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ARTICLE

Comparative analysis of gender and prefecture-based attitudes toward future parenthood following the Fukushima Daiichi Nuclear Power Plant accident

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Abstract – This study aimed to examine both concerns about future childbirth and childcare associated with radiation exposure among men and women in different prefectures. In December 2018, a cross-sectional, online questionnaire-based survey was conducted on 620 adults in the general population. The survey included 155 men and 155 women who lived in Fukushima Prefecture at the time of the Great East Japan Earthquake (March 11, 2011), and 155 men and 155 women who lived outside of Fukushima Prefecture. Regardless of gender and prefecture, the greater the perceived anxiety about radiation effects on a partner, the greater the perceived anxiety about future childbirth. In addition, those who did not want to have children were more anxious about rearing children in the future. Compared with women in other prefectures, men in Fukushima Prefecture were more knowledgeable about radiation, thought that radiation would have fewer health effects on their children, and were more confident about future childbearing. These findings suggest that for those who are anxious about future childbirth and childcare, it is important to create an environment where necessary information can be accessed regardless of gender or residence in an area affected by a nuclear accident.

Keywords: Fukushima Daiichi Nuclear Power Plant / radiation effects / childbearing intentions / epidemiology

1 Introduction

The Fukushima Daiichi Nuclear Power Plant accident released a substantial number of radioactive materials, which has led many people to feel concerned about radiation exposure. Nuclear accidents have been shown to have long-term effects on the mental health of mothers and children (Bromet *et al.*, 2011), and mothers tend to worry about their children even when no health problems are apparent (Bromet *et al.*, 2009). For example, mothers who blamed themselves for the Chernobyl Nuclear Power Plant accident were twice as likely to experience major depression and post-traumatic stress disorder 11–19 yr after the accident (Adams *et al.*, 2002; Adams *et al.*, 2011) compared with their peers who had not evacuated. In addition, mothers who had evacuated were more likely to rate their health as poor and worry about the health effects of radiation exposure (Bromet *et al.*, 2002). Similarly, in the case of the Fukushima Daiichi Nuclear Power Plant accident, the proportion of mothers with depressive symptoms has decreased over time. However, the rates of postpartum depression according to the Hamamatsu Birth Cohort in Japan were 11% within the first month postpartum and 4% at 2–3 months' postpartum, while the rate of mothers in Fukushima Prefecture with depressive symptoms was as high as 28% (Aoyagi *et al.*, 2019; Ishii *et al.*, 2022; Ito *et al.*, 2018a).

Although investigations of anxiety about childbirth and childcare associated with radiation exposure have been conducted on mothers who have been exposed to radiation, few studies have been conducted on men who have been exposed to radiation, or on women who have been exposed to radiation but do not currently have any children. For example, our group conducted a questionnaire survey on female college students who were living in Fukushima Prefecture at the time of the Fukushima Daiichi Nuclear Power Plant accident and found that some women were concerned about future childbirth and childcare (Ito *et al.*, 2018b). However, as that was a descriptive epidemiological survey, it only ascertained the actual situation and did not compare the results by group. Our subsequent research (Ito *et al.*, 2023) examined anxiety about future childbirth and childcare among female university students in Fukushima Prefecture in 2015 and 2018, and

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reported that the number of students who said they were not confident childbirth increased from 16.8% in 2015 to 19.4% in 2018. However, whether more women in Fukushima Prefecture are anxious about future childbirth and childcare compared with women in other prefectures remains unclear. In addition, to our knowledge, no studies on anxiety about childbirth and childcare have been conducted on men who have been exposed to radiation. Suzuki *et al.* (Suzuki *et al.*, 2015) assessed stress and anxiety about radiation exposure and health hazards among residents who had experienced the Fukushima Daiichi Nuclear Power Plant accident. The results showed that a greater proportion of women perceived anxiety compared with men. However, 3133 (35.9%) of the 8717 respondents who reported feeling very stressed were men, which suggests that many men also experience anxiety. In addition, Kuroda *et al.* (Kuroda *et al.*, 2018) conducted a questionnaire survey on residents in the evacuated and non-evacuated areas of Fukushima and reported that radiation anxiety was correlated with health literacy only in the evacuated areas. This difference between evacuated and non-evacuated areas suggests that regional differences may also affect confidence in future childbearing and child-rearing.

