

Explanatory Meetings on Thyroid Examination for the “Fukushima Health Management Survey” after the Great East Japan Earthquake: Reduction of Anxiety and Improvement of Comprehension

Yuko Hino,^{1,2} Michio Murakami,^{1,2} Sanae Midorikawa,^{1,2} Akira Ohtsuru,^{1,2}
Shinichi Suzuki,^{1,2} Kumiko Tsuboi¹ and Tetsuya Ohira^{1,2}

¹Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University, Fukushima, Fukushima, Japan

²Fukushima Medical University School of Medicine, Fukushima, Fukushima, Japan

After the Fukushima Daiichi nuclear accident in 2011 and thyroid examinations of children in Fukushima, the Radiation Medical Science Center began “Explanatory meetings on thyroid examination” as a method of communication with residents such as the subjects themselves and their guardians. Through questionnaires, we examined the relationship between anxiety (regarding the effects of radiation on the thyroid) before the meetings and individual attributes including attitudes on radiation, and then verified the effects of the meetings using measures of anxiety, comprehension, and satisfaction, as the outcomes. Of the meetings in 2014-2015, 799 people attended 30 sessions in Kenchu, Kenpoku, Iwaki, Soso, and outside of Fukushima Prefecture, and 594 people responded the questionnaires before and after the meetings on the same day. Level of anxiety before the meetings varied depending on individual attributes (including attitudes regarding collection information on radiation, advisors on radiation, and levels of subjective understanding), highlighting the importance of presenting information about radiation in a manner that is easy to understand, as well as providing opportunities for the exchange of opinions. Participation in meetings reduced anxiety. This was largely attributed to explanations about general characteristics of cancer and objective facts, including doses; status of the Chernobyl accident; and comparison in results of thyroid examinations with other prefectures in Japan. An opportunity for a question-and-answer session also contributed to increased overall satisfaction. The lower number of meeting participants was associated with anxiety reduction and higher subjective comprehension. The present findings obtained will be useful to facilitate evidence-based risk communication.

Keywords: Fukushima Daiichi nuclear accident; Great East Japan Earthquake; radiation; risk communication; thyroid ultrasonic examination

Tohoku J. Exp. Med., 2016 August, 239 (4), 333-343. © 2016 Tohoku University Medical Press

Introduction

The Fukushima Daiichi nuclear accident (“the 2011 accident”), a result of the Great East Japan Earthquake that occurred on March 11, 2011, spread radioactive materials and produced both internal and external exposure (United Nations Scientific Committee on the Effects of Atomic Radiation 2014). Though doses in residents affected by the 2011 accident (Tokonami et al. 2012; United Nations Scientific Committee on the Effects of Atomic Radiation 2014) were more than 1-2 orders of magnitude lower than those in those by the 1986 accident (United Nations Scientific Committee on the Effects of Atomic Radiation

2010), such results were not obtained immediately after the disaster. Based on the increased risk for thyroid cancer for those who were children at the time of the disaster (Cardis et al. 2006; Brenner et al. 2011) that became apparent after the 1986 accident, Fukushima Prefecture began thyroid (ultrasonic) examinations among Fukushima residents who were approximately 18 or younger at the time of the earthquake. This took place within the framework of the “Fukushima Health Management Survey” in October 2011, to carefully monitor children’s health over the long term (Yasumura et al. 2012). Details of results from preliminary thyroid examinations in the Fukushima Health Management Survey were described in Suzuki (2016).

Received June 6, 2016; revised and accepted July 13, 2016. Published online August 18, 2016; doi: 10.1620/tjem.239.333.

Correspondence: Tetsuya Ohira, M.D., Ph.D., Department of Epidemiology, Fukushima Medical University School of Medicine,

1 Hikarigaoka, Fukushima, Fukushima 960-1295, Japan.

e-mail: teohira@fmu.ac.jp

“Cancer screening” refers to measures taken with people who do not yet have symptoms, and who have a cancer for which early detection is deemed to have considerable overall benefits. Screening for thyroid cancer, which has a favorable prognosis, is generally not performed. This thyroid examination was therefore the first time that many examinees (or their guardians) were tested in a consultation. Subjects had inadequate medical knowledge about the thyroid, and were unfamiliar with the terms “cyst” or “nodule” used in the documents informing them of the test results; they also were not familiar with characteristics of thyroid cancer, such as its high survival rate after surgery (10-year survival rate of 100% for Stage I and II) (Gunma Prefectural Cancer Center 2016)). “A” category individuals in the test results were those who did not have medical problems and who were encouraged to visit for the next round of examinations; approximately half of the examinees were categorized under A2 (no medical problems; cysts no larger than 20.0 mm or nodules no larger than 5.0 mm observed) in the preliminary baseline screening. Thyroid examination was initially implemented to reduce excessive anxiety; however, though it had the benefit of early detection with the latest technology, it also had the unintended consequence of increasing anxiety about thyroid cancer among residents who expected their examination results to be normal (Ohtsuru et al. 2015).

Slovic (1987) identified two psychological dimensions of risk: dread risk and unknown risk. The health effects of radiation are in step with these two psychological dimensions of risk, including the fact that exposure is involuntary, that the health effects of low-dose exposure are still poorly understood scientifically, and that immediately after the disaster, many residents were especially anxious about effects on their children or future offspring (Suzuki et al. 2015). Radiation risk perception is known to have a relationship with individuals’ psychological stress. A survey of residents in municipalities, including evacuation zones at the time of the disaster, also showed that those who believed that exposure would produce effects were more likely to have high psychological stress after the nuclear accident (degree of depressed mood or anxiety as measured by K6) (Suzuki et al. 2015), suggesting that the nuclear accident can add another psychological stress to effects owing to the Great East Japan Earthquake (Arata et al. 2015). Epidemiological studies have found that when there is high psychological stress or mood disorders, mortality rates and suicide rates are higher (Pratt 2009; Mattisson et al. 2015). After the 1986 accident, some people who underwent thyroid screening also experienced complex socio-economic problems, including evacuation, and reported psychological issues including higher rates of depression, suicide ideation, and attempted suicide (Contis and Foley 2015). Generally, quality of life after thyroid cancer surgery, especially for young people, is lower than that after other cancer surgeries, despite its good prognosis, because of the multiple effects including psychological ones

(Aschebrook-Kilfoy et al. 2015). These findings highlight the importance of risk communication and psychological care.

Risk communication is defined by the U.S. National Research Council (1987) as “an interactive process of exchange of information and opinion among individuals, groups, and institutions.” Given that efforts at appropriate communication were needed, in terms of both a general explanation of the relationship between radioactive iodine exposure and the onset of thyroid cancer, and explanations of the significance and details of thyroid examination, the Radiation Medical Science Center for the Fukushima Health Management Survey began “Explanatory meetings on thyroid examination” in late 2012, to communicate with residents and their guardians for the purpose of promoting an understanding of thyroid examination, observation, and disease. These explanatory meetings provided objective numerical information about the characteristics of thyroid cancer, such as age of onset, as observed from overall examination results and in the aftermath of the 1986 accident. In addition, an explanation of the current understanding of this information was provided, alongside detailed medical explanations of individual results and a mutual exchange of ideas through question-and-answer sessions.

