 580, 34 617, 40 879, 36 764, 25 153, and 24 607 (including multiple records of people working in several municipalities). The highest average dose was 0.7 mSv in 2014 (maximum dose was 10.4 mSv) and remained almost constant between 0.3 and 0.6 mSv from 2013 to 2018. In the same year, Ogawa et al. reported the 2012–2019 dose statistics for approximately 100 000 decontamination-related workers in detail, including dose changes by work content and comparisons with nuclear workers.¹³ The highest recorded dose ranged from 6.7 (2013) to 13.9 mSv/y (2012), but no workers received an annual dose >20 mSv. Although reporting on recent findings using the decontamination registration system has become highly significant, there

is a significant limitation of these studies is that it is not immediately possible to link dose data to the health risk when workers are exposed to high environmental doses for extended periods.

The best way to obtain accurate and reliable information on environmental radiation exposure would be by actual measurement. However, it is complicated to collect precise measurements from all victims in the affected areas from the past to the future. One approach to solving this problem is evaluation using mathematical models. An external exposure dose evaluation model based on measured individual doses and environmental dose equivalent rates inside and outside of houses in Fukushima has been reported.²² The development of such estimation approaches using computational methods is also promising for assessing health hazard risks due to environmental radiation exposure in the future. Nevertheless, the way such information is communicated to the population must be carefully considered to avoid psychosocial effects that may have a more significant impact on health than radiation itself.²³

Spatially and temporally inhomogeneous dose distribution is one of the issues to be considered when recognizing the risk of environmental radiation exposure from the viewpoint of radiobiology, especially radiation

microdosimetry.²⁴ Tissue-level responses resulting from such non-uniform exposure may contribute to individual risks after exposure to environmental radiation.²⁵ Further progress in radiobiological studies on non-uniform radiation-induced biological responses at the tissue level is expected to elucidate this point.²⁶ From an epidemiological perspective, appropriate cohort studies are needed when considering the risk of environmental radiation exposure. However, an accurate assessment of the impact of low doses and dose rates, rare cancers, intake of radioactive elements, and differences in risk between women and men would require a cohort of about one million people for statistical reasons.²⁷ From this perspective, the Million Person Study (MPS) on low-dose radiation-induced health effects is being promoted as a national effort in the United States.²⁸ It is expected that more epidemiological findings in this area will be accumulated in the future.

5 | CONCLUSION

The dose registration system can help identify workers engaged in decontamination and related work that have high cumulative exposure doses and can contribute to their health care management. Although it is unlikely that decontamination workers will experience biological effects from radiation exposure, epidemiological studies are needed to provide evidence for such effects. In addition, further epidemiological findings on non-radiation effects, which present occupational health issues for decontamination workers, are also essential. This registration system may have the potential to provide useful data for analyzing not only radiation effects but also non-radiation effects by allowing the tracking of decontamination workers.

Future issues include estimating the health risk when workers are exposed to environmental radiation for an extended period and understanding how to link this data to occupational health management. Further radiobiological and epidemiological studies on workers engaged in decontamination and related work, including the use of this registration system, are essential for preparing for the next radiological emergency.

DISCLOSURE

Approval of the research protocol: N/A. Informed Consent: N/A. Registry and the Registration No. of the study/trial: N/A. Animal Studies: N/A. Conflict of Interest: The authors have no competing interests to disclose.

AUTHOR CONTRIBUTIONS

All authors contributed to the ideas of this manuscript.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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