Given this background, the present study aimed to compare and identify factors that influence anxiety about future childbirth and childcare associated with radiation exposure between genders, as well as between Fukushima and other prefectures.

2 Materials and methods

2.1 Study design and participants

In December 2018, a cross-sectional, online questionnaire-based survey was conducted on 620 adults in the general population (310 males and 310 females; age range, 18–35 yr). The survey included 155 men and 155 women who lived in Fukushima Prefecture at the time of the Great East Japan Earthquake (March 11, 2011), and 155 men and 155 women who lived outside of Fukushima Prefecture. This survey was conducted *via* an online survey company, and because the number of respondents living in Fukushima Prefecture was small, all applicable residents of Fukushima Prefecture registered with the survey company were included in the survey. Those who lived outside of Fukushima Prefecture were randomly selected from prefectures other than Fukushima.

2.2 Questionnaire

2.2.1 Personal characteristics

Data on the respondents' demographic characteristics were derived from their responses to single-item questions on age, gender, marital status, family structure, desire for future children, whether they had a radiation adviser (regardless of the subject), knowledge of radiation ("Do you consider yourself knowledgeable about nuclear power and radiation?"), stress in daily life, and concerns about radiation effects on a future partner.

2.2.2 Fukushima Future Parents Attitude Measure (FPAM)

The FPAM assesses attitudes about childbirth and infant care following radiation exposure (Ito *et al.*, 2018a). First, the respondents were given the following instructions: "Please answer the following questions. Please assume that you will live and raise a family in Fukushima Prefecture." The FPAM consists of two factors, "Caring for a baby" and "Giving birth to a baby," each of which contain three items. "Caring for a baby" includes the item 'I look forward to caring for the baby,' and "Giving birth to a baby" includes the item 'I am confident that I will have a normal childbirth.' All items are measured on a four-point Likert-type scale, from 1 = *strongly agree* to 4 = *strongly disagree*. The scores of the constructs range from 3 to 12, with lower scores indicating more confidence in successful future childbirth and infant care.

2.2.3 Depressive symptoms

The following two items were used to screen for depressive symptoms (Mishina *et al.*, 2009): 'During the past month, have you often felt down, depressed, or hopeless?' and 'During the past month, have you often found little interest or pleasure in doing things?'. Participants who answered yes to at least one of these questions were classified as displaying depressive symptoms.

2.2.4 Rosenberg Self-Esteem Scale (RSES)

The RSES defines self-esteem as a global concept about the self and a sense of worth or value, not as the possession or accumulation of particular qualities or abilities (Rosenberg, 1965). It is composed of 10 items that offer response options on a four-point Likert-type scale, from 10 = *strongly disagree* to 40 = *strongly agree*, with higher scores indicating higher self-esteem.

2.2.5 World Health Organization-Five Well-Being Index (WHO-5)

The WHO-5 is a self-administered five-item scale used to measure quality of life (QOL) (Awata *et al.*, 2007). Each item measures the respondent's sense of positive well-being during the previous 2 weeks. Response options are offered on a six-point ranking scale ranging from 0 to 5, with higher scores indicating greater well-being.

2.2.6 Communicative and Critical Health Literacy Scale

The Communicative and Critical Health Literacy Scale is composed of three items on communicative health literacy (*e.g.*, obtaining health-related information from various sources) and two items on critical health literacy (*e.g.*, assessing the reliability of health information) (Ishikawa *et al.*, 2008). Response options are offered on a five-point Likert-type scale, from 1 = *strongly disagree* to 5 = *strongly agree*. The mean of the five item scores is considered to indicate overall communicative and critical health literacy.

2.2.7 Attitudes Toward Seeking Professional Psychological Help-Short Form (ATSPPH-SF)

The ATSPPH-SF is a self-administered 10-item index that assesses attitudes about mental health treatment (Elhai *et al.*, 2008). Response options are offered on a four-point Likert-type scale, from 0 = *disagree* to 3 = *agree*. Total scores range from 0 to 30, with higher scores indicating a more positive attitude.

2.2.8 Perceptions of the risk of radiation health effects

A screening tool was adapted from the Fukushima Health Management Survey (Fukushima Prefecture & Fukushima Medical University, 2011; Yabe *et al.*, 2014) to assess the perceptions of the risk of radiation health effects using the following two items: 'What do you think is the likelihood of damage to your health (*e.g.*, cancer onset) in later life as a result of your current level of radiation exposure?' and 'What do you think is the likelihood that the health of your future (*i.e.*, as yet unborn) children and grandchildren will be affected as a result of your current level of radiation exposure?' The first question concerns delayed effects, and the second concerns genetic effects. Response options are offered on a four-point Likert-type scale, from 1 = *very unlikely* to 4 = *very likely*, with higher scores indicating a greater perception of adverse health effects.

