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Knowledge and risk perception of radiation for Japanese nursing students after the Fukushima Nuclear Power Plant disaster

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A R T I C L E I N F O

Keywords:
Radiation education
Nuclear power
Nursing education
Risk perception
Questionnaire
X-ray

A B S T R A C T

Background: The Japanese have had three experiences of radiation disasters: the atomic bombs dropped on Hiroshima and Nagasaki in 1945, and the 2011 Fukushima Nuclear Power Plant disaster. The former two experiences have been covered in compulsory education programs. In light of these incidents, a strong fear of radiation has pervaded people of several generations. In such a situation, the role of nurses is important. When nurses treat residents, their attitudes change depending on how they understand and feel about radiation. The foundations of these attitudes are formed through student education. Hence, it is necessary to explore nursing students' understanding and risk perception of radiation, and the nature of radiation education received.
Objectives: To assess the levels of understanding and risk perception of nursing students regarding radiation.
Design: Cross-sectional survey.
Methods: A questionnaire survey was administered to all students (74 first-year, 79 second-year, 65 third-year, and 69 fourth-year students) in the nursing department of a Japanese national university. The response rate was 84%. Respondents were asked to rate their level of understanding of 50 phrases chosen from two supplementary texts about radiation for elementary school students and for middle and high school students, prepared by the Japanese Ministry. Further, they were asked to rate their risk perception for 30 events, and to answer six questions about radiation.
Results: It was found that knowledge about radiation among Japanese nursing students was poor, because sufficient radiation education had not been provided. Hence, they displayed a greater fear of X-rays as compared to American students and members of the League of Woman Voters. However, it was also found that an increase in understanding might decrease risk perception.
Conclusions: It was concluded that nursing students require adequate education about radiation, in order to reduce their fear of X-rays and to mitigate their risk perception.

1. Introduction

Many Japanese people do not have a positive impression of nuclear power because the word “nuclear” is reminiscent of the disastrous situation caused by the bombings of Hiroshima and Nagasaki in 1945. As a result, the long-term effects of radiation exposure as well as the scale of nuclear explosions are highly feared in Japan. Nevertheless, radiation education has been neglected for 30 years in compulsory education programs in elementary and junior high schools (Yoshida and Honda, 2018). Against such a background, the Japanese government began to issue supplementary texts for radiation education programs from April 2011 (MECSST, 2011). However, when the Fukushima Nuclear Power Plant (FNPP) disaster occurred in March 2011, the public's fear of radiation greatly increased. Moreover, the government-prepared texts did not include any descriptions related to nuclear power because the possibility of nuclear accidents had not been anticipated. As a result, the texts were forced to be revised. The revised supplementary texts were issued from 2013, including descriptions related to nuclear power disasters (MECSST, 2013).

Medical professionals such as physicians and nurses are expected to

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have specialized knowledge, including regarding radiation, and are accountable to patients. In particular, nurses comprise more than half of medical personnel in Japan, and hence have a critical impact on patients (Kako et al., 2014; Kawasaki et al., 2016; Nagai et al., 2017). Following the FNPP disaster, radiation effects on health have become a major concern for the public, and recognition has grown that the role of nurses is important in the area of radiation disasters as with other areas of medicine.

Radiation education was not previously considered a necessary part of nursing education. However, the Science Council of Japan had proposed that nurses and public health nurses should sufficiently understand radiation to fulfill their professional roles. The proposal stated: "Although radiation and radio isotopes are widely used in medicine and medical procedures ranging from diagnosis to treatment, the current medical education system has created an alarming condition by sending out into the medical field physicians, nurses, and public health nurses who do not understand enough about radiation effects and radiation protection (Science Council of Japan, 2014).

In response to the proposal, the topic of "Human responses to medical use of radiation" was included among the items of basic knowledge required to be covered in the 2017 model core curriculum for nursing education (MECSST, 2017). The aim was for nursing students to learn more about medical uses of radiation, actions of radiation on the human body, health effects and risks of radiation, and radiation protection measures for personnel using radiation in medical settings. Thus, in order to understand the extent of nurses' scientific knowledge about radiation, and to ensure best practices of care, it is necessary to examine the manner in which radiation education is included as part of basic nursing education. For this purpose, it is necessary to clarify how well nursing students understand the contents of the supplementary texts on radiation prepared for primary and secondary education programs. Nursing students may also be affected by anxieties and fears about radiation specific to Japanese people. Further, it is also necessary to grasp the current risk perception of radiation.