Based on personal experience, Fischhoff (1995) identified seven stages of risk communication, and highlighted the importance of explanations based on numerical data at the initial step. Furthermore, the guidelines of the Risk Communication Expert Committee of the Japan Cabinet Office’s Food Safety Commission (Food Safety Commission of Japan Cabinet Office 2008), suggest that holding sessions on a smaller scale to clarify objectives, goals, and the target audience may be valuable, in contrast to larger-scale sessions in excess of 100 people. However, regarding the effects and applicability of guidelines and tools for risk communication, it has been noted that little quantified evidence exists, that application to different cultural situations is especially poorly understood, and that tools should be empirically evaluated (Sato 2015). Investigations of the effects of risk communication since the 2011 accident have been extremely limited. Sugimoto et al. (2013) investigated differences in anxiety and the effects of media contact before and after explanatory meetings on radiation and health in the cities of Soma and Minamisoma in Fukushima Prefecture in 2011, and suggested that implementing the explanatory meetings had the effect of reducing anxieties stemming from the earthquake. However, it is not known what kind of explanatory sessions reduce anxiety about radiation and its health effects. Knowledge is also limited, and quantified experimental studies are lacking, on the effects of session size. Thus, it is necessary to accumulate experimental studies on these factors to facilitate evidence-based risk communication.

The objective of this study was therefore to investigate the “Explanatory meetings on thyroid examination” conducted from 2014 to 2015, when surveys began to be imple-

mented before and after meetings to study changes in anxiety. In this respect, the study had two goals. First, to examine the relationship between level of anxiety regarding the effects of radiation on the thyroid before the meetings, and individual attributes such as sex and area of residence, and attitudes with respect to radiation. The second goal was to verify the effects of the meetings. To contribute to improving the meetings themselves, effects were verified using a scale measuring not only anxiety levels, which were assessed by Sugimoto et al. (2013), but also levels of comprehension and satisfaction, as outcomes. Specifically, the study investigates whether the meetings brought about a decrease in anxiety, and how individual attributes, attitudes about radiation, number of participants in the meetings, and content of individual meetings were associated with anxiety reduction and affected levels of comprehension and satisfaction.

Methods

Meeting implementation and subjects

The Radiation Medical Science Center for the Fukushima Health Management Survey began its “Explanatory meetings on thyroid examination” with resident participation in late 2012. Since 2013, with the support of doctors dispatched by the Japan Radioisotope Association, the meetings have become well known among educational institutions such as nursery schools, kindergartens, and elementary, junior high, and senior high schools, as well as schools for the disabled. One doctor (a thyroid specialist or nuclear medicine specialist) was dispatched as an instructor to each institution that applied. The meetings addressed guardians, teachers, and the general public. The number of participants in meetings ranged from several to more than 100, corresponding to the intentions of the applicant institution.

The doctors responsible varied from meeting to meeting, and the time required for the meetings varied as well, from 60 to 90 min-

utes, depending on the applicant institution; however, uniform basic materials were used for explanations to standardize the quality of the meetings. Test results and related material were updated to the most recent information available. In addition, a place for question-and-answer sessions was provided whenever possible; rather than one-way transmission of information, this involved two-way exchange of information. In meetings, the doctor providing the explanation was always accompanied by a representative responsible for moderating meetings or coordinating questions and answers. Furthermore, doctors responsible for meetings were instructed to avoid wording that reflected values such as “safe” or “okay,” and to focus purely on objective explanations.

Of the explanatory meetings on thyroid examination conducted between September 2014 and June 2015, 30 sessions during which surveys were implemented served as the subject of analysis (22 sessions with an institution within Fukushima Prefecture that made an application, and 8 sessions held by Fukushima Medical University in Yamagata Prefecture, for a total of 30 sessions). In total, 749 people in Fukushima and 50 outside Fukushima (in Yamagata) participated. The meetings were held once for each educational institution; therefore, people were considered to attend the meetings only once. Surveys were conducted anonymously and excluded those who were younger than 20 or who did not provide their age. The valid response rate was 74% overall. The number of respondents in each region of meeting implementation and the external exposure for four months (Ishikawa et al. 2015) are shown in Fig. 1. The surveys did not contain personal data, and only information that had already been untraceably anonymized was handled, falling outside the scope of the ethical guidelines on epidemiological research from the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare (2002).

Survey items

Participants responded to the survey items before and after the start of the sessions on the same day. Before the sessions, they were asked about individual attributes—sex, age, type of respondent (test

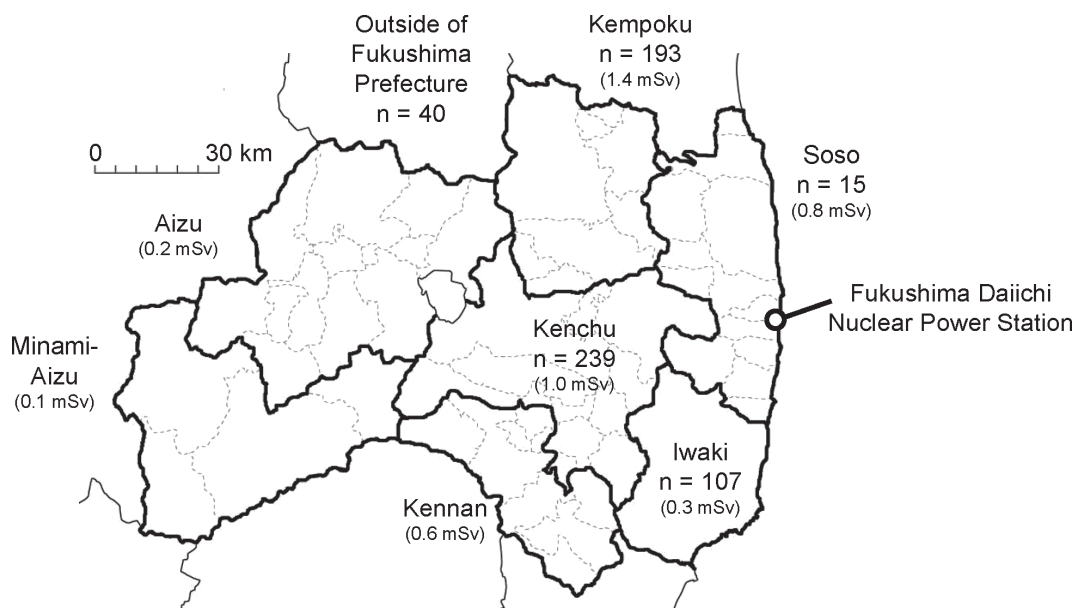


Fig. 1. The number of respondents in each region implemented. The data within parentheses indicate the external exposure for four months (Ishikawa et al. 2015).

subject, guardian of a test subject, teaching staff, municipal employee, or other), and region of residence (at the municipality level) at the time of the earthquake—and also were asked to assess their level of anxiety regarding the effects of radiation on the thyroid on a scale of 1 to 10, where 1 was “not very anxious” and 10 as “very anxious.” Regarding attitudes about radiation, bearing in mind the existence of discussions of the relationship between radioactive risk perceptions and attitudes on gathering information about radiation, advisors on radiation, or knowledge (Perko et al. 2012; Science Council of Japan Committee on Supporting Reconstruction after the Great East Japan Earthquake 2012; Sugimoto et al. 2013; Goto et al. 2014), the subjects were asked to select the statement that applied to them from among seven items: “I collect information on radiation” (information), “I have previously collected information because of anxiety, but not now” (information, previously), “I can talk about radiation with my family without experiencing stress” (family with whom to talk), “I can talk about radiation with my friends or acquaintances without experiencing stress” (friends with whom to talk), “I have no people around me to whom I can talk about radiation” (no one with whom to talk), “I understand radiation to some degree” (understanding), “I do not know about radiation” (no understanding). Level of understanding can be measured subjectively through respondents’ self-reported knowledge (Imai et al. 2015), objectively based on whether questions are answered correctly or incorrectly (Perko et al. 2012), or both (Vandermoere 2008). However, in this study, it was thought that asking respondents to correctly answer questions would likely cause psychological burden; therefore, level of understanding was measured according to self-judgments of knowledge.