2.3 Statistical analyses

Chi-square and independent sample mean *t*-tests were used to compare differences by gender and place of residence at the time of the Great East Japan Earthquake (Fukushima Prefecture *vs.* other prefectures). Multiple regression analysis (stepwise method) was conducted after calculating Pearson's correlation coefficients to examine factors affecting anxiety about childbirth and child-rearing associated with radiation exposure by gender and region (Fukushima Prefecture and other prefectures). The dependent variables were the measures of future reproductive confidence in "Caring for a baby" and "Giving birth to a baby." The independent variables were future child desires, depressive symptoms, stress in daily life, availability of a radiation consultant, knowledge of nuclear power and radiation, radiation effects on a partner, perception of radiation risks, the WHO-5, the Communicative and Critical Health Literacy Scale, the RSES, and the ATSPPH-SF. The adjustment variables were age, marital status, presence of children, and cohabitation. All analyses were performed using IBM SPSS ver. 25.0 for Windows (IBM SPSS Japan, Tokyo, Japan).

2.4 Research ethics

This study was approved by the Kitasato University School of Nursing Ethics Committee (No. 2018-9-2). The respondents were informed that the questionnaire responses were anonymous. The goals of the study were explained to the respondents in a cover letter accompanying the questionnaire. The cover letter asked the respondents to return a blank questionnaire if they were not interested in participating. The respondents were also told that there would be no adverse consequences resulting from any of their responses or a refusal to participate.

3 Results

The results of the comparison between genders and place of residence at the time of the Great East Japan Earthquake (Fukushima Prefecture and other prefectures) are shown in Table 1. The respondents ranged in age from 18 to 35 yr. The men living in Fukushima Prefecture were more likely to indicate "unmarried," "have no children," "knowledge of nuclear power and radiation," and "perception of radiation risk: unlikely." In addition, the scores for "Giving birth to a baby" were significantly lower among men in Fukushima Prefecture than among women in other prefectures. The men living in other prefectures were more likely to indicate "living alone" and "radiation consultant absent." The women living in Fukushima Prefecture were more likely to indicate "married," "have children," and "living together," whereas the women living in other prefectures were more likely to indicate "desire to have children," "no depressive symptoms," "radiation consultant present," "no knowledge of nuclear power and radiation," and "perception of radiation risk: likely."

To clarify the strength between items before conducting a multiple regression analysis, we calculated correlation coefficients by gender and prefecture (Tabs. 2 and 3, respectively). Then, we performed multiple regression analyses to identify associations between "Giving birth to a baby" and "Caring for a baby" and items in the FPAM (Tabs. 4 and 5, respectively). For "Giving birth to a baby," "Radiation effects on partners" was significantly associated in all groups. "Perception of radiation risk: Delayed effects" was significantly associated for women in both prefectural groups. Next, "Future child desires" was significantly related to "Caring for a baby" for all groups. "Perception of radiation risk: Genetic effects" was significantly related to "Caring for a baby" for all groups, and "Perception of radiation risk: Genetic effects" was significantly related to "Caring for a baby" for both men and women living in Fukushima Prefecture.

4 Discussion

The results of this survey indicate that anxiety about future childbirth and childcare related to radiation exposure varies by gender and among prefectures. First, men in Fukushima Prefecture considered themselves knowledgeable about nuclear power and radiation, thought that their children and grandchildren had a slight chance of experiencing health effects from radiation, and had confidence in their future childbearing. Conversely, women in other prefectures did not know much about radiation, thought that their children and grandchildren had a high chance of experiencing health effects from radiation, and lacked confidence in their future childbearing. Second, perceptions of radiation effects (genetic and/or delayed) were associated with anxiety about childbirth and rearing children among all participants except men who resided outside of Fukushima Prefecture. Third, regardless of gender or prefecture, the respondents who were anxious about the effects of radiation exposure on a partner were also more anxious about future childbirth, and the respondents who did not want children were more anxious about rearing them.