While the contents and the structure of credits of basic nursing education courses are defined by a set of designated rule, the details of these courses are entrusted to each educational institution in Japan (Sasatake et al., 2017). It has been reported that, in the majority of courses, little or no time is actually provided for radiation education (Morishima et al., 2012). It follows that nursing students are not systematically provided knowledge on radiation, and hence lack sufficient knowledge at graduation. Similarly, looking at the curriculum of the top-ranked nursing colleges or universities in the USA, no courses related to radiation could be found.

In this study, the level of understanding of nursing students regarding radiation was examined using the supplementary texts issued by the Japanese government in 2013, with the aim of exploring the training necessary to provide nurses with correct knowledge regarding radiation, and to consider the introduction of radiation education to nursing basic education. Moreover, the study also sought to clarify risk perception regarding radiation, and to obtain basic information on radiation education.

2. Methods

A cross-sectional study using a questionnaire survey was conducted on nursing students of all grades at the Japanese T National University in 2016. The participants consisted of 74 first-year students, 79 second-year students, 65 third-year students and 69 fourth-year students. The response rate was 84.3% (242/287).

2.1. Understanding of phrases related to radiation

A total of 50 phrases were selected, 25 each from two supplementary texts about radiation for elementary school students and middle and high school students (MECSST, 2014) (Tables 1, 2). For each phrase, nursing students were asked to rate their level of understanding using a four-point scale (thorough understanding = 3, a little knowledge = 2, have heard of it = 1, no knowledge = 0). The average understanding scores of the phrases was compared across grades. The levels of understanding of phrases relating to radiation were ranked based on the average of first-year students' scores, in order to evaluate educational effects.

Table 1
Average understanding score of a supplemental text for elementary school students for Japanese nursing students.

Phrase	Grade				
	First	Second	Third	Fourth	Total
	n = 69	n = 53	n = 59	n = 61	n = 242
1. atomic bombing of Hiroshima and Nagasaki	2.26	2.26	2.12	2.39	2.26
2. Fukushima Daiichi Nuclear Power Plant disaster	1.86	1.83	1.73	1.80	1.81
3. radiation	1.84	1.91	1.73	1.90	1.84
4. radioactivity	1.77	1.64	1.44**	1.74	1.65
5. radioactive material	1.72	1.72	1.61	1.80	1.72
6. X-ray	1.71	1.58	1.36*	1.72	1.60
7. renewable energy	1.68	1.38	1.12**	1.41	1.41
8. harmful rumor	1.64	1.66	1.49	1.89	1.53
9. areas to which evacuation orders	1.58	1.64	1.39	1.80	1.60
10. decontamination	1.52	1.40	1.31	1.64	1.47
11. Chernobyl Nuclear Power Plant disaster	1.45	1.57	1.51	1.59	1.52
12. half-life	1.33	1.47	0.88*	1.38	1.26
13. sievert	1.33	1.47	1.31	1.39	1.37
14. environmental radiation	1.26	1.17	1.10	1.33	1.22
15. cesium	1.25	1.15	1.05	1.16	1.16
16. standard for radioactive material in food	1.20	1.09	1.07	1.26	1.16
17. 100 millisieverts	1.14	1.25	1.20	1.16	1.19
18. plutonium	0.94	0.77	0.73	0.88	0.84
19. radioactive strontium	0.71	0.55	0.41	0.46	0.54
20. Three Mile Island Nuclear Power Plant accident	0.65	0.68	0.68	0.70	0.68
21. iodine 131	0.64	0.55	0.66	0.66	0.63
22. cesium 137	0.54	0.51	0.49	0.54	0.52
23. cesium 134	0.49	0.47	0.49	0.54	0.50
24. aircraft monitoring	0.46	0.32	0.36	0.46	0.40
25. Tokai-mura nuclear accident	0.42	0.32	0.39	0.43	0.39
Average score	1.26	1.21	1.10	1.28	1.22

* $p < 0.05$.
** $p < 0.01$.

2.2. Risk perception of radiation and medical care

Risk perception was measured using 30 items used in several previous studies, and based on a questionnaire originally developed by Slovic et al. (1979) in the USA. Nursing students were asked to rate their risk perceptions using a seven-point scale (the maximum being 7 and the minimum being 1) (Table 3). Thirty events were ranked based on average risk value. The average risk value of five events related to radiation or medical care, "nuclear power," "X-ray," "vaccinations," "surgery," and "prescription antibiotics," was compared across the grades. Moreover, the risk rankings were compared with those of three groups of American populations (college students, the League of Woman Voters, and experts).

