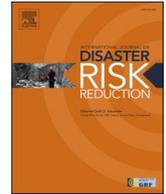




ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdr

Risk perception regarding a nuclear accident and common factors related to health among guardians residing near a restarted nuclear power plant in Japan after the Fukushima accident

Hitomi Matsunaga^{a,*}, Makiko Orita^a, Yasuyuki Taira^a, Kaoru Shibayama^b, Koichi Shinchi^b, Noboru Takamura^a

^a Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute, Nagasaki University, 1-12-4 Sakamoto, Nagasaki, 852-8523, Japan

^b Faculty of Medicine, Nursing, Department of Comprehensive & Fundamental Nursing, Saga University, 5-1-1 Nabeshima, Saga, 849-8501, Japan

ARTICLE INFO

Keywords:

Risk perception
Restarted nuclear power plant
Children

ABSTRACT

Ten years have passed since the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in Japan, and nine of 33 reactors have gradually been restarted following the new regulations outlined by the Nuclear Regulatory Authority. The purpose of the study was to assess the risk perception regarding a nuclear accident and to identify common factors related to health among guardians residing near the Genkai Nuclear Power Plant (GNPP), one of the nuclear power plants restarted after the FDNPP accident. We distributed self-administered questionnaires to approximately 3400 guardians of children in 36 kindergartens located around the GNPP, including the precautionary action zone and the urgent protective action planning zone. We obtained responses from 2249 guardians. Results showed that 58.9% of guardians thought that genetic effects would occur among the generations who were children at the time of the FDNPP accident. In contrast, 28.8% of guardians were anxious about their children consuming foods from Fukushima. Regression analysis showed that females were 1.9 times more anxious about administering prophylactic stable iodine (SI) than male guardians. A total of 1.5 times more female than male guardians considered that genetic effects would occur in the generations who were children at the time of the FDNPP accident. Interestingly, there was no significant relationship between overall risk perception and the distance of guardians' residence to the GNPP.

1. Introduction

Ten years have passed since the Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in 2011 [1]. The FDNPP accident caused several complicated issues for individuals and communities, and it has had large and long-lasting societal, environmental, and economic consequences [2]. For example, some people believe that children who resided in the affected area at the time of the nuclear accident will experience some form of genetic effect due to radiation exposure from the FDNPP accident [3]. Further, some people were concerned about the safety of foods from Fukushima due to radioactive contamination, and they have avoided purchasing such foods [4,5]. Further, 62% of citizens in 24 countries across the world currently oppose the use of nuclear energy, with a quarter of those having changed their minds after the FDNPP accident [6]. Some countries, such as Germany

* Corresponding author. Department of Global Health, Medicine and Welfare, Atomic Bomb Disease Institute, Nagasaki University, Japan.
E-mail address: hmatsu@nagasaki-u.ac.jp (H. Matsunaga).

<https://doi.org/10.1016/j.ijdr.2021.102776>

Received 5 April 2021; Received in revised form 10 December 2021; Accepted 30 December 2021

Available online 4 January 2022

2212-4209/© 2022 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

and Taiwan, changed their energy policy and ceased to supply electricity generated using nuclear energy [7,8]. In Japan, the operation of all domestic nuclear power plants was stopped immediately after the FDNPP accident. However, following the adoption of new energy policy regulations by the Nuclear Regulatory Authority (NRA) of Japan, nine of 33 shuttered reactors (five of 18 power plants) have been restarted since September 2014 [9,10]. Nevertheless, the risk perception of people residing near the restarted nuclear power plants in Japan has not been clarified to date.

Kyushu Electric Power Co., Inc.'s Genkai Nuclear Power Plant (GNPP) is located in Genkai Town, Saga Prefecture, Japan (Fig. 1). In 2018, two of the four reactors were restarted following the implementation of new regulations outlined by the NRA [11]. Since 2014, municipalities near the GNPP started distributing stable iodide (SI) and provided explanations about its use to residents; these measures are similar to measures adopted by other countries with nuclear power plants [12–14].

Administering prophylactic SI is effective for minimizing internal exposure, especially to the thyroid glands of children, and its use is advised given the elevated risk of developing thyroid cancer at a young age after exposure to fallout after a nuclear accident [15–17]. On the other hand, it has been reported that guardians tend to be hesitant in medicating their children, with female guardians being more hesitant than male guardians [18]. To conduct effective risk communication and facilitate preparations for future unexpected nuclear accidents, it is important to comprehend how parental guardians perceive, and react to, hazards such as a nuclear accident [19, 20]. Consequently, the present study aimed to assess the risk perception among guardians with respect to the health effects associated with radiation exposure, food consumption, and medication in areas near the reopened nuclear power plants in Japan.

