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Environmental radiation level, radiation anxiety, and psychological distress of non-evacuee residents in Fukushima five years after the Great East Japan Earthquake: Multilevel analyses[☆]



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ABSTRACT

The present study aimed to clarify the associations among radiation exposure or psychological exposure to the Fukushima nuclear power plant accident (i.e., fear/anxiety immediately after the accident), current radiation anxiety, and psychological distress among non-evacuee community residents in Fukushima five years after the Great East Japan Earthquake, which occurred in March 2011. A questionnaire survey was administered to a random sample of non-evacuee community residents from 49 municipalities of Fukushima prefecture from February to April 2016, and data from 1684 respondents (34.4%) were analyzed. Environmental radiation levels at the time of the accident were ascertained from survey meter data, while environmental radiation levels at the time of the survey were ascertained from monitoring post data. In the questionnaire, immediate fear/anxiety after the accident, current radiation anxiety, and psychological distress were measured using a single-item question, a 7-item scale, and K6, respectively. Multilevel linear or logistic regression models were applied to analyze the determinants of radiation anxiety and psychological distress. The findings showed that environmental radiation levels at the time of the survey were more strongly associated with radiation anxiety than radiation levels immediately after the accident. Disaster-related experiences, such as direct damage, disaster-related family stress, and fear/anxiety after the accident, and demographic characteristics (e.g., younger age, being married, low socioeconomic status) were significantly associated with radiation anxiety. Environmental radiation levels at the time of the accident or survey were not significantly associated with psychological distress. Radiation anxiety largely mediated the association between fear/anxiety after the accident and psychological distress. In addition to environmental radiation levels, respondents' radiation anxiety was affected by multiple factors, such as disaster-related experiences and demographic characteristics. Radiation levels were not associated with psychological distress in non-evacuee community residents. Rather, fear/anxiety after the nuclear power plant accident may be a determinant of psychological distress, mediated by radiation anxiety.

1. Introduction

The Great East Japan Earthquake and tsunami of March 11, 2011, caused the Fukushima Daiichi Nuclear Power Plant accident. Studies conducted after the previous nuclear power plant accidents at Three

Mile Island (TMI) and Chernobyl reported long-term mental health problems among community residents (Bromet, Havenaar & Guey, 2011; Bromet, 2014; Ginzburg, 1993; Havenaar, Rumyantzeva, Kasyanenko, et al., 1997; Havenaar, Rumyantzeva, van den Brink, et al., 1997; Viinamäki et al., 1995), and the perception about the

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possible health effects of radiation exposure was found to underlie this increased psychological distress (Adams, Guey, Gluzman & Bromet, 2011; Bromet, Gluzman, Schwartz & Goldgaber, 2002; Dew & Bromet, 1993). Also, after the accident in Fukushima, the affected population's mental health problems (Oe, Fujii, et al., 2016; Yabe et al., 2014) and their associations with a perception of possible adverse health effects (Oe, Maeda, et al., 2016; Suzuki et al., 2015) or anxiety about personal radioactive contamination (Niitsu et al., 2014) were reported.

However, to date, the nature of radiation anxiety (i.e., worry and anxiety about the possible adverse health effects of exposure to radiation) and its impact on prolonged psychological distress after a nuclear power plant accident have yet to be disentangled. First, it is not clear what the determinants of radiation anxiety are after a nuclear power plant accident. It is reasonable to assume that high environmental levels of radiation contamination affect the development of radiation anxiety. However, other factors may also play a role. From surveys of evacuees from the Fukushima prefecture, it has been reported that disaster-related experiences, such as house damage, bereavement, and loss of employment, in addition to sociodemographic characteristics, such as female gender, age (both younger and older), low educational attainment (Suzuki et al., 2015), and having a spouse and children (Murakami, Nakatani & Oki, 2016), were associated with a higher risk perception for the health effects of radiation exposure. A study after the TMI accident also reported that women, younger people, and people living near the plant perceived a greater threat to their health from radiation exposure (Dohrenwend et al., 1981). Thus, cognition and perception of the harmful effects of radiation on their health may also be affected by sociodemographic, disaster-related, and social support factors. However, these studies did not adjust for environmental levels of radiation exposure.