As respondents who did not correctly answer the questionnaire were excluded from the analysis, the effective response rates of first-year, second-year, third-year, and fourth-year students were 36% (25/69), 87% (46/53), 66% (39/59) and 85% (52/61).

Table 2
Average understanding score of a supplemental text for middle school and high school students for Japanese nursing students.

Phrase	Grade				
	First	Second	Third	Fourth	Total
	n = 69	n = 53	n = 59	n = 61	n = 242
1. isotope	1.91	1.83	1.63*	1.61*	1.75
2. atomic nucleus	1.80	1.70	1.56	1.57	1.66
3. radiation exposure	1.72	1.77	1.46*	1.82	1.69
4. difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order	1.61	1.74	1.54	1.72	1.65
5. alpha ray	1.45	1.30	0.97**	0.97**	1.18
6. beta ray	1.45	1.32	0.98**	0.95**	1.18
7. electromagnetic ray	1.32	1.51	1.03*	1.21	1.26
8. neutron ray	1.28	1.21	1.02	0.90*	1.10
9. gamma ray	1.26	1.38	0.93*	0.97*	1.13
10. becquerel	0.86	1.26**	0.93	1.10*	1.02
11. external exposure	0.86	1.55**	0.76	1.02	1.02
12. internal exposure	0.86	1.53**	0.81	1.07	1.05
13. inspection of all rice bags	0.80	0.53	0.56	0.66	0.60
14. carbon 14	0.77	0.58	0.64	0.51	0.63
15. natural radiation	0.71	1.06*	0.76	0.82	0.83
16. man-made radiation	0.59	1.02*	0.73	0.85*	0.79
17. radiation monitoring	0.55	0.51	0.58	0.72	0.59
18. gray	0.49	1.17**	0.83**	1.11**	0.88
19. spatial dose rate	0.43	0.38	0.32	0.39	0.38
20. absorbed dose	0.42	0.72*	0.47	0.54	0.53
21. high dose exposure	0.39	0.72*	0.41	0.55	0.51
22. low dose exposure	0.36	0.72**	0.42	0.56*	0.50
23. three principles of radiation protection against external exposure	0.32	0.40	0.63*	1.03**	0.59
24. physical dose	0.30	0.34	0.34	0.30	0.32
25. International Commission on Radiological Protection (ICRP)	0.28	0.26	0.27	0.32	0.28
Average score	0.91	1.06	0.82	0.93	0.93

* $p < 0.05$.
** $p < 0.01$.

2.3. Understanding of basic radiation

Six questions were asked about basic knowledge about radiation needed in the nursing field, with each answered using the four-point scale described earlier (Table 4). Further, the relationship between understanding and risk perception of radiation was examined using a regression line analysis of the scores of the two variables.

2.4. Statistical methods

Kruskal-Wallis test and a Steel's multiple comparisons test were used to evaluate differences in understanding of phrases related to radiation among the different grades (Tables 1–4). A chi-squared test was used to evaluate differences in understanding of basic knowledge about radiation among the different grades (Table 5). The scores of first-year students formed the standard for Steel's multiple comparisons test. The regression line obtained from understanding and risk value of radiation was evaluated using the correlation coefficient (Fig. 1). The statistical software tool Excel Statistics (ver.12, BellCurve, Tokyo, Japan) was utilized for the analysis. The significance level was set to 0.05.

2.5. Ethics statement

All procedures in this study were approved by the Ethical Committee of Tokushima University hospital No. 2580.

3. Results

3.1. Phrases from the elementary school text

Overall, there were no clear differences in the average scores of each grade. In terms of individual phrases, the understanding score for “atomic bombing of Hiroshima and Nagasaki” was the highest in all grades, and this was the only the phrase that exceeded two points. In the case of the phrases, “radio activity,” “X-ray,” “renewable energy,” and “half-life,” the average scores of third-year students were significantly lower than those of first-year students ($p < 0.05$). Phrases scoring less than 1 point, which indicated that students had never heard of them, comprised one third of the total, and were related to nuclear power. The result was the same for each grade.