2. Materials and methods

2.1. Study participants

This study was conducted from January to June 2020 in three municipalities (Genkai Town, Karatsu City, and Imari City) located within a 30-km radius of the GNPP in Saga Prefecture, Japan (Fig. 1). In the vicinity of the GNPP, the total population of the precautionary action zone (PAZ), i.e., parts of Genkai Town and Karatsu City, is 8126 people (2876 households). The number of people in the urgent protective action planning zone (UPZ), i.e., parts of Genkai Town, Karatsu City, and Imari City, is 179,503 people (72,241 households). A self-administered questionnaire was distributed to approximately 3400 parental guardians to assess their risk perception of a nuclear accident and the associated health effects. The questionnaire was sent to guardians with children at 36 kindergartens that were randomly selected from approximately 50 kindergartens in the three municipalities. Respondents were not required to declare whether the children in their care were male or female. Responses were obtained from 2249 guardians, and after excluding 190 incomplete responses, data were obtained from 114 (5.5%) guardians who resided within 5 km of the GNPP [PAZ], 1336 (64.9%) who resided within 5–30 km of the GNPP [UPZ], 236 (11.5%) who resided more than 30 km from the GNPP, and 373 (18.1%) responded that they did not know the distance from their residence to the GNPP. Eventually, 2059 guardians (1819 mothers, 222 fathers, 16 grandparents, and two others) were included in the analysis (the valid response rate was 91.6%). This study was approved by the ethics committee of the Nagasaki University Graduate School of Biomedical Sciences (No. 19083003).

2.2. Data collection

The questionnaire used in the study was based on the Fukushima Health Management Survey, which was organized by the government of Fukushima Prefecture after the FDNPP accident [21,22]. In addition, we set question items focusing on radiation exposure, food consumption, and medication, referring to previous studies targeting parents [23–26].

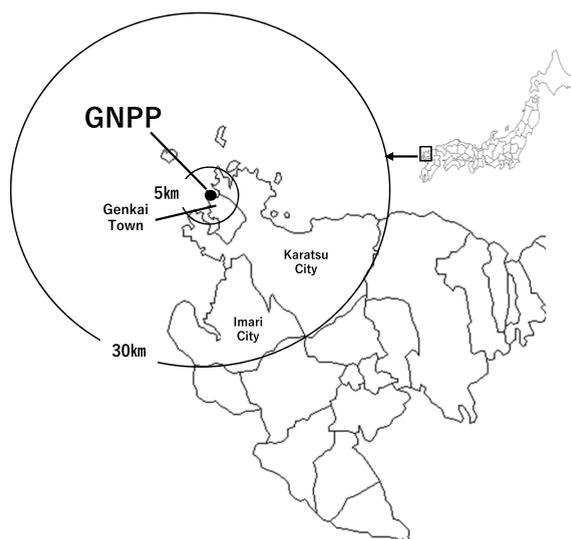


Fig. 1. Location of the Genkai nuclear power plant (GNPP) in Saga Prefecture, Japan.

The self-administered questionnaire assessed the guardians' risk perception regarding radiation exposure, food consumption, and medication using two questions for each of these items. The questions related to medication asked whether they were anxious about administering prophylactic SI to their children during a nuclear emergency and whether they were anxious about administering general medication to their children. The questions regarding food consumption asked whether they were anxious about their children consuming foods from Fukushima and whether they were anxious about giving their children food containing additives. Finally, the questions about radiation exposure asked whether they thought that genetic effects would manifest among the generation of people who were children at the time of the FDNPP accident and whether they were anxious about their children undergoing radiographic examination. For each of these questions, guardians were asked to select from one of the following four responses: "yes", "probably", "probably not", or "no". We classified "yes" and "probably" responses as "YES", and "no" and "probably not" responses as "NO". Demographic factors, including guardian sex and age, and social factors, including distance from the GNPP to their residence (within 5 km [PAZ], within 30 km [UPZ], more than 30 km, and unknown), were also included in the questionnaire.