The second and third results are in line with our previous studies that showed an association between child-rearing anxiety and health risk anxiety toward radiation exposure among female college students who had experienced radiation exposure living in Fukushima Prefecture (Ito *et al.*, 2023). On the other hand, the lack of an association between perceptions about radiation risks and childbirth- and childcare-related anxiety among men outside of Fukushima Prefecture might be associated with their low desire to have children and their lack

Table 1. Comparisons by gender and place of residence (Fukushima *vs.* other prefectures).

	Male				Female					
	Fukushima[1] (n = 155)		Others[2] (n = 155)		Fukushima[3] (n = 155)		Others[4] (n = 155)		P-value	Phi or Cramer's V
	n	%	n	%	n	%	n	%		
Marital status										
Married	53	34.2%*	58	37.4%	84	54.2%*	73	47.1%	0.001	0.16
Unmarried	102	65.8%	97	62.6%	71	45.8%	82	52.9%		
Children										
Presence	45	29.0%*	48	31.0%	70	45.2%*	58	37.4%	0.013	0.13
Absence	110	71.0%	107	69.0%	85	54.8%	97	62.6%		
Cohabitant										
Living alone	31	20.0%	43	27.7%*	10	6.5%*	23	14.8%	0.000	0.21
Living together	124	80.0%	112	72.3%	145	93.5%	132	85.2%		
Future child desires										
Desired	99	63.9%	96	61.9%	103	66.5%	117	75.5%*	0.560	0.11
Not desired[a]	56	36.1%	59	38.1%	52	33.5%	38	24.5%		
Depressive symptoms										
Yes	98	63.2%	101	65.2%	84	54.2%	80	51.6%*	0.037	0.12
No	57	36.8%	54	34.8%	71	45.8%	75	48.4%		
Stress in daily life										
Strong	61	39.4%	70	45.2%	54	34.8%	62	40.0%	0.036	0.10
Somewhat strong	56	36.1%	57	36.8%	82	52.9%	60	38.7%		
Somewhat weak	23	14.8%	20	12.9%	10	6.5%	23	14.8%		
Weak	15	9.7%	8	5.2%	9	5.8%	10	6.5%		
Availability of radiation consultant										
Presence	101	65.2%	86	55.5%*	113	72.9%	115	74.2%*	0.001	0.16
Absence	54	34.8%	69	44.5%	42	27.1%	40	25.8%		
Knowledge of nuclear power and radiation										
With knowledge	16	10.3%*	6	3.9%	2	1.3%	0	0.0%*	0.000	0.22
Somewhat knowledgeable	60	38.7%	23	14.8%	31	20.0%	10	6.5%		
Not very knowledgeable	50	32.3%	82	52.9%	88	56.8%	95	61.3%		
Without knowledge	29	18.7%	44	28.4%	34	21.9%	50	32.3%		
Radiation effects on partners										
Concerned	19	12.3%	20	12.9%	13	8.4%	18	11.6%	0.496	0.07
Slightly concerned	59	38.1%	56	36.1%	51	32.9%	55	35.5%		
Do not care too much	39	25.2%	47	30.3%	48	31.0%	54	34.8%		
Do not care	38	24.5%	32	20.6%	43	27.7%	28	18.1%		
Perception of radiation risk: Genetic effects										
Very unlikely	33	21.3%*	18	11.6%	19	12.3%	9	5.8%	0.000	0.14
Unlikely	73	47.1%	63	40.6%	86	55.5%	77	49.7%		
Likely	35	22.6%	62	40.0%	46	29.7%	62	40.0%		
Very likely	14	9.0%	12	7.7%	4	2.6%	7	4.5%		
Perception of radiation risk: Delayed effects										
Very unlikely	30	19.4%*	22	14.2%	18	11.6%	10	6.5%*	0.001	0.12
Unlikely	71	45.8%	61	39.4%	79	51.0%	63	40.6%		
Likely	37	23.9%	59	38.1%	51	32.9%	71	45.8%		
Very likely	17	11.0%	13	8.4%	7	4.5%	11	7.1%		
M	SD	M	SD	M	SD	M	SD	P-value		
Age	29.4	4.5	29.7	4.5	28.9	4.6	28.7	4.5	0.214	
FPAM: Giving birth to a baby	6.8	1.9	7.1	1.9	7.2	2.2	7.7	2.0	0.002	1 < 4
FPAM: Caring for a baby[b]	6.6	2.3	6.6	2.6	6.0	2.6	5.9	2.5	0.019	
WHO-5	17.8	6.2	18.0	5.8	17.6	5.8	17.5	5.5	0.898	
HL: Communicative	10.1	2.7	10.5	2.7	10.3	2.1	10.4	2.3	0.513	
HL: Critical	6.3	1.7	6.5	1.7	6.3	1.6	6.4	1.6	0.858	
Self-esteem	23.1	5.6	22.6	5.7	22.1	5.2	22.8	5.1	0.454	
ATSPPH-SF	23.7	3.9	24.0	4.4	24.1	4.4	24.8	4.0	0.113	