3.2. Phrases from the middle and high school text

As with the phrases from the elementary school text, there was no clear difference among the average scores of each grade with the phrases from the middle and high school text. Among the phrases that exceeded 1 point, the average scores for “becquerel” and “gray” for second- and fourth-year students, “external exposure,” “natural radiation,” and “internal exposure” for second-year students, and “three principles of radiation protection against external exposure” for fourth-year students were significantly higher than those of first-year students ($p < 0.05$). Further, the overall average score for fourth-year students was low, averaging at almost 1 point.

Conversely, with the phrases where the average score for first-year students exceeded 1 point, the average scores of “isotope,” “alpha ray,” “beta ray,” and “gamma ray” for third- and fourth-year students, “radiation exposure” and “electromagnetic ray” for third-year students, and “neutron ray” for fourth-year students were significantly lower than those of the first-year students ($p < 0.05$). The average scores of four phrases, “alpha ray,” “beta ray,” “gamma ray,” and “neutron ray,” for fourth-year students fell below 1 point. Moreover, the average scores for “alpha ray,” “beta ray,” and “gamma ray” were less than 1 point even for third-year students ($p < 0.05$). The percentage of phrases scoring less than 1 point for fourth-year students was high, standing at 60% (15/25).

3.3. Risk ranking of 30 events

In the case of risk perception, the order of risk ranking was “nuclear power,” “handguns,” and “smoking” for Japanese nursing students, with the order remaining the same for all grades. The same tendency also applied to American college students. For the League of Women Voters (LOWV) in America, one difference that emerged was the high ranking observed for “motor vehicles.” Further, while the ranking of “motor vehicles” was not so high for Japanese nursing students, ranging between 8th and 15th, it was ranked 1st for American experts. Similarly, the ranking of “nuclear power” by the experts was low, standing at 20th.

Concerning the ranking of risk perception of “X-rays,” it ranged from fourth to ninth for Japanese nursing students. However, this element received a moderate to low ranking from American students (17th) and the LOWV (22nd). Conversely, the ranking for the experts was high (7th) and comparable to Japanese nursing students (Table 3).

3.4. Risk values related to medical care

With regard to events related to medical care, “surgery,” “X-rays,”

Table 3
Comparison of risk ranking.

Event	Japanese nursing students				American		
	First	Second	Third	Fourth	College students	LOWV	Experts
	n = 25	n = 46	n = 39	n = 52	n = 30	n = 40	n = 15
nuclear power	1	1	1	1	1	1	20
handguns	2	2	2	2	2	3	4
smoking	3	3	3	3	3	4	2
motorcycles	4	9	4	4	6	5	6
X-rays	5	4	8	9	17	22	7
fire fighting	6	5	5	5	10	11	18
large construction	7	6	6	6	14	12	13
prescription antibiotics	8	13	21	23	21	28	24
alcoholic beverage	9	14	13	12	7	6	3
surgery	10	7	7	7	11	10	5
pesticides	11	8	10	10	4	9	8
high school & college football	12	22	15	15	26	23	27
food coloring	13	24	27	18	20	26	21
hunting	14	11	14	13	18	13	23
motor vehicles	15	12	9	8	5	2	1
food preservatives	16	20	26	21	12	25	14
police work	17	10	12	11	8	8	17
mountain climbing	18	15	16	14	22	15	29
contraceptives	19	19	25	28	9	20	11
power mowers	20	16	18	19	28	27	28
spray cans	21	21	22	27	13	14	26
commercial aviation	22	17	17	16	16	17	16
general (private) aviation	23	18	11	17	15	7	12
vaccinations	24	25	26	25	29	30	25
electric power	25	23	20	24	19	18	9
bicycles	26	28	28	26	24	16	15
railroads	27	27	19	20	23	24	19
skiing	28	26	23	22	25	21	30
home appliances	29	30	30	29	27	29	22
swimming	30	29	29	30	30	19	10

LOWV: the League of Women Voters.

Table 4
Average risk value of Japanese nursing students.

Event	Grade				
	First	Second	Third	Fourth	Total
	n = 25	n = 46	n = 39	n = 52	n = 162
surgery	3.40	4.00	4.23*	4.25**	4.04
X-rays	4.04	4.63	4.18	3.79	4.16
prescription antibiotics	3.68	3.41	3.00	2.85*	3.17
vaccinations	2.56	2.93	2.87	2.73	2.80
nuclear power (the highest value)	6.16	6.07	6.15	6.06	6.10
swimming (the lowest value)	1.58	2.35**	2.05	1.71	1.96

* $p < 0.05$.
** $p < 0.01$.