2.3. Statistical analysis

After collating the descriptive statistics, we evaluated the differences in the risk ratios for medication, food consumption, and radiation exposure responses using a chi-square test. Then, we identified the relative contribution of each factor (i.e., sex, age, number of children, and distance from GNPP to home) by binominal logistic regression analysis. All p-values <0.05 were considered significant. The statistical analysis was performed using IBM SPSS Statistics (version 19; SPSS Japan, Tokyo, Japan) and the SAS software package (version 8.2; SAS Institute, Cary, NC).

3. Results

Table 1 shows the characteristics of the study subjects. A total of 1496 (72.7%) guardians responded that they were anxious about administering prophylactic SI to their children during a nuclear emergency, and 610 (29.6%) guardians responded that they were anxious about administering general medication to their children ($p < 0.01$). Regarding their risk perception of food consumption, 593 (28.8%) guardians responded that they were anxious about their children consuming foods from Fukushima, and 1087 (52.8%) guardians responded that they were anxious about giving their children food containing additives ($p < 0.01$). Regarding their risk perception of radiation exposure, 1213 (58.9%) guardians responded that they thought that genetic effects would manifest among the generations of people who were children at the time of the FDNPP accident, and 812 (39.4%) guardians responded that they were anxious about their children undergoing radiographic examinations ($p < 0.01$) (Table 2).

Table 3 shows the results of the logistic regression analysis. Compared to male guardians, female guardians were independently associated with all risk perceptions except for risk 3; foods produced in Fukushima. Specifically, compared to males, females were 1.9 times more anxious about administering prophylactic SI to their children (95%CI: 1.4–2.6; $p < 0.01$), and 1.5 times more anxious about administering general medication to their children (95%CI: 1.1–2.0; $p < 0.01$). In addition, compared to males, females were 2.7 times more anxious about giving their children food containing additives (95%CI: 2.0–3.6; $p < 0.01$). Regarding the risk of radiation exposure, 1.5 times more females thought that genetic effects would develop in the generations of people who were children at the time of the FDNPP accident (95%CI: 1.2–2.0; $p < 0.01$). Female guardians were also 2.5 times more anxious about their children undergoing radiographic examinations (95%CI: 1.8–3.5; $p < 0.01$) than male guardians.

Regarding the age of the guardians, compared to respondents younger than 30 years old, guardians in their 30s were 1.4 times more

Table 1
Characteristic of the study subject.

	n	%
Sex		
Female	1837	89.2
Male	222	10.8
Relationship with children		
Mother	1819	88.3
Father	222	10.8
Grandparents	18	0.9
Age(y)		
<30	298	14.5
30s	1264	61.4
40s	475	23.1
≥50	22	1.0
Number of children		
1	389	18.9
2	850	41.3
3 or more	820	39.8
Distance from GNPP to home		
PAZ (>5 km)	114	5.5
UPZ (>5 km, <30 km)	1336	64.9
30 km <	236	11.5
unknown	373	18.1

Note. GNPP; Genkai nuclear power plant, PAZ; precautionary action zone, UPZ; urgent protective action planning zone.

Table 2
Risk perceptions regarding a nuclear accident and common factors related to health.

Risk of meditation		% (n)	%	
RISK 1	Yes	22.2 (458)	72.7	p < 0.01** ^a
Stable iodine	Probably	50.5 (1038)		
	Probably not	22.6 (467)	27.3	
	No	4.7 (96)		
RISK 2	Yes	8.0 (165)	29.6	
General medicine	Probably	21.6 (445)		
	Probably not	50.0 (1029)	70.4	
	No	20.4 (420)		
Risk of food consumption				
RISK 3	Yes	7.6 (156)	28.8	p < 0.01** ^a
Foods made in Fukushima	Probably	21.2 (437)		
	Probably not	47.4 (975)	71.2	
	No	23.8 (491)		
RISK 4	Yes	16.1 (332)	52.8	
Food additives	Probably	36.7 (755)		
	Probably not	36.3 (748)	47.2	
	No	10.9 (224)		
Risk of radiation exposure				
RISK 5	Yes	14.3 (294)	58.9	p < 0.01** ^a
Genetic effects	Probably	44.6 (919)		
	Probably not	35.4 (728)	41.1	
	No	5.7 (118)		
RISK 6	Yes	12.1 (250)	39.4	
Radiographic inspection	Probably	27.3 (562)		
	Probably not	45.3 (933)	60.6	
	No	15.3 (314)		

^a) Chi-square test.

Table 3
Logistic regression analysis of Sociodemographic and each risk perception of the guardians.