Fukushima Future Parents Attitude Measure, World Health Organization-Five Well-Being Index, Communicative and Critical Health Literacy, Rosenberg Self-Esteem Scale, and Attitudes Towards Seeking Professional Psychological Help Scale-Short Form.

★Items for which the results of the residual analysis are significantly different at the 5% level.

[a] including "No idea"

[b] The results of group comparisons using the Tukey method showed no significant differences in any of the items.

Table 2. Correlation coefficients between Fukushima and other prefectures for males (upper right = Fukushima Prefecture, lower left = other prefectures).

	Item (Meaning at high scores)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	FPAM: Giving birth to a baby (Anxious)		.44**	.06	.16*	-.01	-.33**	-.25**	.17*	.25**	.20*	.08	.31**	-.11	-.23**	.40**	.36**	-.16	.06
2	FPAM: Caring for a baby (Anxious)	.43**		.18*	.20*	.04	-.45**	.02	.11	.22**	.22**	.03	.22**	-.10	-.19*	.23**	.16*	-.23**	.12
3	Marital status (Unmarried)	.20*	.46**		.83**	-.33**	-.06	.16*	.04	-.04	.21**	.10	.11	.17*	.10	-.03	-.11	-.08	.04
4	Children (Absence)	.19*	.33**	.78**		-.25**	-.07	.10	.02	.01	.22**	.12	.17*	.14	.05	-.02	-.05	-.09	.05
5	Cohabitant (Living together)	-.04	-.09	-.42**	-.32**		-.07	-.01	.03	.20*	-.21**	-.14	-.08	.11	.03	.00	.08	.01	-.10
6	Future child desires (Desired)	-.34**	-.64**	-.28**	-.21**	.02		.05	-.13	-.25**	-.04	-.03	-.21**	-.04	.10	-.10	-.08	.25**	-.03
7	Radiation effects on partners (No care)	-.09	.04	.11	.09	-.06	.06		.09	.02	-.06	-.03	.08	.15	.12	-.33**	-.32**	.09	-.08
8	Availability of radiation consultant (Absence)	.31**	.35**	.24**	.24**	-.05	-.34**	.06		.40**	-.06	.03	.22**	-.10	-.12	.13	.06	-.24**	.05
9	Knowledge of nuclear power and radiation (Without knowledge)	.17*	.22**	.15	.18*	-.03	-.22**	.03	.24**		-.18*	.02	.30**	-.05	-.14	.19*	.20*	-.25**	-.12
10	Depressive symptoms (Existing)	.07	-.11	.11	.07	-.06	.18*	-.03	-.05	-.10		.26**							
11	Stress in daily life (Weak)	.08	-.02	.03	-.02	-.09	.08	.03	-.02	.01	.33**		.44**	.18*	.01	-.04	.03	-.43**	-.18*
12	WHO-5 (Low QoL)	.21**	.18*	.19*	.14	-.10	-.14	.18*	.19*	.18*	.39**	.47**		-.05	-.23**	.19*	.23**	-.53**	-.16*
13	HL: Communicative (Information available)	-.20*	-.20*	-.01	-.08	.02	.20*	-.01	-.24**	-.27**	.05	.22**	-.05		.60**	-.17*	-.10	.04	-.15
14	HL: Critical (Information available)	-.25**	-.28**	-.05	-.15	-.02	.30**	-.03	-.23**	-.28**	.09	.14	-.12	.67**		-.14	-.19*	.27**	-.16*
15	Perception of radiation risk: Genetic effects (Very likely)	.10	.01	-.09	-.12	.12	.07	-.37**	.08	.04	.01	-.07	-.03	-.18*	-.17*		.81**	-.13	.03
16	Perception of radiation risk: Delayed effects (Very likely)	.04	-.08	.01	-.04	.04	.08	-.29**	.03	.05	-.02	-.05	-.01	-.01	-.02	.75**		-.17*	.00
17	Self-esteem (High self-esteem)	-.38**	-.31**	-.26**	-.25**	.06	.26**	-.10	-.13	-.24**	-.27**	-.32**	-.53**	.12	.35**	.04	.04		.07
18	ATSPPH-SF (Consult with an expert)	-.19*	-.21*	-.08	-.05	-.08	.22**	.02	-.21*	-.13	.11	.04	-.01	-.03	.04	.09	.06	.14	

Upper right: Male, in Fukushima prefecture; Lower left: Male, in other prefectures; numbers in the columns match the item numbers in the rows.