"prescription antibiotics," and "vaccinations" received average risk values ranging from 3 to 4. These average values were lower than the median between the maximum (average of 6.1) of "nuclear power" and the minimum (average of 2.0) of "swimming." The average value of "prescription antibiotics" decreased with each grade, with the average value for fourth-year students standing significantly lower than that for first-year students ($p < 0.05$). However, the average value for "surgery" increased with each grade, and those for the third- and fourth-year students were significantly higher than that for the first-year students ($p < 0.05$). The average values of "X-rays" and "vaccination" did not show as much change with each grade (Table 4).

Table 5
Understanding of basic knowledge about radiation.

	Grade			
	First	Second	Third	Fourth
	n = 69	n = 53	n = 59	n = 61
1. Dosage methods for iodine agents after nuclear power plant accident	0.36 (8.7)	0.62 (20.8)	0.49 (15.3)	0.48 (8.2)
2. Exposure doses affecting human health	1.09 (27.5)	1.21 (30.2)	0.93 (20.3)	0.98 (19.7)
3. Differences in radiation sensitivity among organs	0.54 (8.7)	0.60 (13.2)	0.81 (22.0)	0.85* (21.3)
4. Differences in radiation sensitivity by age	0.64 (13.0)	0.89 (26.4)	0.81 (15.3)	0.97** (21.3)
5. Differences in penetration by radiation	0.77 (17.4)	0.89 (20.8)	0.81 (16.9)	0.67 (11.5)
6. Protective measures to minimize radiation exposure	0.70 (14.5)	0.92 (20.8)	0.98 (23.7)	1.54** (55.7)**

Each number (%) shows the ratio of scores of 2 and 3 on a 4-point scale.
* $p < 0.05$.
** $p < 0.01$.

3.5. Basic knowledge about radiation

The items that showed an increase understanding score with the grade related to radiation protection and radiation sensitivity (questions 3, 4, and 6), with the levels for fourth-year students standing higher than those for the first-year students ($p < 0.05$). However, only the score for question 6 exceeded 1 in the 4-point scale. Moreover, when the ratio of scores of 2 or 3 points was evaluated, a significant difference was seen in question 6 ($p < 0.01$) (Table 5).

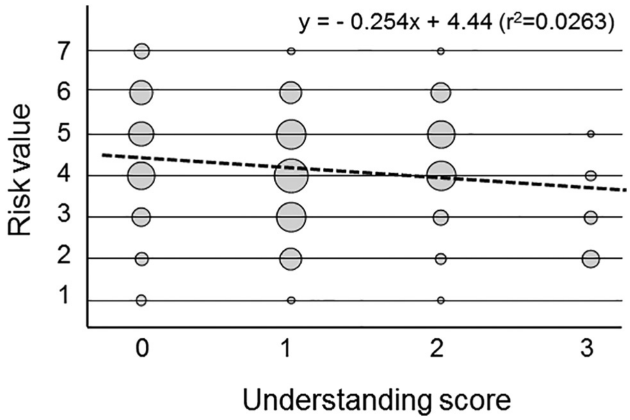

Fig. 1. Relationship between understanding score and risk value for X-ray. The size of each bubble on the graph indicates the number of respondents. The minimum is 1 and the maximum is 18. The total number of respondents was 161. The formula shows a regression line (dotted line).

Further, a significant relationship between the understanding score for question 6 and risk value for "X-rays" was observed by regression analysis ($p < 0.05$) (Fig. 1). The correlation coefficient and regression coefficient were 0.162 and −0.25 respectively.

4. Discussion

4.1. Participants

There are 218 universities with nursing departments (42 national universities, 48 public universities and 128 private universities) and 825 nurse training institutions in Japan (as of 2017). The admission capacities of the former and the latter are 17,878 and 43,751 students, respectively. The T University, where the survey was conducted, is ranked academically as average among the national universities and within the top 10% of all universities and institutions. While the contents of nursing courses are basically the same, radiology is not offered as a compulsory program. As a radiation technology department has been established at the T University, a two-hour radiology course (1 h each in the first and fourth grades) is compulsorily as a part of the nursing program. Moreover, a credit course (15 h) is also available optionally, but is rarely selected by students. This system is uncommon among the various other Japanese universities, and from the view of radiology education. According to a recent survey by the radiology department congress of 42 national universities, a program of radiation education for nursing students by radiologists was conducted in 12 universities, with the course consisting of 1 to 8 h of class (2 h on average). Thus, the results are considered to be obtained from a group with higher knowledge regarding radiation than general nursing students.