After the meetings, respondents were asked to indicate whether they comprehended the content of the meetings using a Likert scale with four levels: “4 = comprehended well,” “3 = comprehended somewhat,” “2 = did not comprehend much,” and “1 = did not comprehend.” This also represented the use of a subjective level of comprehension. Respondents were also asked to assess their anxiety about the effects of radiation on the thyroid on a scale from 1 to 10, as well as to rate items about the content of the meetings using a Likert scale with five levels: “5 = very good,” “4 = rather good,” “3 = neither,” “2 = not good,” “1 = bad.” The items were as follows: “There was an explanation of objective data, such as radiation doses and the results from the 1986 accident” (“objective data”), “There was an explanation from a doctor” (“explanation from a doctor”), “There was a description of the characteristics of cysts and nodules” (“nodule”), “There was an explanation of the characteristics of thyroid cancer” (“thyroid cancer”), “The latest results from thyroid examination were listed” (“thyroid examination results”), “There was a general explanation of cancer” (“cancer”), “The number of participants” (“session sizes”), “There was an opportunity to ask questions and receive answers” (“Q&A”), and overall satisfaction (“satisfaction”). Open-ended answers were also accepted.

Analysis methods

Region of residence was classified into four categories: Kenchu, Kempoku, Iwaki, and Soso. Places where meetings were held were classified into five categories, including the aforementioned regions as well as outside of Fukushima Prefecture. Region classifications and external doses have been summarized in a previous report (Ishikawa et al. 2015). The number of participants in meetings was classified into three categories: ≤ 25 people, 26 to 99 people, and 100 or more people. For “session sizes”, results showed not only the per-

ception among participants that the number of participants in meetings was appropriate, but also satisfaction with the content of the meetings. Opinions given for open-ended questions indicated that they therefore valued them less because they wanted more people to attend the meeting; thus, the assessment of “session sizes” was not used for analysis.

In order to study the relationship between pre-meeting anxiety and individual attributes (including the region of meeting implementation), number of participants, and attitudes about radiation, comparisons between two groups were tested with the Mann-Whitney U test, and comparisons of three or more groups were tested using the Kruskal-Wallis test as well as the Dunn-Bonferroni post-hoc test. To assess the effects of the meetings, anxiety levels before and after meetings were compared using the Wilcoxon signed rank test. Then, in order to assess the causes of the effects of the meetings, a multivariate ordered logistic regression analysis was performed with the change in anxiety for before/after meetings and the levels of anxiety, comprehension, and overall satisfaction after meetings as objective variables, and individual attributes, attitudes about radiation, and the number of participants and assessments of the content of the meetings as explanatory variables. For change in anxiety, reduction, no change, and increase were regarded as -1 , 0 , and 1 , respectively. For assessment of contents of meetings, ≥ 4 (“good” or “very good”) and < 4 (“bad”, “not good” or “neither”) were regarded as 1 and 0 , respectively. In terms of sex, age, type of respondent, region of residence at the time of the earthquake, region of meeting implementation, the number of participants, and attitude about radiation, dummy variables were created with women, 20’s, guardian, Kenchu, Kenchu, 100 or more people, and “not applicable” as references, respectively. The variance inflation factor (VIF) for the multivariate ordered logistic regression analysis ranged from 1.08 to 7.60; values less than 10 indicate that multicollinearity is not a concern. $P < 0.05$ was regarded as statistically significant. SPSS Version 22 was used for analysis.

Results

Pre-meeting anxiety about the effects of radiation on the thyroid

Table 1 summarizes respondent’s individual attributes and attitudes about radiation. The relationships between pre-meeting anxiety levels and individual attributes or attitude about radiation were investigated (Fig. 2). Women had significantly higher levels of anxiety before meetings ($P < 0.01$). There were no significant differences between age groups ($P > 0.05$). In terms of types of respondents, guardians and test subjects had significantly higher levels of anxiety than did teaching staff or municipal employees ($P < 0.01$). Whereas there were no significant differences among regions of residence at the time of the earthquake ($P > 0.05$), there were significant differences among regions of meeting implementation, with those outside of Fukushima Prefecture having significantly higher levels of anxiety than those from all other regions, and those from Soso having lower levels of anxiety ($P < 0.05$). There were no significant differences by the number of participants in meetings.

Regarding attitudes about radiation, those who responded “applicable” to “information”/“no one with whom to talk”/“no understanding” and those who responded

Table 1. Respondents' individual attributes and attitudes about radiation.

	n	(%)
Sex		
Women	510	86%
Men	84	14%
Age		
20-29 y	51	9%
30-39 y	207	35%
40-49 y	235	40%
50-59 y	70	12%
≥ 60 y	31	5%
Type		
Guardians	417	70%
Test objects	32	5%
Teaching staff and municipal employees	78	13%
Other	36	6%
No response	31	5%
Region of residence area at disaster		
Kenchu	198	33%
Kempoku	198	33%
Iwaki	95	16%
Soso	48	8%
Other regions or no response	55	9%
Region of meeting		
Kenchu	239	40%
Kempoku	193	32%
Iwaki	107	18%
Soso	15	3%
Outside of Fukushima Prefecture	40	7%
Number of participants		
≤ 25	227	38%
26-99	125	21%
≥ 100	242	41%
Attitudes about radiation		
Information	87	15%
Information, previously	344	58%
Family with whom to talk	323	54%
Friends with whom to talk	255	43%
No one with whom to talk	45	8%
Understanding	251	42%
No understanding	126	21%

“not applicable” to “family with whom to talk”/“friends with whom to talk”/“understanding” had significantly higher levels of anxiety before meetings ($P < 0.001$ for “information,” $P = 0.05$ for “understanding,” and $P < 0.01$ for the others).

Effects of the meetings on levels of anxiety, comprehension, and satisfaction

Fig. 3 shows the distribution of changes in levels of anxiety before and after the meetings. Areas of circles are proportional to the number of participants, and plots located below the line of $y = x$ represent reduction of anxiety after meetings. Levels of anxiety after meetings were signifi-

cantly reduced from those before the meetings ($P < 0.001$). Though some participants' levels of anxiety remained unchanged before and after the meetings (one with low anxiety, 6%; five with moderate anxiety, 5%; ten with high anxiety, 4%), overall the meetings were shown to reduce anxiety.