** $p < 0.01$, * $p < 0.05$

Table 3. Correlation coefficients between Fukushima and other prefectures for females (upper right = Fukushima Prefecture, lower left = other prefectures).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	FPAM: Giving birth to a baby (Anxious)		.46**	.26**	.35**	-.10	-.24**	-.29**	.12	-.01	.24**	.25**	.34**	-.26**	-.25**	.18*	.23**	-.39**	.02
2	FPAM: Caring for a baby (Anxious)	.36**		.40**	.36**	-.04	-.54**	.02	.20*	-.05	.11	.14	.24**	-.05	-.05	.07	.03	-.23**	-.13
3	Marital status (Unmarried)	-.04	.30**		.73**	-.23**	-.22**	.13	.17*	.03	.30**	.33**	.33**	-.01	-.04	-.17*	-.15	-.34**	-.08
4	Children (Absence)	.07	.27**	.58**		-.19*	-.10	.09	.09	-.05	.34**	.23**	.27**	-.03	-.03	-.21**	-.19*	-.31**	-.09
5	Cohabitant (Living together)	.04	-.17*	-.36**	-.32**		.04	-.06	-.08	.04	-.08	-.18*	-.16*	.03	-.03	-.07	.00	.02	.10
6	Future child desires (Desired)	-.02	-.47**	-.18*	-.07	.14		.12	-.15	-.01	.03	-.13	-.16*	-.03	.08	.07	.00	.11	.09
7	Radiation effects on partners (No care)	-.28**	.06	.15	.17*	-.13	.24**		-.01	.11	-.05	.02	.00	.09	.06	-.49**	-.40**	.02	-.08
8	Availability of radiation consultant (Absence)	.15	.29**	.17*	.09	-.09	-.21**	.20*		.15	.09	.11	.18*	-.02	-.05	.05	-.03	-.16*	-.09
9	Knowledge of nuclear power and radiation (Without knowledge)	-.02	.04	-.07	-.02	.16*	-.01	.00	.12		.12	.18*	.16*	-.11	-.17*	.06	-.09	-.21**	-.08
10	Depressive symptoms (Existing)	.21*	.23**	.22**	.29**	-.26**	-.22**	-.06	.13	-.11		.35**	.53**	-.13	-.15	.02	-.06	-.40**	-.03
11	Stress in daily life (Weak)	.25**	.26**	.19*	.18*	-.02	-.19*	-.05	.15	-.04	.38**		.48**	.09	-.03	-.02	-.07	-.36**	-.09
12	WHO-5 (Low QoL)	.31**	.31**	.19*	.23**	-.13	-.17*	-.03	.25**	.00	.55**	.56**		-.24**	-.32**	.10	.01	-.60**	-.14
13	HL: Communicative (Information available)	-.15	-.08	.04	-.04	-.04	-.04	.03	-.14	-.14	-.04	-.06	-.15		.57**	-.16*	-.10	.25**	.00
14	HL:Critical (Information available)	-.09	-.03	-.01	-.07	.02	-.01	-.02	-.09	-.14	-.06	-.06	-.18*	.73**		-.07	-.14	.25**	.08
15	Perception of radiation risk: Genetic effects (Very likely)	.37**	.10	-.09	-.10	.11	.12	-.27**	-.01	.03	.09	.05	.23**	.09	.07		.74**	.00	.10
16	Perception of radiation risk: Delayetd effects (Very likely)	.40**	.08	-.11	-.11	.13	.17*	-.34**	.03	.07	.09	.02	.21**	.02	.01	.81**		-.03	.14
17	Self-esteem (High self-esteem)	-.36**	-.36**	-.18*	-.24**	.17*	.32**	-.06	-.25**	-.03	-.45**	-.43**	-.57**	.19*	.26**	-.10	-.14		.08
18	ATSPPH-SF (Consult with an expert)	.21**	-.07	-.14	-.12	.15	.08	-.06	-.13	-.01	-.15	-.10	-.10	.11	.16*	.14	.11	.10	

Upper right: Feale, in Fukushima prefecture; Lower left: Female, in other prefectures; numbers in the columns match the item numbers in the rows.