The two supplementary textbooks were created in the year when the respondents were middle or high school students, but were not approved as a required textbook. And the number of teachers who could provide radiation education was very small because radiation education was not conducted in Japanese elementary, middle and high schools for 30 years as previously mentioned (Yoshida and Honda, 2018). As a result, most Japanese middle and high school students did not read the two supplementary textbooks. Therefore, most respondents had never read them in middle or high schools and were not even given before the questionnaire.

4.2. Differences in understanding of phrases

The fact that there was no difference in the average scores of phrases from both the elementary school text and the middle and high school text among all grades reflected the fact that radiation education had not been conducted.

With regard to individual phrases from the elementary school text, the score for "atomic bombing of Hiroshima and Nagasaki" was the highest and exceeded 2 points. As the historical facts of the atomic bombing have always been taught, right from the elementary school level in Japan, all Japanese know it well. The phrase is also well known in other countries. It has been reported that this phrase was the best-known in a similar questionnaire survey administered to Indonesian dental students (Yoshida et al., 2019). Japan is the only country to have suffered the effects of an atomic bomb, and people around the world may be looking at the facts. This time, the score for "Fukushima Daiichi Nuclear Power Plant disaster" was also very high. As the disaster has recently come to be taught to elementary school students using a supplementary text about radiation, it is expected that everyone will become as familiar with it as with the facts of Hiroshima and Nagasaki in the future.

With regard to individual phrases from the middle- and high school text, the understanding scores for "isotope," "alpha ray," "beta ray," and "gamma ray" for first-year students were higher than those of the third- and fourth-year students. Further, the score for "neutron ray" for first-year students was higher than that of fourth-year students. All those scores exceeded 1 point. This indicates that the questionnaire had been answered using knowledge gained during the high school years for first-year students. Moreover, the phrases had been forgotten because they had not been used in the university for several years. Conversely, "becquerel" and "gray" were taught as part of university lectures. Hence, the scores for second- and fourth-year students were higher than those for first-year students. The scores for "three principles of radiation protection against external exposure" were higher for third- and fourth-year students as compared to those for first-year students. It was found that knowledge about radiation protection increased along with nursing practice for radiotherapy patients as well as lectures. The university lecture was considered to be effective because of the fact that all those scores exceeded 1.

With regard to some phrases from the middle and high school text, the scores for only second-year students were significantly higher than those for first-year students. This was thought to be because first-year students were taught about medical radiation and environmental radiation as part of the introduction to the health science class after the questionnaire survey, and the phrases did not appear in the subsequent classes. The time allotted for the lecture was only 1 h, but the significant improvement in knowledge indicated that increasing time and teaching more specialized knowledge would help increase radiation knowledge.

4.3. Difference in risk perception

It is known that differences in risk perception between laypeople and experts emerge owing to differences in risk evaluation methods. Laypeople evaluate risk based on the two factors of the unknown and dread, and the risk value rises if either becomes larger. The unknown and dread risks imply that they are not observable and controllable. Slovic (1987) represented these two factors along two-dimensional coordinates, and plotted 81 general hazards on it.

The questionnaire showed that risk perceptions regarding "nuclear power" were different for Japanese nursing students as compared to those for the American experts. This tendency was the same for American college students and the League of Women Voters (LOWV). The experts regard risk in terms of mortality rate (Slovic et al., 1979). The mortality rate due to nuclear power is considered to be very low, and hence the risk perception of experts is not high. However, members of the general public are extremely afraid of nuclear power. In particular, the Japanese people are very sensitive to radiological effects owing to the atomic bombing. Moreover, the FNPP disaster in 2011 has raised doubts regarding the safety of nuclear power, and instilled a great deal of fear in people. Many researches in Japan clearly support it. It is also natural that risk perception of nuclear power was the highest for all grades in this questionnaire.

This questionnaire includes four medicine-related events. “Vaccination” is located within the average for unknown risk and low dread risk regarding the Slovic's hazard map. When enrolling in a nursing college, nursing students are required to confirm that they have acquired necessary antibodies through vaccination in childhood and that further vaccination had been conducted, if found necessary. Such an educational background may lower the risk perception of “vaccination.” “Prescription antibiotics” is located within the average for dread risk, but its unknown risk stands high. The risk ranking for Japanese first-year nursing students was high (8th), but the ranking dropped sharply to 23rd for fourth-year students. The reason for this could be that they learn about the necessity and usefulness of antibiotics through practice and lectures. As a result, the risk value might have decreased significantly for fourth-year students.