Next, Fig. 4 shows the distribution of levels of comprehension and satisfaction with the content of the meetings. Levels of comprehension of the meetings were “comprehended well” (57%) and “comprehended somewhat” (35%); thus, a high level of comprehension of the meetings was present overall (92%). The overall level of satisfaction with the meetings was “very good” (50%) and “rather

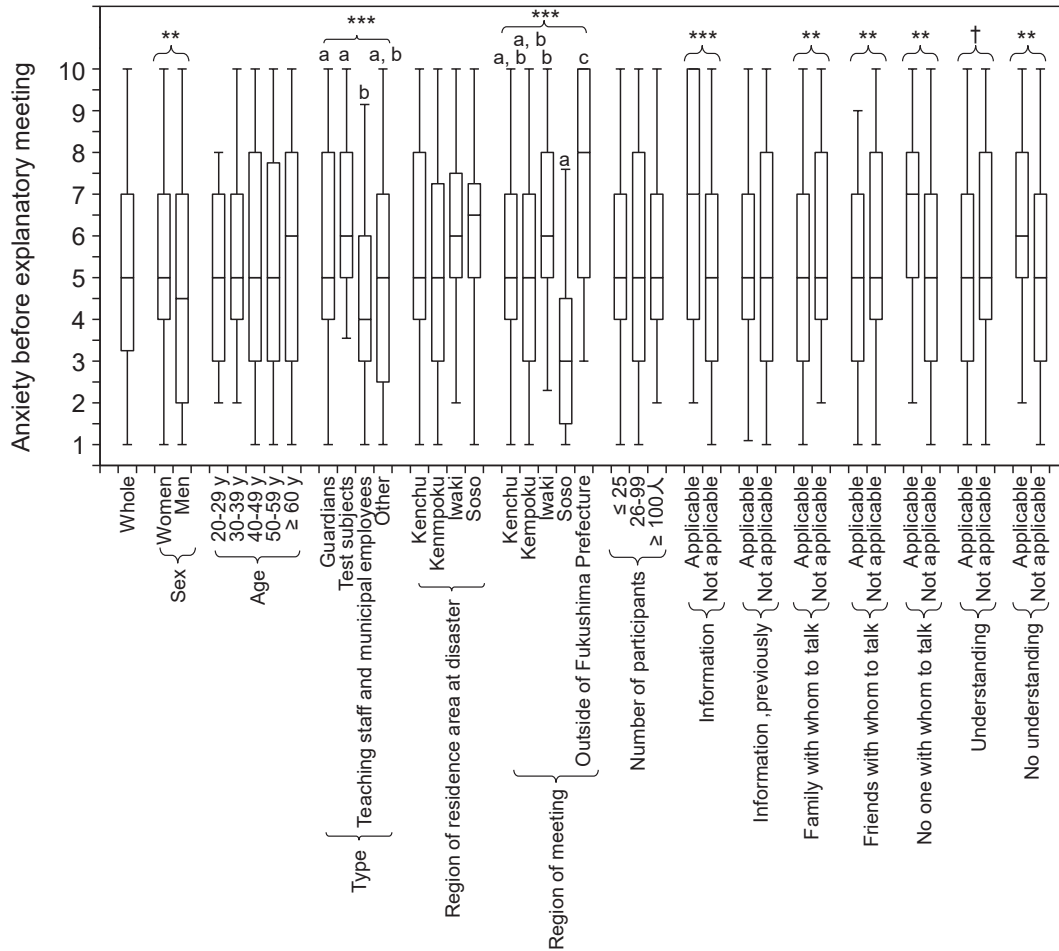


Fig. 2. Individual characteristics and anxiety about the effects of radiation on the thyroid before the explanatory meeting. Minimum value, 5th percentile; bottom of box, 25th percentile; horizontal line in middle of box, 50th percentile; top of box, 75th percentile; maximum value; 95th percentile. † $P = 0.05$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Different letters represent significant differences among groups by post-hoc test ($P < 0.05$). Information: I collect information on radiation; information, previously: I have previously collected information because of anxiety, but not now; family with whom to talk: I can talk about radiation with my family without experiencing stress; friends with whom to talk: I can talk about radiation with my friends or acquaintances without experiencing stress; no one with whom to talk: I have no people around me to whom I can talk about radiation; understanding: I understand radiation to some degree; no understanding: I do not know about radiation.

good” (39%), for a total of 90% showing satisfaction. Assessments of “very good” and “rather good” of specific content ranged between 69% for “session sizes” and 95% for “nodule”; overall there was a high level of satisfaction with the content.

Multivariate ordered logistic regression analysis was used to analyze which individual attributes or factors related to the meetings affected levels of anxiety, comprehension, and satisfaction (Table 2). The results of multivariate ordered logistic regressions were significant with regard to the regression formula ($P < 0.001$).

With respect to change in anxiety before and after meetings, there were significant negative associations (anxiety was lower after meetings than before) for “number of participants (26-99),” “objective data,” and “cancer,” but a positive association was seen for “sex (men).”

For anxiety after meetings, there were significant neg-

ative associations (anxiety after meetings was low) for “objective data,” and “cancer,” and positive associations for “region of meeting implementation (outside of Fukushima Prefecture),” “information,” “information (previously),” and “no understanding.”

For level of comprehension, there were significant positive associations (comprehension was high) for “number of participants (≤ 25 people),” “objective data,” and “cancer,” and negative associations for “type of respondent (other)” and “no understanding.”

For levels of overall satisfaction, assessments of “objective data,” “thyroid examination results,” “cancer,” and “Q&A” had significant positive associations (satisfaction was high), while a negative association were seen for “sex (men).” Among assessments of contents of meetings, adjusted odds ratio were highest for “objective data,” followed by “thyroid examination results,” “cancer,” and

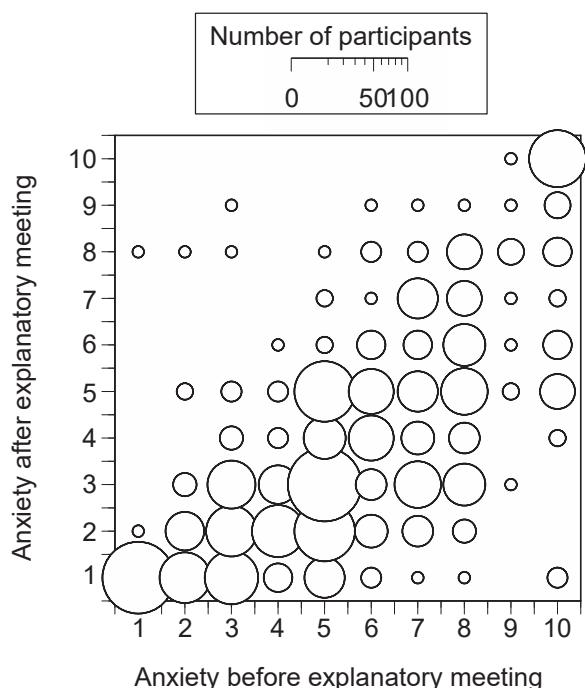


Fig. 3. Relationship between anxiety about the effects of radiation on the thyroid before and after the explanatory meeting. Areas of circles are proportional to the number of participants. Wilcoxon signed rank test showed that anxiety after explanatory meetings was significantly lower than that before explanatory meetings ($P < 0.001$).

“Q&A.”

Discussion

The results of this study show that levels of anxiety before meetings varied depending on individual attributes such as sex and type of respondent, and attitudes about radiation. Participation in the meetings was also shown to reduce anxiety about the effects of radiation on the thyroid. With respect to the effects of the meetings on change in anxiety and levels of anxiety, comprehension, and satisfaction after the meetings, the content of the meetings was shown to be a factor that has an effect independent of individual attributes and attitudes about radiation. Change in anxiety and comprehension of the meetings was also shown to be affected by the number of participants in the meetings.