Table 4. Examination of factors related to "Giving birth to a baby" (multiple regression analysis).

FPAM: Giving birth to a baby (Anxious)	B	SE	Standard β	P-value	95% CI	VIF	
						Lower	Upper
Male, Fukushima Prefecture (R^2 = 0.33, Adjusted-R^2 = 0.31)							
(Constant)	4.2	1.4		0.004	1.4	7.0	
Perception of radiation risk: Genetic effects (Very likely)	0.6	0.2	0.3	0.000	0.3	0.9	1.2
WHO-5 (Low QoL)	0.1	0.0	0.2	0.004	0.0	0.1	1.2
Radiation effects on partners (No care)	-0.4	0.1	-0.2	0.015	-0.6	-0.1	1.2
Knowledge of nuclear power and radiation (Without knowledge)	0.4	0.2	0.2	0.012	0.1	0.7	1.2
Male, Other Prefectures (R^2 = 0.29, Adjusted-R^2 = 0.24)							
(Constant)	6.5	1.8		0.000	3.0	10.1	
Self-esteem (High self-esteem)	-0.1	0.0	-0.3	0.000	-0.2	-0.1	1.2
Future child desires (Desired)	0.8	0.3	0.2	0.022	0.1	1.4	1.3
Availability of radiation consultant (Absence)	0.7	0.3	0.2	0.020	0.1	1.4	1.2
Radiation effects on partners (No care)	-0.3	0.2	-0.1	0.052	-0.6	0.0	1.0
Female, Fukushima Prefecture (R^2 = 0.48, Adjusted-R^2 = 0.43)							
(Constant)	3.0	3.0		0.316	-2.9	8.9	
WHO-5 (Low QoL)	0.1	0.0	0.2	0.034	0.0	0.1	1.6
Perception of radiation risk: Delayed effects (Very likely)	0.6	0.3	0.2	0.014	0.1	1.1	1.4
Future child desires (Desired)	1.3	0.4	0.3	0.001	0.5	2.0	1.2
Self-esteem (High self-esteem)	-0.1	0.0	-0.2	0.050	-0.2	0.0	1.6
Radiation effects on partners (No care)	-0.5	0.2	-0.2	0.017	-0.9	-0.1	1.3
Female, Other Prefectures (R^2 = 0.37, Adjusted-R^2 = 0.31)							
(Constant)	7.4	2.5		0.003	2.5	12.3	
Perception of radiation risk: Delayed effects (Very likely)	0.7	0.2	0.2	0.004	0.2	1.2	1.2
Self-esteem (High self-esteem)	-0.1	0.0	-0.3	0.000	-0.2	-0.1	1.2
ATSPPH-SF (Consult with an expert)	0.1	0.0	0.2	0.006	0.0	0.2	1.1
HL: Communicative (Information available)	-0.2	0.1	-0.2	0.025	-0.3	0.0	1.1
Radiation effects on partners (No care)	-0.5	0.2	-0.2	0.017	-0.9	-0.1	1.2

Table 5. Examination of factors related to "Caring for a baby" (multiple regression analysis).