Risk perception of “X-rays” was high. X-rays are located at the low end for dread risk, but show a high unknown risk. Hence, the ranking was high because “X-rays” were feared. However, the ranking was reversed with that of surgery in the upper grades. The risk ranking is based on the average risk value. The risk value of “X-rays” for each grade was not very different because there are few lectures related to X-rays. On the other hand, that of “surgery” significantly increased for third- and fourth-year students. Nursing students perceived more dangers through their lectures and practice than that they had expected, because of which the value might increase with each grade. This caused an inverse phenomenon.

The risk ranking of major healthcare-related events for Japanese nursing students and nurses was reported (Kanda et al., 2008). For all grades of nursing students, the events used in this study were ranked in the order of “surgery,” “X-rays,” and “antibiotics.” This was consistent with the results of this study for third- and fourth-year students. However, the differences in the ranking of “surgery” for first- and second-year students indicated that it was necessary to evaluate the educational effects in each grade. Among nurses, the risks were ranked in the order of “surgery,” “antibiotics,” and “X-rays.” This showed that the risk perception of “X-rays” decreased. Because the targeted nurses belonged to the radiation department and had received radiation safety education, it was considered that their risk perception was lowered owing to an increase in knowledge.

4.4. Differences in basic knowledge about radiation

Six questions used in the study are routinely used to assess the effects of radiation education. Most students did not know how to administer iodine. Knowing how to administer iodine was not necessary before the FNPP disaster occurred. However, it became a problem that iodine was not administered at the time of the disaster. When medical professionals were informed on how to do it, they came to know that exposure doses could be reduced. Most nursing students were not interested in radiation exposure because the location of the university where the survey was conducted was not affected by radioactivity. This might be reflected in the result. The understanding score for the effects of radiation on the human body and the penetration of radiation was almost less than 1, regardless of grade. Knowledge about radiation did not increase because radiation education was insufficient. The understanding score for “Protective measures to minimize radiation exposure” was significantly improved for fourth-year students. However, this has been found to be due to the effects of training, rather than radiation education.

It was found that Japanese nursing students with more knowledge of protection measures tended to be less anxious. This indicates that radiation safety education is significant for decreasing risk perceptions regarding X-rays. It has also been reported that, even after lectures, Japanese nursing students with high anxiety were likely to obtain less knowledge (Kunugita, 2008). This indicates that it is necessary for nurses to obtain sufficient knowledge regarding radiation because nurses in direct contact with patients might increase the patient's anxiety by having excessive anxiety themselves.

In addition, when the relationship between the knowledge of the influence of radiation on human body and the fear of radiation for Japanese first- to fourth-year nursing students was examined, it was found that knowledge increased with the grade, while fear decreased (Tomisawa et al., 2012). This indicates that an increase in knowledge lowers risk perception. Radiation safety education is important to eliminate fears of excessive radiation. It has also been reported that Japanese nurses demonstrate significantly more fear regarding radiation than physicians (Miura et al., 2008). It may be because women may be more afraid of radiation than men.

On the contrary, one survey at a large Australian hospital with more than 1000 nurses working and receiving radiation safety practice, stated that radiation education did not necessarily lead to improvement in knowledge (Badawy et al., 2016). This indicates that radiation safety education knowledge related to one's work has been improved, but that necessary knowledge has been lacking. Therefore, it is emphasized that radiation safety education along the site is effective.

4.5. Limitations

As the results of this study are based on a self-reported questionnaire survey, it is unclear whether the scores reflect participants' understanding levels correctly. To assess the accurate understanding levels of students, it will be necessary to impose an objective examination. However, it is very difficult to conduct an examination as part of a survey. Hence, this question may remain an issue for the future.

The results may also be lacking in universality because nursing students at only one university in Japan were targeted.

5. Conclusions

Japanese people are hypersensitive toward radiation because of the atomic bombing of Hiroshima and Nagasaki, and the Fukushima Nuclear Power Plant disaster. Radiation has come to be felt as a persistent threat across several generations. Under such circumstances, the authors conducted a questionnaire survey to examine the understanding and risk perception of radiation for nursing students, who will become familiar with medical radiation in the future. The results showed that the manner in which radiation education is conducted in nursing departments should be reconsidered because nursing students' understanding level of the supplementary texts on radiation for elementary and middle and high school students was not sufficient. Moreover, it was found that the risk perception of X-rays for Japanese nursing students was higher as compared to American students and the League of Woman Voters. It was concluded that nursing students need to be adequately educated about radiation because there is the possibility of having disproportionate fears of X-rays, and that an increase in understanding will decrease risk perception.