Second, only a small number of studies examined the association between environmental levels of radiation exposure and the mental health of community residents, and the findings of those are inconsistent. In the 20 years since the Chernobyl disaster, Beehler et al. (2008) found no association between the level of caesium-137 ground contamination at the time of the survey and residents' depression and anxiety. On the other hand, Lehmann and Wadsworth (2011) did report an association between area-level dose of caesium-137 at the time of the accident and poor self-reported health at 20 years after the accident. Among evacuee residents in the Fukushima prefecture, Kunii et al. (2016) found an ecological association between area-based environmental radiation levels at the time of the survey and the proportion of residents with high psychological distress. Thus, the mediating role of radiation anxiety over the association between environmental radiation levels and poor mental health is not clear.

The aims of the present study were two-fold. First, it aimed to investigate the association of environmental radiation exposure at the time of the accident and at the time of the survey and the demographic and disaster-related variables with radiation anxiety of community non-evacuee residents of Fukushima prefecture. Second, it aimed to investigate the association of environmental radiation exposure at the time of the accident and at the time of the survey and radiation anxiety with psychological distress, controlling for demographic and disaster-related variables. Our particular interest was to clarify the link among (1) environmental radiation exposure or psychological exposure to the nuclear power plant accident (i.e., fear/anxiety immediately after the accident), (2) radiation anxiety as a mediator, and (3) psychological distress.

2. Methods

2.1. Study design and study population

In the present study, the target communities comprised 49 of the total 59 municipalities of the Fukushima prefecture, excluding restricted areas close to the nuclear power plant as designated by the

Japanese government at the time of the survey. In each municipality, we randomly sampled 100 residents aged 20 to 80 years old, with double weighting for residents aged 20 to 39 years old; thus, we yielded a total of 4900 initial subjects, to whom we administered a cross-sectional questionnaire survey from February to April 2016.

2.2. Study variables

2.2.1. Psychological distress

Psychological distress was assessed using the K6 (Japanese version), a 6-item self-administered screening instrument of non-specific psychological distress over the past 30 days (Furukawa et al., 2008; Kessler et al., 2002). Items are rated on a 5-point Likert scale from 0 (none) to 4 (all the time), with a summary score ranging from 0 to 24. When individuals answered at least three items, we calculated their total scores by supplementing missing scores with the mean of the other items. We decided persons scoring 5 or more exhibited psychological distress, based on the study reporting the score of 5 as the optimal cutoff point for the Japanese version of K6 to maximize the sum of sensitivity and specificity (Sakurai, Nishi, Kondo, Yanagida & Kawakami, 2011). This was also based on previous studies of community residents conducted after the Great East Japan Earthquake using the score of 5 or more in K6 to identify cases with psychological distress (Horikoshi, Iwasa, Kawakami, Suzuki & Yasumura, 2016; Niitsu et al., 2014).

2.2.2. Radiation anxiety

We defined "radiation anxiety" as negative cognition and perception, such as worry and anxiety, of the possible adverse health effects of radiation exposure, and related psychosocial problems, such as perceived stigma and discrimination due to radiation exposure. Radiation anxiety was assessed using the 7-item Radiation Anxiety Scale developed by Umeda et al. (Kawakami, 2013; Umeda et al., 2014). The items were selected from a qualitative analysis of descriptions of worry, anxiety, and problems related to radiation exposure from community evacuee residents in the Fukushima prefecture. The scale consists of (1) I am concerned about getting a serious illness in the future due to the effects of radiation; (2) Every time I feel ill, I am afraid this is caused by radiation exposure; (3) I am concerned that radiation effects can be inherited by the next generation such as children and grandchildren; (4) I feel strong anxiety when I see news reports concerning the nuclear power plant accident; (5) I have had the experience of being discriminated against (or unfairly treated) because I lived in the area that is reported to have high levels of radiation; (6) I try not to tell others that I am a resident of that area as far as possible; and (7) I have experienced conflicts and trouble with my family members over the radiation health effects. The items were rated on a 4-point Likert scale from 1 (do not agree at all) to 4 (strongly agree), and the item scores were added together to obtain the total scale score, ranging from 7 to 28, with a higher score indicating a higher level of radiation anxiety. The Cronbach's alpha coefficient of the scale has been reported as 0.81 (Kawakami, 2013; Umeda et al., 2014), and in the present study sample it was 0.85. When individuals answered at least four items, we calculated their total scores by supplementing their missing scores with the mean of the other items.

2.2.3. Demographic characteristics

The demographic characteristics included in this study were sex, age, educational attainment, household income, household size, marital status, living arrangement, working status, and comorbid chronic conditions (chronic physical disease and mental illness under treatment). To adjust household income by household size, we divided overall household income in the previous year by the square root of the number of household members (Ichida et al., 2009) and generated three categories.

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