	Risk of meditation		Risk of food consumption		Risk of radiation exposure	
	Risk 1	Risk2	Risk3	Risk4	Risk5	Risk6
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Sex/head						
Male	1	1	1	1	1	1
Female	1.9** (1.4–2.6)	1.5** (1.1–2.0)	1.4 (0.9–1.9)	2.7** (2.0–3.6)	1.5** (1.2–2.0)	2.5** (1.8–3.5)
Age						
<30	1	1	1	1	1	1
30s	0.9 (0.6–1.1)	1.4* (1.0–1.8)	1.8** (1.3–2.5)	1.7** (1.3–2.1)	1.4** (1.1–1.9)	1.2 (0.9–1.6)
40s	0.8 (0.6–1.2)	1.3 (0.9–1.8)	1.8** (1.3–2.6)	1.7** (1.3–2.3)	1.7** (1.3–2.3)	1.4* (1.1–1.9)
≥50	0.6 (0.2–1.4)	0.7 (0.2–2.1)	0.7 (0.2–2.3)	0.5 (0.2–1.4)	0.6 (0.2–1.4)	0.6 (0.2–1.6)
Number of children						
1	1	1	1	1	1	1
2	0.9 (0.7–1.2)	0.9 (0.7–1.1)	1.0 (0.8–1.4)	0.9 (0.7–1.1)	1.3(0.9–1.7)	1.0 (0.8–1.3)
3 or more	0.9 (0.7–1.3)	0.9 (0.7–1.2)	1.0 (0.8–1.3)	0.9 (0.7–1.2)	1.3(0.9–1.6)	0.9 (0.8–1.3)
Distance from GNPP to residence						
PAZ (>5 km)	1	1	1	1	1	1
UPZ (>5 km, <30 km)	1.0 (0.7–1.6)	1.1 (0.7–1.7)	1.1 (0.7–1.6)	1.5 (0.9–2.2)	1.5 (0.9–2.2)	1.4 (0.9–2.1)
30 Km<	0.8 (0.5–1.3)	0.9 (0.6–1.5)	0.6 (0.4–1.0)	1.2 (0.7–1.8)	1.2 (0.7–1.8)	0.9 (0.5–1.4)
unknown	1.3 (0.8–2.1)	1.1 (0.7–1.8)	0.8 (0.5–1.3)	1.1 (0.7–1.6)	1.1 (0.7–1.7)	1.0 (0.6–1.6)

Note. Binominal logistic Regression analysis, OR; odds ratio, 95%CI; 95% confidence interval, GNPP; genkai nuclear power plant, PAZ; precautionary action zone, UPZ; urgent protective action planning zone, Risk1; perception of stable iodine, Risk2; perception of General medicine, Risk3; perception of foods from Fukushima, Risk4; perception of food additives, Risk5; perception of genetic effects, Risk6; perception of radiographic inspection.

anxious about administering general medication to their children (95%CI: 1.0–1.8 p < 0.05). Further, guardians in their 40s were 1.4 times more anxious about their children undergoing radiographic examination (95%CI: 1.1–1.9; p < 0.05). On the other hand, compared to guardians younger than 30 years old, guardians in their 30s and 40s were 1.8 times more anxious about giving their children foods produced in Fukushima (30s; 95%CI: 1.3–2.5; p < 0.01, 40s; 95%CI: 1.3–2.6; p < 0.01), and 1.7 times more anxious about giving their children food containing additives (30s; 95%CI: 1.3–2.1; p < 0.01, 40s; 95%CI: 1.3–2.3; p < 0.01). Furthermore, compared to guardians in their 30s, guardians in their 40s were 1.4 times more anxious about their children undergoing radiographic examination (95%CI: 1.1–1.9; p < 0.05).

Interestingly, the distance from their residence to the GNPP was not significantly related to any of the risk perceptions.

4. Discussion

In this study, we assessed the risk perceptions regarding a nuclear accident and common factors related to health among guardians of children aged 0–6 years residing in the vicinity of a recently restarted nuclear power plant after the FDNPP accident in Japan. The GNPP is located on Kyushu Island in Saga Prefecture, about 700 miles from the FDNPP in Fukushima Prefecture on Honshu Island. Therefore, the region surrounding the GNPP and its residents did not experience any direct damage due to the Great East Japan Earthquake or the subsequent tsunami, or due to the FDNPP accident in 2011 [27]. Although numerous studies have assessed people's risk perception after the FDNPP accident [3–5,21,23] the results of this study provide a foundation that can be used by guardians residing close to reopened reactors to mitigate against the adverse effects of a future nuclear accident.