CRediT author statement

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References

Badawy, M.K., Mong, K.S., Lykhun, U.P., Deb, P., 2016. An assessment of nursing staffs' knowledge of radiation protection and practice. J. Radiol. Prot. 36, 178–183.

Kako, M., Ranse, J., Yamamoto, A., Arbon, P., 2014. What was the role of nurses during the 2011 great east earthquake of Japan? An integrative review of the Japanese literature. Prehosp. Disaster Med. 29, 275–279.

Kanda, R., Tsuji, S., Shirakawa, Y., Yonehara, H., 2008. Preliminary survey for communicating risk in medical exposure -perception of risk among nurses working in radiology. Jpn. J. Radiol. Technol. 64, 937–947 (in Japanese).

Kawasaki, C., Omori, J., Ono, W., Konishi, E., Asahara, K., 2016. Public health nurses' experiences in caring for the Fukushima community in the wake of the 2011 Fukushima nuclear accident. Public Health Nurs. 33 (4), 335–342.

Kunugita, N., 2008. Investigation of the relationship between knowledge concerning radiation and the level of anxiety toward radiation in student nurses. The UOEH Association of Health Sciences 30, 421–429 (in Japanese).

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011. Japan. in Japanese. http://www.mext.go.jp/b_menu/shuppan/sonota/attach/1313004.htm, Accessed date: 2 July 2019.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2013. Japan. in Japanese. http://www.mext.go.jp/b_menu/shuppan/sonota/detail/1344732.htm, Accessed date: 2 July 2019.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2014. Japan. in Japanese. http://www.mext.go.jp/b_menu/shuppan/sonota/attach/1344729.htm, Accessed date: 2 July 2019.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2017. Model core curriculum in nursing education. in Japanese. http://www.mext.go.jp/b_menu/shingi/chousa/koutou/078/gaiyou/__icsFiles/afieldfile/2017/10/31/1397885_1.pdf, Accessed date: 2 July 2019.

Miura, M., Yoshida, M., Takao, H., Matsuda, N., 2008. Perception of risks from radiation by faculty and students of Nagasaki University. Radiat. Saf. Manag. 7 (1), 1–5.

Morishima, Y., Chida, K., Shigeizumi, K., Katahira, Y., Seto, H., Chiba, H., 2012. Importance of radiation education for nurses. Nihon Hoshasen Gijutsu Gakkai Zasshi 68 (10), 1373–1378 (in Japanese).

Nagai, T., Konishi, E., Kobayashi, M., Umeda, M., Ono, W., Mitumori, Y., Asahara, K., 2017. Importance and effectiveness of radiation education for public health nursing students. J. Radiol. Nurs. Soc. Jpn. 5, 39–46 (in Japanese).

Sasatake, H., Kitajima, M., Urushizaka, M., Noto, Y., 2017. Current status and issues of radiological nursing education of nursing faculty involved in basic nursing education. J. Radiol. Nurs. Soc. Jpn. 5, 23–30 (in Japanese).

Science Council of Japan, 2014. Enhancement of health risk science education of radiation including compulsory in medical education. in Japanese. http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-22-t197-3.pdf, Accessed date: 2 July 2019.

Slovic, P., 1987. Perception of risk. Science 236, 280–285.

Slovic, P., Fischhoff, B., Lichtenstein, S., 1979. Rating the risks. Environment 24, 14–20.

Tomisawa, T., Aizu, K., Ohgino, A., Itaki, C., Noto, Y., 2012. Relationship between risk perceptions of radiation and grade level in nursing school students. Radiat. Emerg. Med. 1 (1–2), 99–107.

Yoshida, M., Honda, H., 2018. Current status and history of radiation education: considering the Fukushima Dai-ichi nuclear disaster. Ochanomizu igaku zasshi 66 (2), 1–19 (in Japanese).

Yoshida, M., Yanuaryska, R.D., Shantiningsih, R.R., Mudjosemedi, M., Honda, E., 2019. Comparison of radiation risk perception and knowledge of radiation between Indonesian and Japanese dental students. J. Environ. Radioact. 204, 104–110.