Pre-meeting anxiety about the effects of radiation on the thyroid

Pre-meeting anxiety about the effects of radiation on the thyroid, that is, anxiety that was originally present, was found to be significantly higher for women compared to men and for guardians and test subjects compared to teaching staff and municipal employees. This result is in accordance with previous findings that women have higher anxiety and risk perception regarding radiation (Sugimoto et al. 2013; Fukushima City 2014; Goto et al. 2014; Suzuki et al. 2015) and that civil servants and institutional staff have the least anxiety about the health effects of exposure (Fuku-

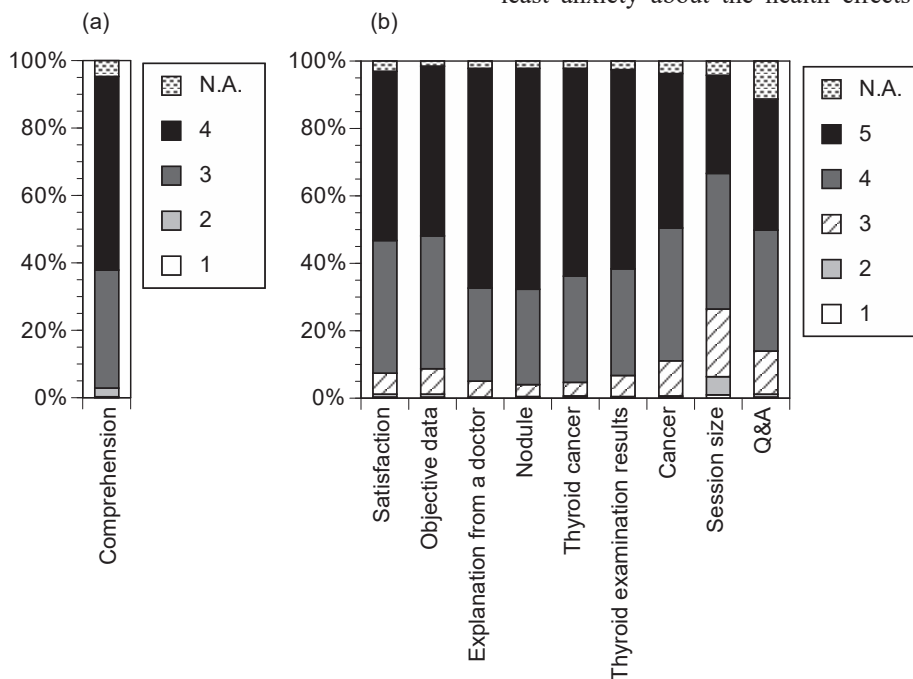


Fig. 4. Level of comprehension (a) and evaluation (b) of the explanatory meetings by the participants. (a) 1 = did not comprehend; 2 = did not comprehend much; 3 = comprehended somewhat; 4 = comprehended well; N.A. = not available. (b) 1 = bad; 2 = not good; 3 = neither; 4 = good; 5 = very good; N.A. = not available. Satisfaction: overall satisfaction; objective data: there was an explanation of objective data, such as radiation doses and the results from the 1986 accident; explanation from a doctor: there was an explanation from a doctor; nodule: there was a description of the characteristics of cysts and nodules; thyroid cancer: there was an explanation of the characteristics of thyroid cancer; thyroid examination results: the latest results from thyroid examination were listed; cancer: there was a general explanation of cancer; session sizes: the number of participants; Q&A: there was an opportunity to ask questions and receive answers.

Table 2. Associations between individual factors and outcomes on effects of meetings.

	Change in anxiety		Anxiety after explanatory meeting		Comprehension		Overall satisfaction		VIF
	AOR (95% CI)	P	AOR (95% CI)	P	AOR (95% CI)	P	AOR (95% CI)	P	
Sex (ref = women)									
Men	3.17 (1.75 - 5.72)***		0.74 (0.44 - 1.23)		0.65 (0.34 - 1.22)		0.41 (0.22 - 0.76)**		1.20
Age (ref = 20-29 y)									
30-39 y	1.06 (0.45 - 2.50)		0.76 (0.39 - 1.48)		0.90 (0.38 - 2.15)		1.18 (0.53 - 2.62)		3.93
40-49 y	0.80 (0.33 - 1.98)		1.02 (0.51 - 2.06)		1.06 (0.42 - 2.63)		0.84 (0.37 - 1.91)		4.64
50-59 y	0.69 (0.23 - 2.05)		0.64 (0.27 - 1.50)		0.83 (0.27 - 2.50)		1.29 (0.46 - 3.63)		2.85
≥ 60 y	0.46 (0.10 - 2.13)		0.73 (0.20 - 2.62)		3.87 (0.70 - 21.3)		1.47 (0.33 - 6.63)		1.79
Type (ref = guardians)									
Test objects	0.90 (0.36 - 2.25)		1.38 (0.69 - 2.75)		1.92 (0.71 - 5.23)		1.69 (0.71 - 4.02)		1.08
Teaching staff and municipal employees	1.25 (0.59 - 2.62)		0.71 (0.40 - 1.27)		0.79 (0.37 - 1.72)		1.00 (0.49 - 2.08)		1.75
Other	2.07 (0.76 - 5.67)		0.57 (0.24 - 1.36)		0.25 (0.09 - 0.72)*		0.45 (0.16 - 1.24)		1.35
Region of residence area at disaster (ref = Kenchu)									
Kempoku	1.45 (0.57 - 3.73)		0.92 (0.44 - 1.93)		0.95 (0.35 - 2.61)		0.86 (0.35 - 2.09)		5.05
Iwaki	3.26 (0.71 - 15.0)		0.68 (0.20 - 2.25)		1.54 (0.35 - 6.91)		1.77 (0.40 - 7.83)		7.26
Soso	1.85 (0.56 - 6.10)		1.13 (0.44 - 2.94)		1.01 (0.29 - 3.48)		1.13 (0.36 - 3.59)		2.42
Region of meeting (ref = Kenchu)									
Kempoku	0.40 (0.15 - 1.06)		0.62 (0.29 - 1.33)		1.14 (0.40 - 3.23)		1.32 (0.52 - 3.33)		5.08
Iwaki	0.31 (0.07 - 1.43)		2.39 (0.72 - 7.98)		0.50 (0.11 - 2.22)		0.79 (0.18 - 3.48)		7.60
Soso	1.18 (0.23 - 6.06)		0.51 (0.13 - 2.04)		1.86 (0.25 - 13.9)		5.77 (0.73 - 45.4)		2.23
Outside of Fukushima Prefecture	0.40 (0.12 - 1.31)		3.10 (1.25 - 7.67)*		0.49 (0.15 - 1.58)		0.92 (0.32 - 2.68)		1.69
Number of participants (ref = ≥ 100)									
≤ 25	0.56 (0.30 - 1.03)		0.76 (0.47 - 1.23)		3.35 (1.75 - 6.44)***		1.77 (0.99 - 3.17)		2.15
26-99	0.48 (0.23 - 0.99)*		0.60 (0.34 - 1.06)		1.76 (0.86 - 3.60)		1.42 (0.73 - 2.77)		2.04
Assessments of contents of meetings (ref = ≤ 3 at 5-point Likert scales)									
Objective data	0.40 (0.17 - 0.96)*		0.36 (0.17 - 0.79)*		5.57 (2.07 - 15.0)***		11.5 (4.20 - 31.3)***		1.84
Explanation from a doctor	1.09 (0.35 - 3.37)		0.96 (0.36 - 2.57)		0.38 (0.11 - 1.32)		1.06 (0.31 - 3.64)		1.64
Nodule	0.91 (0.22 - 3.75)		1.57 (0.45 - 5.53)		0.98 (0.18 - 5.40)		0.61 (0.13 - 2.75)		1.90
Thyroid cancer	0.47 (0.13 - 1.70)		0.46 (0.15 - 1.43)		1.54 (0.36 - 6.51)		3.24 (0.84 - 12.5)		2.01
Thyroid examination results	0.72 (0.24 - 2.15)		0.59 (0.22 - 1.55)		1.78 (0.53 - 5.97)		4.92 (1.46 - 16.6)*		2.03
Cancer	0.40 (0.20 - 0.82)*		0.39 (0.21 - 0.73)**		3.39 (1.56 - 7.36)**		3.67 (1.71 - 7.85)***		1.61
Q&A	1.17 (0.59 - 2.33)		1.29 (0.74 - 2.26)		1.06 (0.53 - 2.13)		2.18 (1.12 - 4.27)*		1.47
Attitudes about radiation (ref = not applicable)									
Information	1.45 (0.73 - 2.87)		4.82 (2.72 - 8.56)***		0.97 (0.46 - 2.05)		1.27 (0.64 - 2.52)		1.57
Information, previously	0.90 (0.55 - 1.49)		1.81 (1.21 - 2.70)**		0.88 (0.53 - 1.47)		1.01 (0.63 - 1.63)		1.43
Family with whom to talk	0.90 (0.54 - 1.47)		0.84 (0.57 - 1.25)		1.37 (0.82 - 2.29)		1.13 (0.70 - 1.80)		1.45
Friends with whom to talk	0.95 (0.58 - 1.57)		1.12 (0.76 - 1.66)		0.65 (0.39 - 1.09)		1.06 (0.66 - 1.70)		1.45
No one with whom to talk	1.15 (0.48 - 2.78)		0.90 (0.45 - 1.83)		2.14 (0.77 - 5.94)		0.88 (0.36 - 2.13)		1.13
Understanding	1.25 (0.77 - 2.02)		0.81 (0.56 - 1.18)		1.35 (0.82 - 2.22)		1.23 (0.78 - 1.94)		1.33
No understanding	1.17 (0.64 - 2.11)		1.90 (1.20 - 3.02)**		0.50 (0.28 - 0.89)*		0.64 (0.37 - 1.11)		1.30