Surprisingly, 58.9% of guardians responded that they thought genetic effects would develop in the generations of people who were children in Fukushima at the time of the FDNPP accident. Based on the findings of previous studies on the FDNPP accident and several international scientific reports, there is no scientific consensus of any discernible increase in genetic effects among the people affected by the FDNPP accident [28]. A possible reason for the lack of any such evidence is because the external and internal exposure doses of people affected by the FDNPP accident were ≤ 100 mSv, which is considered less than the levels associated with the manifestation of radiation health effects, including genetic effects [28]. On the other hand, the Fukushima Health Management Survey also reported that 36.0% of people in Fukushima Prefecture had concerns about health effects to their offspring due to radiation exposure from the nuclear accident [29]. After the FDNPP accident in 2011, risk perception of radiation exposure and its health effects, including genetic effects, tended to recognize negative impact be compared to other common risks, such as food containing additives and radiographic examinations. For example, a survey of university students in Japan revealed that radiation exposure was of greater concern than global warming or HIV infection [25]. Risk perception depends on a variety of complex factors including trust, education, knowledge, and personal experience [30]. Shirai et al. reported that there is a difference in the information received, knowledge about the FDNPP accident, and evidence of the health effects associated with radiation exposure between people residing inside and outside Fukushima [31]. People residing inside Fukushima who experienced the FDNPP accident showed a gradual decrease in risk perception regarding the possibility of genetic effects manifesting in children due to the accident [29]. However, the results of the study suggested that there was a gap between the risk perceptions of the health effects of radiation exposure and scientific consensus inside and outside Fukushima. Risk perception is also closely linked to health literacy [32], which is defined by the World Health Organization as the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand, and use information in ways that promote and maintain good health [33]. A previous study showed that there was a gap between the actual situation and people's risk perception of the radiation health effects associated with the FDNPP accident [34,35]. To bridge these gaps, it is important to provide education and/or information to increase health literacy, such as how to gain access to, understand, and use health information properly.

Interestingly, the guardians in this study were more anxious about their children consuming food containing additives than giving them foods produced in Fukushima, although a previous study showed that guardians with infants were less concerned about food containing additives compared to foods containing radioactive materials [26]. Furthermore, our previous study in Fukushima showed that younger generations and females were more anxious about consuming foods from Fukushima than older generations and males [36]. The safety of foods from Fukushima attracted considerable interest from other countries in Asia, which negatively affected international trade in traditional Japanese brands of fish products, vegetables, and fruits [37]. The anxiety related to the contamination of food from Fukushima appears to have subsided over time, although damage to the reputation of foods from Fukushima remains a serious challenge internationally.

Compared to anxiety about administering general medicine, the guardians surveyed in this study were anxious about administering prophylactic SI to their children. Administering prophylactic SI is a key strategy for decreasing the possibility of thyroid cancer developing among younger generations. In some areas around nuclear power plants in Japan, SI is distributed for free to residents under 40 years old [11]. However, 72.7% of guardians in the study indicated they were anxious about administering prophylactic SI to their children. Further, our previous study revealed that reasons for guardians not administering SI were "anxiety about the side effects of SI", "distrust of the effectiveness of SI", "complicated procedures for receiving SI" and "missed the date for receiving SI" [38]. In addition, our previous study conducted at the Sendai Nuclear Power Plant, which also resumed operations after the FDNPP accident, showed that 89.8% of mothers of infants were anxious about administering prophylactic SI to their children. The mothers who had high anxiety about administering prophylactic SI to their children wished to consult an expert [39]. These findings show the importance of science-based risk communication initiatives directed at parental guardians to reduce their anxiety and to demonstrate how to administer prophylactic SI to children and discuss the side effects of SI.

In this study, compared to males, female guardians had a higher overall risk perception regarding radiation exposure, food consumption, and medication for their children. In a previous study on the risk perception of food consumption, such as genetically modified food, females tended to be more anxious than males [24]. Among younger females who experienced the FDNPP accident, more were anxious about consuming food or drinking tap water from the affected area than older males [40]. In this study, the finding that the risk perception of factors associated with a nuclear accident, even among people who had not experienced a nuclear disaster previously, tended to be more acute among females than males, corroborating the findings of previous studies. Consequently, it is important to communicate effectively the risks associated with radiation health effects and radiation protection to guardians, especially females, residing near restarted nuclear power plants in preparation for future possible nuclear accidents.