FPAM: Caring for a baby (Anxious)	B	SE	Standard β	P-value	95% CI	VIF	
						Lower	Upper
Male, Fukushima Prefecture (R^2 = 0.32, Adjusted-R^2 = 0.26)							
(Constant)	2.6	1.3		0.053	0.0	5.2	
Future child desires (Desired)	-1.5	0.4	-0.3	0.000	-2.3	-0.8	1.1
Perception of radiation risk: Genetic effects (Very likely)	0.4	0.2	0.2	0.039	0.0	0.8	1.1
Depressive symptoms (Existing)	1.0	0.4	0.2	0.008	0.3	1.6	1.0
Knowledge of nuclear power and radiation	0.5	0.2	0.2	0.013	0.1	0.9	1.2
ATSPPH-SF (Consult with an expert)	0.1	0.0	0.2	0.030	0.0	0.2	1.0
Male, Other Prefectures (R^2 = 0.54, Adjusted-R^2 = 0.51)							
(Constant)	1.0	1.9		0.595	-2.8	4.9	
Future child desires (Desired)	2.6	0.4	0.5	0.000	1.9	3.3	1.3
Self-esteem (High self-esteem)	0.0	0.0	-0.1	0.136	-0.1	0.0	1.2
Availability of radiation consultant (Absence)	0.7	0.4	0.1	0.044	0.0	1.4	1.2
Female, Fukushima Prefecture (R^2 = 0.51, Adjusted-R^2 = 0.48)							
(Constant)	3.3	0.9		0.001	1.5	5.2	
Future child desires (Desired)	-3.2	0.4	-0.6	0.000	-3.9	-2.4	1.0
Children (Absence)	2.0	0.4	0.4	0.000	1.2	2.7	1.1
Perception of radiation risk: Genetic effects (Very likely)	0.9	0.2	0.2	0.001	0.4	1.4	1.0
Female, Other Prefectures (R^2 = 0.30, Adjusted-R^2 = 0.29)							
(Constant)	-6.7	2.7		0.013	-12.0	-1.4	
Future child desires (Desired)	2.8	0.4	0.5	0.000	2.0	3.6	1.2
WHO-5 (Low QoL)	0.1	0.0	0.2	0.035	0.0	0.1	1.2

of access to a radiation consultant. Their indifference regarding both child-rearing and radiation implies a higher risk of sudden anxiety occurring at the time they plan a pregnancy or their partners become pregnant. As a part of long-term restoration activities, the continuous provision of information on radiation and health is warranted both within and outside Fukushima, as is the evaluation of such activities (Murakami *et al.*, 2017).

In terms of prefectures, residents of Fukushima Prefecture who reported having a lower QOL were more anxious about future childbirth, as were people in other prefectures who reported having lower self-esteem. These results were similar to those in a previous study that investigated anxiety about future childbirth among female college students living in Fukushima Prefecture (Ito *et al.*, 2018b). In the present survey, the factors regarding anxiety about future childbirth differed between Fukushima and other prefectures in terms of QOL and self-esteem, but because these items are highly correlated, it is possible that there is little difference between prefectures. These results suggest that measures for anxiety about future childbirth due to radiation exposure should be integrated into more general mental health support in communities.

The main strength of this study is that it examined the need for measures to address anxiety about future childbirth and childcare associated with radiation exposure among not only expectant and nursing mothers in Fukushima Prefecture, but also men in Fukushima Prefecture and both men and women in other prefectures.

This study also has some limitations. First, we could not randomize the selection of the participants. Although the survey was conducted *via* an online survey company, the number of appropriately aged residents of Fukushima Prefecture was small. Because Fukushima Prefecture is a long prefecture stretching from east to west across the Aizu and Iwaki regions, residents may have vastly different attitudes toward radiation exposure. In addition, the social structure of the participants from Fukushima Prefecture is not representative of the entire population of Fukushima Prefecture, so the survey results should be generalized with caution. Second, the percentages for "child or not" and "marital status" differed among the four groups by prefecture and gender. In this study, a smaller percentage of men in Fukushima Prefecture were married and had children, whereas a larger percentage of women in Fukushima Prefecture were married and had children. These differences in the attributes of the respondents may have influenced their attitudes toward childbirth and childcare. Third, as this was a cross-sectional study, causal relationships could not be determined. For example, regardless of prefecture, with regard to women, those who did not wish to have children in the future reported having more anxiety about rearing children in the future. Whether women do not have children or do not wish to have children because they are anxious about future child-rearing as a result of radiation exposure remains unclear; alternatively, women who are anxious about future family planning may also be anxious about radiation exposure. Finally, it is possible that those who did not wish to have children, regardless of the effects of radiation, had concerns about future childbirth and child-rearing.

5 Conclusion

The results of this study suggest that concerns about future childbirth and childcare associated with radiation exposure vary by gender and prefecture. Therefore, it is important to create an environment where those who are anxious about future childbirth and childcare have access to the necessary information, regardless of gender or whether they live in an area that may be affected by a nuclear accident.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contribution statement

S. Ito: Conceptualization, Methodology, Writing original draft, Investigation, A. Goto: Supervision, Conceptualization, Editing.

Ethics approval

The Kitasato University School of Nursing ethics committee approved this study (No. 2018-9-2).

Informed consent

Written informed consent was obtained from all patients and/or families.

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