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

AOR, adjusted odds ratio; CI, confidential interval; VIF, variance inflation factors; Ref, reference.

shima City 2014). In the United States, it has been noted that cultural worldviews are reflected in risk perception (Kahan et al. 2007). Though little is known about the relationship between risk perception and cultural worldviews in Japan, one's own role in society or in the home is thought to possibly be involved in risk perception.

In addition, there were no significant differences among regions of residence at the time of the earthquake (Kempoku, Kenchu, Iwaki, Soso); however, among regions of meeting implementation, anxiety was highest outside of Fukushima Prefecture (in Yamagata Prefecture), followed by Iwaki, Kenchu, Kempoku, and Soso. The region of meeting implementation is believed to be reflective of the participants' residence during the meetings. It is not known whether participants in meetings outside of Fukushima Prefecture were mandatory evacuees or voluntary evacuees; however, it can be inferred that many of them evacuated to outside of Fukushima Prefecture because of their high anxiety about radiation. In Iwaki, as well, there are not only people who lived in Iwaki before the disaster, but also many who are evacuees. These results correspond to those of another study in which having a history of evacuation correlated to a higher risk perception of radiation (Suzuki et al. 2015). Those in Soso had significantly lower anxiety; how-

ever, this result is based only on one implementation location, and should be interpreted with caution.

Regarding "attitudes about radiation," anxiety was higher for those who responded that they actively collected information on radiation, those who had no one with whom to speak about radiation, and those who responded that their understanding of radiation was subjectively low. Attitudes about collecting information on radiation, advisors on radiation, and levels of understanding and anxiety have been shown to be related. Reports on the relationship between risk perception and knowledge have shown that people with knowledge have a higher risk perception (Imai et al. 2015), that increasing knowledge can both decrease and increase risk perception (Kinoshita 2009), that there is little impact of knowledge (Perko et al. 2012), and that objective and subjective knowledge has no relationship with risk perception, but that for hazard perception, objective knowledge has a positive correlation and subjective knowledge has a negative correlation (Vandermoere 2008). In the present study, people who deemed themselves to have subjective understanding had lower anxiety. However, the causal relationships remain unclear in terms of whether they were collecting information because of high anxiety, whether anxiety increased as a result of information collection, whether

gaining an understanding was followed by a decrease in anxiety, or whether they judged that they understood enough because of their low anxiety. Overall, these results show that in explanatory meetings, presenting information about radiation in a manner that is easy to understand, and providing opportunities for the exchange of opinions between organizers and participants or among participants through question-and-answer sessions or the like is meaningful for people with high anxiety.

Effects of meetings (anxiety change and post-meeting levels of anxiety, comprehension, and satisfaction)

Because anxiety decreased significantly from before to after the meetings, the explanatory meetings were shown to be effective for reducing anxiety. Regarding the change in anxiety, anxiety fell more readily in women than in men, and women also had higher overall satisfaction. It has been suggested that men change less readily, whereas women tend to more readily change their attitudes in a positive direction due to information acquisition (Maruyama et al. 1996). However, it is also possible that women's anxiety more readily decreased compared to that of men because women had higher anxiety before the meetings and, therefore, their anxiety were more likely to change. Thus differences between men and women will need to be examined in greater detail in the future.

In terms of type of respondent, guardians tended to have higher comprehension than "others." Many people who were "others" may be residents of places near where the meetings were held, who had a high interest in radiation risks, etc. Comprehension with meetings may be explained by the fact that guardians, who had a direct relationship with a thyroid test subject, received information in the explanatory meetings on thyroid examination in the context of their own problems.

While region of residence at the time of the earthquake had no impact, differences were observed between regions where the meetings were implemented. Anxiety after meetings tended to be higher in outside of Fukushima Prefecture than in Kenchu, as similarly found in pre-meetings. External exposure for four months after the disaster in Kenchu, Kempoku, Iwaki, and Soso was 1.0, 1.4, 0.3, and 0.8 mSv, respectively (Ishikawa et al. 2015), and the thyroid-equivalent dose for children was estimated at 33-52 mGy (Rest of Fukushima Prefecture, including Kenchu and Kempoku), 52 mGy (Iwaki), and 53-82 mGy (Soso) (United Nations Scientific Committee on the Effects of Atomic Radiation 2014); these rankings are not consistent with those for anxiety after meetings.

Regarding attitudes about radiation, people who were currently collecting or had previously collected information had higher anxiety after meetings. People who felt they did not understand radiation also had higher anxiety and lower comprehension after the meetings. During the 2011 accident, differences in "expert" opinions on radiation may have created confusion among the population. The percep-

tions differences in opinion exist between "experts" may be one reason why people who were collecting or had collected information, and those who did not think they understood, still had high anxiety after meetings.