The study has several limitations. First, the questionnaire was administered to the resident guardians of children in only three towns around the GNPP, which might have led to sampling bias. Second, the risk perception of genetic effects was relatively high among respondents compared to previous studies [29]. Although the reasons for this are very complex and it is not clear how these

high levels can be decreased, it is crucial that this issue is addressed in the near future. Third, other factors could be affecting risk perceptions, such as social factors and people's lifestyles. Lastly, our study found sex differences between different types of risk perception. However, only 11% of respondents were male, which might have led to response bias; it is possible that male participants may have stronger motivations than female guardians. Furthermore, the difference between sexes may suggest differences in paternal and maternal outlooks in relation to risk perception. Despite these limitations, this is the first study to examine risk perception among parental guardians residing near operational nuclear power plants towards nuclear accidents after the FDNPP accident in Japan.

Funding

This work was supported by JSPS KAKENHI Grant Number 20H04017.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to thank all study participants and municipal staff in Genkai town, Karatsu City, and Imari City in Saga Prefecture, Japan.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2021.102776>.

References

- [1] International Atomic Energy Agency, The Fukushima Daiichi Accident, Report by the Director-General, 2015, <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1710-ReportByTheDG-Web.pdf>. (Accessed 10 August 2021).
- [2] International Commission on Radiological Protection, ICRP Publication 146: Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident: Update of ICRP Publications 109 and 111, 2021. <https://www.icrp.org/docs/Free%20Excerpt%20from%20ICRP%20Publication%20146.pdf>. (Accessed 10 August 2021).
- [3] M. Orita, N. Hayashida, Y. Nakayama, T. Shinkawa, H. Urata, Y. Fukushima, Y. Endo, S. Yamashita, N. Takamura, Bipolarization of risk perception about the health effects of radiation in residents after the accident at Fukushima nuclear power plant, *PLoS One* 10 (2015), e0129227, <https://doi.org/10.1371/journal.pone.0129227>.
- [4] K. Yamamoto, S. Nomura, M. Tsubokura, M. Murakami, A. Ozaki, C. Leopold, T. Sawano, M. Takita, S. Kato, Y. Kanazawa, H. Anbe, Internal exposure risk due to radiocesium and the consuming behavior of local foodstuffs among pregnant women in Minamisoma City near the Fukushima nuclear power plant: a retrospective observational study, *PLoS One* 9 (2019), e023654, <https://doi.org/10.1136/bmjopen-2018-023654>.
- [5] D. Lee, S. Seo, M.K. Song, H.K. Lee, S. Park, Y.W. Jin, Factors associated with the risk perception and purchase decisions of Fukushima-related food in South Korea, *PLoS One* 12 (2017), e0187655, <https://doi.org/10.1371/journal.pone.0187655>.
- [6] The Guardian - Damian Carrington, Citizens across the World Oppose Nuclear Power, Poll Finds, 2011. <http://www.guardian.co.uk/environment/damian-carrington/blog/2011/jun/23/nuclear-power-nuclear-waste>. (Accessed 10 August 2021).
- [7] B. Knight, Merkel Shuts Down Seven Nuclear Reactors, 2011. <https://www.dw.com/en/merkel-shuts-down-seven-nuclear-reactors/a-14912184>. (Accessed 10 August 2021).
- [8] World Nuclear Association, Nuclear Power in the World Today, 2021. <https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx>. (Accessed 10 August 2021).
- [9] Agency for Natural Resources and Energy, Japan's Energy, 2021. <https://www.enecho.meti.go.jp/en/category/special/>. (Accessed 10 August 2021).
- [10] Japan Nuclear Safety Institute, Licensing Status for the Japanese Nuclear Facilities, 2021. <http://www.genanshin.jp/english/facility/map/>. (Accessed 10 August 2021).
- [11] Nuclear Regulation Authority, Genkai NRA Regional Office, 2021. <https://www.nsr.go.jp/english/nuclearfacilities/genkai/index.html>. (Accessed 10 August 2021).
- [12] L.R. Zwolinski, M. Stanbury, S. Manente, Nuclear power plant emergency preparedness: results from an evaluation of Michigan's potassium iodide distribution program, *Disaster Med. Public Health Prep.* 6 (2013) 263–269, <https://doi.org/10.1001/dmp.2012.41>.
- [13] U.S. Department of Health & Human Services, Potassium Iodide (KI), 2021. <https://remm.hhs.gov/potassiumiodide.htm>. (Accessed 10 August 2021).
- [14] Nuclear Regulation Agency, NRA Annual Report FY 2018, 2018. <https://www.nsr.go.jp/data/000312806.pdf>. (Accessed 10 August 2021).
- [15] A.B. Schneider, D.H. Sarne, Long-term risks for thyroid cancer and other neoplasms after exposure to radiation, *Nat. Clin. Pract. Endocrinol. Metabol.* 1 (2005) 82–91.
- [16] M. Jang, H.K. Kim, C.W. Choi, C.S. Kang, Age-dependent potassium iodide effect on the thyroid irradiation by ¹³¹I and ¹³³I in the nuclear emergency, *Radiat. Protect. Dosim.* 130 (2008) 499–502, <https://doi.org/10.1093/rpd/ncn068>.
- [17] A.A. Rooney, G.S. Cooper, G.D. Jahnke, J. Lam, R.L. Morgan, A.L. Boyles, J.M. Ratcliffe, A.D. Kraft, H.J. Schünemann, P. Schwingl, T.D. Walker, K.A. Thayer, R. M. Lunn, How Credible are the Study Results? Evaluating and Applying Internal Validity Tools to Literature-Based Assessments of Environmental Health Hazards. *Environment Internet.* 92–93, 2016, pp. 617–629, <https://doi.org/10.1016/j.envint.2016.01.005>.
- [18] World Health Organization, Iodine Thyroid Blocking Guidelines for Use in Planning and Responding to Radiological and Nuclear Emergencies, 2021. https://www.who.int/ionizing_radiation/pub_meet/iodine-thyroid-blocking/en. (Accessed 10 August 2021).
- [19] World Health Organization, Guidelines for Iodine Prophylaxis Following Nuclear Accidents, 1999. https://www.who.int/ionizing_radiation/pub_meet/Iodine_Prophylaxis_guide.pdf. (Accessed 10 August 2021).
- [20] International Atomic Energy Agency, IAEA Safety Standards for Protecting People and the Environment. Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency: General Safety Guide No. GSG-2, 2016. https://www-pub.iaea.org/MTCD/publications/PDF/Pub1467_web.pdf. (Accessed 10 August 2021).
- [21] Mitsubishi Research Institute, INC, Fukushima Reconstruction: Current Status and Radiation Health Risks, *MTR_Fukushima_1712.pdf* (mri.co.jp), 2021. (Accessed 10 August 2021).