Regarding the number of meeting participants, groups of 25 or fewer people had higher comprehension than groups of 100 or more people. Groups of 26-99 people had higher reduction of anxiety than groups of 100 or more people. This suggests that implementing meetings with a small number of people is a more effective approach to risk communication for increasing comprehension and/or reducing anxiety than large-scale explanatory meetings, a suggestion that is harmonious with the guidelines (Food Safety Commission of Japan Cabinet Office 2008). However, it is important to note that the present study did not examine participants' motivation in participating in the meetings. Large-scale meetings, in particular, are often concurrent with school events (open houses or PTA events), and it is not known whether participants participated in the meetings of their own volition. Though there was no difference in anxiety before meetings by numbers of participants (Fig. 2), it remains possible that participants in small-scale meetings had more proactive participation and thus had higher comprehension or anxiety reduction; this will need to be further examined in the future. Here, too, it is necessary to note that only effects were addressed, and there was no discussion of cost effectiveness.

Regarding the content of the meetings, "objective data" were associated with anxiety reduction, lower anxiety after meetings, higher comprehension, and overall satisfaction. In addition, "cancer" was found to be an important factor that was associated with the above outcomes. This matches Fischhoff's and the Ministry of the Environment's recommendations that presenting numerical data is effective in risk communication (Fischhoff 1995; Ministry of the Environment 2002). As previously stated, differences in opinion between "experts" have been noted as one of the causes of anxiety about radiation risks. Being dispassionate in explaining objective facts is believed to have been associated with anxiety reduction and improvements of comprehension and satisfaction for people who highly evaluated "objective data." In particular, it may be attributed to the fact that the features of thyroid cancer do not match general perceptions of cancer. Healthy people tend to think of cancer predominantly in terms of "it can be cured if detected early," "it is scary," "is surgery necessary?" and "it is painful" (Kamezaki et al. 2008). However, papillary cancer—the most general form of thyroid cancer—involves a slow speed of progression and the practice of follow-up observation so long as the cancer is small. Compared to other cancers, it has a very high survival rate (Gunma Prefectural Cancer Center 2016). For those who were concerned about the onset of thyroid cancer, having a doctor provide a medical explanation of the features of this cancer and convey objective facts on the high survival rate may have been associated with anxiety reduction. The meeting also pro-

vided an explanation of thyroid ultrasound reports for children from three Japanese Prefectures: Aomori, Yamanashi, and Nagasaki (42.5% A1, 56.5% A2, 1.0% B, and 0% C) (Hayashida et al. 2015); results of thyroid examinations from other prefectures were found not to differ significantly from Fukushima Prefecture. These explanations may have been associated with reduction in anxiety.

“Thyroid examination results” and “Q&A” were associated with high satisfaction. Satisfaction is believed to have been high because there was an opportunity for a question-and-answer session, allowing participants to gain more information and experts (or participants themselves) giving opinions on questions asked by participants.

Limitations of the study and future challenges

Bias of the participants was one potential limitation. Even though fundamentally participants participated of their own volition, motivation for participating was not assessed; thus, it is possible that this created bias with respect to reduction in anxiety or levels of comprehension and satisfaction. Most meetings were implemented at schools, and often were held during the day on workdays; therefore, fewer men attended than women, producing a bias in participants. Similarly, investigation of the different regions shows that few meetings were implemented in the Soso district, because the evacuation made it impossible to maintain school functions. In Aizu in Fukushima Prefecture, as well, the exposure dose was relatively low within the prefecture (Ishikawa et al. 2015); thus, not many guardians had anxiety, and the Aizu district did not implement meetings during the same period. This produced a bias in the regions of implementation.

Secondly, the present study was a survey conducted before and after the explanatory meetings, and therefore it is possible that there was a test-retest effect. However, even if one did exist, the test-retest effect would have brought about an independent effect irrespective of the individual factors (explanation content etc.) that bring about a decrease in anxiety; thus, the test-retest effect is believed to have caused little bias in the association of the factors. Thirdly, information was obtained only about the day of meeting implementation, and therefore does not show whether anxiety remained reduced in the long term.

Future challenges include the need to ensure an adequate sample size for distinguishing between sexes and among regions, ascertaining long-term effects, and investigating in greater detail factors related to the presenter (doctor's gender, etc.).

The present study has suggested that participation in explanatory meetings leads to reduced anxiety about radiation, that explanatory meetings with fewer people are more effective in reducing anxiety and raising the level of subjective comprehension, and that objective numerical information and explanation of cancer are factors for reducing anxiety and improving comprehension and satisfaction. The results obtained in this study have the potential to help in

the design of effective evidence-based risk communication in the future.

Acknowledgments

We wish to extend our gratitude to the doctors who participated as teachers, to the schools and other institutions that held the explanatory meetings, and to the participants. This survey was supported by the national “Health Fund for Children and Adults Affected by the Nuclear Incident.” The findings and conclusions of this article are solely the responsibility of the authors and do not represent the official views of Fukushima Prefecture government.

Conflict of Interest

The authors declare no conflict of interest.

References

- Arata, Y., Horii, A., Saito, H., Miyamoto, M., Matsuoka, H. & Kanatsuka, H. (2015) Life and mental health of medical students after the Great East Japan Earthquake. *Tohoku J. Exp. Med.*, **235**, 311-325.
- Aschebrook-Kilfoy, B., James, B., Nagar, S., Kaplan, S., Seng, V., Ahsan, H., Angelos, P., Kaplan, E.L., Guerrero, M.A., Kuo, J.H., Lee, J.A., Mitmaker, E.J., Moalem, J., Ruan, D.T., Shen, W.T. & Grogan, R.H. (2015) Risk factors for decreased quality of life in thyroid cancer survivors: initial findings from the North American thyroid cancer survivorship study. *Thyroid*, **25**, 1313-1321.
- Brenner, A.V., Tronko, M.D., Hatch, M., Bogdanova, T.I., Olyinik, V.A., Lubin, J.H., Zablotska, L.B., Tereschenko, V.P., McConnell, R.J., Zamotaeva, G.A., O’Kane, P., Bouville, A.C., Chaykovskaya, L.V., Greenebaum, E., Paster, I.P., et al. (2011) I-131 dose response for incident thyroid cancers in Ukraine related to the Chernobyl accident. *Environ. Health Perspect.*, **119**, 933-939.
- Cardis, E., Howe, G., Ron, E., Bebeshko, V., Bogdanova, T., Bouville, A., Carr, Z., Chumak, V., Davis, S., Demidchik, Y., Drozdovitch, V., Gentner, N., Gudzenko, N., Hatch, M., Ivanov, V., et al. (2006) Cancer consequences of the Chernobyl accident: 20 years on. *J. Radiol. Prot.*, **26**, 127-140.
- Contis, G. & Foley, T.P. Jr. (2015) Depression, suicide ideation, and thyroid tumors among ukrainian adolescents exposed as children to chernobyl radiation. *J. Clin. Med. Res.*, **7**, 332-338.
- Fischhoff, B. (1995) Risk perception and communication unplugged: twenty years of process. *Risk Anal.*, **15**, 137-145.
- Food Safety Commission of Japan Cabinet Office (2008) Ikenkou-kankai no jisshi to hyouka nikansuru guideline. https://www.fsc.go.jp/senmon/risk/riskcom_guideline.pdf [Accessed: February, 2016].
- Fukushima City (2014) Dai 2 kai houshanou nikansuru shimin ishiki tyosa houkokusho. <http://www.city.fukushima.jp/soshiki/7/kouchou12090501.html> [Accessed: February, 2016].
- Goto, A., Rudd, R.E., Lai, A.Y., Yoshida, K., Suzuki, Y., Halstead, D.D., Yoshida-Komiya, H. & Reich, M.R. (2014) Leveraging public health nurses for disaster risk communication in Fukushima City: a qualitative analysis of nurses’ written records of parenting counseling and peer discussions. *BMC Health Serv. Res.*, **14**, 129.
- Gunma Prefectural Cancer Center (2016) <http://www.gunma-cc.jp/sarukihan/seizonritu/seizonritu2007.html> [Accessed: February, 2016].
- Hayashida, N., Imaizumi, M., Shimura, H., Furuya, F., Okubo, N.,