- [22] S. Yasumura, M. Hosoya, S. Yamashita, K. Kamiya, M. Abe, M. Akashi, K. Kodama, K. Ozasa, For the Fukushima health management survey group, study protocol for the Fukushima health management survey, *J. Epidemiol.* 22 (2012) 375–383, <https://doi.org/10.2188/jea.JE20120105>.
- [23] M. Oe, S. Fujii, M. Maeda, M. Nagai, M. Harigane, I. Miura, H. Yabe, T. Ohira, H. Takahashi, Y. Suzuki, S. Yasumura, M. Abe, Three-year trend survey of psychological distress, post-traumatic stress, and problem drinking among residents in the evacuation zone after the Fukushima Daiichi Nuclear Power Plant accident, *Psychiatr. Clin. Neurosci.* 70 (2016) 245–252, <https://doi.org/10.1111/pcn.12387>.
- [24] K. Komoto, S. Okamoto, M. Hamada, N. Obana, M. Samori, T. Imamura, Japanese consumer perceptions of genetically modified food: findings from an international comparative study, *Interac. J. Med. Res.* 5 (2016) 1–20, <https://www.i-jmr.org/2016/3/e23/>.
- [25] S. Iwamoto, K. Sugita, I. Kon, T. Kato, K. Sugita, K. Yoshimoto, Current search for radiation education in junior-high and high-school students -From the radiation risk perception survey for university students- (in Japanese), *Bull. Facult. Edu. Chiba Univ.* 67 (2019) 369–377, <https://doi.org/10.20776/S13482084>.
- [26] K. Tanaka, Y. Sakamoto, M. Mori, C. Nakajima, The concept of food risk, knowledge, awareness, and behavior of preschool children's mothers (in Japanese), *Jpn. J. Publ. Health* 64 (2017) 567–576, <https://doi.org/10.11236/jph.64.9.567>.
- [27] Fire and Disaster Management Agency, About the 2011 off the Pacific Coast of Tohoku Earthquake (Great East Japan Earthquake), 2021 (No. 161) (in Japanese), <https://www.fdma.go.jp/disaster/higashinohon/items/161.pdf>. (Accessed 10 August 2021).
- [28] United Nations Scientific Committee on the Effects of Atomic Radiation, Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2020 Report SCIENTIFIC ANNEX B, 2021. https://www.unscear.org/docs/publications/2020/UNSCEAR_2020_AnnexB_AdvanceCopy.pdf. (Accessed 10 August 2021).
- [29] Fukushima Revitalization Station, Survey on Mental Health and Lifestyle, result report, 2018 (in Japanese), <https://www.pref.fukushima.lg.jp/uploaded/attachment/386028.pdf>. (Accessed 10 August 2021).
- [30] Y. Takebayashi, Y. Lyamzina, Y. Suzuki, M. Murakami, Risk perception and anxiety regarding radiation after the 2011 Fukushima nuclear power plant accident: a systematic qualitative review, *Int. J. Environ. Res. Publ. Health* 14 (2017) 1316, <https://doi.org/10.3390/ijerph14111306>.
- [31] K. Shirai, N. Yoshizawa, Y. Takebayashi, M. Murakami, Modeling reconstruction-related behavior and evaluation of influences of major information sources, *PLoS One* 14 (2019), e0221561, <https://doi.org/10.1371/journal.pone.0221561>.
- [32] Y. Kuroda, H. Iwasa, M. Orui, N. Moriyama, C. Nakayama, S. Yasumura, Association between health literacy and radiation anxiety among residents after a nuclear accident: comparison between evacuated and non-evacuated areas, *Int. J. Environ. Res. Publ. Health* 15 (2018) 1463. <https://www.mdpi.com/1660-4601/15/7/1463>.
- [33] World Health Organization, Health literacy. <https://www.euro.who.int/en/health-topics/health-determinants/behavioural-and-cultural-insights-for-health/health-literacy> (accessed 5 December 2021).
- [34] T. Kusumi, R. Hirayama, Y. Kashima, Risk perception and risk talk: the case of the Fukushima Daiichi nuclear radiation risk, *Risk Anal.* 37 (2017) 2305–2320, <https://doi.org/10.1111/risa.12784>.
- [35] Y. Yumiya, A. Goto, M. Murakami, T. Ohira, R.E. Rudd, Communication between health professionals and community residents in Fukushima: a focus on the feedback loop, *Health Common.* 35 (2020) 1274–1282, <https://doi.org/10.1080/10410236.2019.1625004>.
- [36] H. Matsunaga, M. Orita, Y. Taira, T. Kudo, H. Kondo, S. Yamashita, N. Takamura, Intention to return and perception of the health risk due to radiation exposure among residents in Tomioka Town, Fukushima Prefecture, stratified by gender and generation, *Disaster Med. Public Health Prep.* 1 (2020) 1–8, <https://doi.org/10.1017/dmp.2020.319>.
- [37] Food Industry Affairs Bureau Ministry of Agriculture, Forestry and Fisheries (MAFF), Request and Justification for Lifting the Import Measures on Japanese Food Regarding Radionuclides, 2020. https://www.maff.go.jp/e/export/pdf/safety_en_210129.pdf. (Accessed 10 August 2021).
- [38] H. Matsunaga, M. Orita, T. Taira, N. Takamura, Risk perception of the pre-distribution of stable iodine to guardians of children residing around the Genkai Nuclear Power Plant, Saga Prefecture, Japan, *PLoS One* 16 (2021), e0250570, <https://doi.org/10.1371/journal.pone.0250570>.
- [39] Y. Yamada, M. Orita, H. Matsunaga, T. Yamaguchi, T. Taira, N. Takamura, Risk perception regarding implementation of iodine thyroid blocking during a nuclear disaster of mothers residing near a nuclear power station in Japan, *Endocr. J.* 68 (2021) 553–560, <https://doi.org/10.1507/endocrj.EJ20-0627>.
- [40] H. Matsunaga, M. Orita, Y. Taira, N. Takamura, Intention to return in residents of tomioka, Fukushima prefecture, Japan stratified by sex after the accident at Fukushima Daiichi nuclear power station, *Prehospital Disaster Med.* 35 (2020) 235–236, <https://doi.org/10.1017/S1049023X20000254>.