- Asari, Y., Nigawara, T., Midorikawa, S., Kotani, K., Nakaji, S., Ohtsuru, A., Akamizu, T., Kitaoka, M., Suzuki, S., Taniguchi, N., et al. (2015) Thyroid ultrasound findings in a follow-up survey of children from three Japanese prefectures: Aomori, Yamanashi, and Nagasaki. *Sci. Rep.*, **5**, 9046.
- Imai, H., Okumiya, K., Fukutomi, E., Wada, T., Ishimoto, Y., Kimura, Y., Chen, W.L., Tanaka, M., Sakamoto, R., Fujisawa, M. & Matsubayashi, K. (2015) Association between risk perception, subjective knowledge, and depression in community-dwelling elderly people in Japan. *Psychiatry Res.*, **227**, 27-31.
- Ishikawa, T., Yasumura, S., Ozasa, K., Kobashi, G., Yasuda, H., Miyazaki, M., Akahane, K., Yonai, S., Ohtsuru, A., Sakai, A., Sakata, R., Kamiya, K. & Abe, M. (2015) The Fukushima Health Management Survey: estimation of external doses to residents in Fukushima Prefecture. *Sci. Rep.*, **5**, 12712.
- Kahan, D.M., Braman, D., Gastil, J., Slovic, P. & Mertz, C.K. (2007) Culture and identity-protective cognition: explaining the while-male effect in risk perception. *J. Empir. Leg. Stud.*, **4**, 465-505.
- Kamezaki, A., Muramoto, C., Maeda, Y., Kigo, R., Umeki, S. & Taniguchi, M. (2008) Factors affecting people's attitudes concerning being told of a diagnosis of cancer : a survey of healthy adults. *Bul Kumamoto Univ, Sch Health Sci*, **4**, 35-51 (in Japanese).
- Kinoshita, T. (2009) Rethinking of risk communication: toward an integrated risk communication(2). *Jpn. J. Risk. Anal.*, **19**, 3-17 (in Japanese).
- Maruyama, N., Yanagihara, R., Misumi, J. & Hayashi, C. (1996) Public attitudes toward nuclear power generation preliminary study focusing on characteristics of the attitudes of men and women. *INSS Journal*, **3**, 5-45 (in Japanese).
- Mattisson, C., Bogren, M., Bradvik, L. & Horstmann, V. (2015) Mortality of subjects with mood disorders in the Lundby community cohort: a follow-up over 50 years. *J. Affect. Disord.*, **178**, 98-106.
- Ministry of Education, Culture, Sports, Science and Technology and Ministry of Health, Labour and Welfare (2002) Ekigakukenkylu nikansuru rinrishishin. <http://www.mhlw.go.jp/general/seido/kousei/i-kenkyu/ekigaku/0504sisin.html> [Accessed: May, 2016].
- Ministry of the Environment (2002) Jichitai notameno kagakubus-sitsu nikansuru risk communication manual nitsuite. <http://www.env.go.jp/chemi/communication/manual/> [Accessed: February, 2016].
- National Research Council (1987) *Improving risk communication*. Washington D.C., National Academy Press.
- Ohtsuru, A., Tanigawa, K., Kumagai, A., Niwa, O., Takamura, N., Midorikawa, S., Nollet, K., Yamashita, S., Ohto, H., Chhem, R.K. & Clarke, M. (2015) Nuclear disasters and health: lessons learned, challenges, and proposals. *Lancet*, **386**, 489-497.
- Perko, T., Zeleznik, N., Turcanu, C. & Thijssen, P. (2012) Is knowledge important? Empirical research on nuclear risk communication in two countries. *Health Phys.*, **102**, 614-625.
- Pratt, L.A. (2009) Serious psychological distress, as measured by the K6, and mortality. *Ann. Epidemiol.*, **19**, 202-209.
- Sato, A. (2015) Understanding effective risk communication in the context of a radiological accident. Fukushima Global Communication Programme Working Paper Series, 7, United Nations University Institute for the Advanced Study of Sustainability.
- Science Council of Japan Committee on Supporting Reconstruction after the Great East Japan Earthquake (2012) Recommendations from Science Council of Japan (SCJ) —with confident steps towards reconstruction—. <http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-22-t-shien1e.pdf> [Accessed: February, 2016].
- Slovic, P. (1987) Perception of risk. *Science*, **236**, 280-285.
- Sugimoto, A., Nomura, S., Tsubokura, M., Matsumura, T., Muto, K., Sato, M. & Gilmour, S. (2013) The relationship between media consumption and health-related anxieties after the Fukushima Daiichi nuclear disaster. *PLoS One*, **8**, e65331.
- Suzuki, S. (2016) Childhood and adolescent thyroid cancer in Fukushima after the Fukushima Daiichi Nuclear Power Plant accident: 5 years on. *Clin. Oncol.*, **28**, 263-271.
- Suzuki, Y., Yabe, H., Yasumura, S., Ohira, T., Niwa, S., Ohtsuru, A., Mashiko, H., Maeda, M. & Abe, M. (2015) Psychological distress and the perception of radiation risks: the Fukushima health management survey. *Bull. World Health Organ.*, **93**, 598-605.
- Tokonami, S., Hosoda, M., Akiba, S., Sorimachi, A., Kashiwakura, I. & Balonov, M. (2012) Thyroid doses for evacuees from the Fukushima nuclear accident. *Sci. Rep.*, **2**, 507.
- United Nations Scientific Committee on the Effects of Atomic Radiation (2010) UNSCEAR 2008 Report to the General Assembly, with scientific annexes. United Nation, New York.
- United Nations Scientific Committee on the Effects of Atomic Radiation (2014) Sources, effects and risks of ionizing radiation. UNSCEAR 2013 Reports to the General Assembly with Scientific Annexes. United Nations, New York.
- Vandermoere, F. (2008) Hazard perception, risk perception, and the need for decontamination by residents exposed to soil pollution: the role of sustainability and the limits of expert knowledge. *Risk Anal.*, **28**, 387-398.
- Yasumura, S., Hosoya, M., Yamashita, S., Kamiya, K., Abe, M., Akashi, M., Kodama, K. & Ozasa, K. (2012) Study protocol for the Fukushima Health Management Survey. *J. Epidemiol.*, **22**, 375-383.