Journal of Environmental Radioactivity 155-156 (2016) 7–14

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

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

Availability of Japanese Government's supplemental texts on radiation reflecting the Fukushima Daiichi Nuclear Power Plant accident for elementary and secondary education from dental students' understanding

Midori Yoshida [a, *], Eiichi Honda [a], Oyunbat Dashpuntsag [a], Naoki Maeda [a], Hidehiko Hosoki [a], Minoru Sakama [b], Toshiko Tada [c]

[a] Department of Oral and Maxillofacial Radiology, Tokushima University, Tokushima, Japan
[b] Department of Radiological Science, Tokushima University, Tokushima, Japan
[c] Tokushima University, Tokushima, Japan

ARTICLE INFO

Article history:
Received 15 September 2015
Received in revised form
26 January 2016
Accepted 26 January 2016
Available online 11 February 2016

Keywords:
Radiation education
Dental students
Questionnaire
Fukushima Daiichi nuclear power plant accident
Japanese Government's supplement

ABSTRACT

Following the Fukushima Nuclear Power Plant accident, the Japanese government created two supplemental texts about radiation reflecting the accident for elementary, middle school, and high school students. These texts were made to explain radiation and consequently to obtain public consent for the continuation of the nuclear program. The present study aimed to evaluate the appropriateness of the content of the texts and to collect the basic data on the level of understanding necessary to improve radiation education. Lectures on radiology including nuclear energy and the Fukushima accident were given to 44 fourth-year dental students in 2013. The questionnaire was administered in 2014 when these students were in their sixth-year. The survey was also administered to 40 first-year students and 41 fourth-year students who hadn't any radiology lectures. Students rated their level of understanding of 50 phrases used in the texts on a four-point scale (understanding = 3, a little knowledge = 2, having heard = 1, no knowledge = 0). Questions on taking an advanced physics course in high school and means of learning about radiation in daily life were also asked. The level of understanding of phrases in the supplemental text for middle and high school students was significantly higher among sixth-year students (mean = 1.43) than among first-year (mean = 1.12) or fourth-year (mean = 0.93) students ($p < 0.05$). Overall, the level of understanding was low, with scores indicating that most students knew only a little. First-year students learning about radiation from television but four-year and six-year students learning about radiation from newspaper scored significantly higher ($p < 0.05$). It was concluded that radiation education should be improved by using visual material and preparing educators to teach the material for improving the public's understanding of radiation use—especially nuclear power generation because the phrases used in the supplementary texts are very difficult for students to understand.

1. Introduction

In East Japan, a large-scale earthquake with a magnitude of 9.0 occurred on March 11, 2011. This earthquake caused a great tsunami. The tsunami hit Fukushima Daiichi Nuclear Power Plant in Fukushima Prefecture, stopping all power supplies to the plant. As a result, there were explosions in the nuclear buildings and, within several days, there was a meltdown of the nuclear reactors. Large amounts of radioactive materials were released from the plant into the environment (affecting the air, water, and soil) (Tominaga et al., 2014; UNSCEAR, 2013). Subsequently, many people were obliged to evacuate to prevent radiation exposure. These people have been forced to live as refuges, even to this point, and they continue to have anxieties about their future lives and health (Matsuda et al., 2014).

* Corresponding author. 3-18-15, Kuramoto, Tokushima, Tokushima 770-8504, Japan.
E-mail address: midori2@tokushima-u.ac.jp (M. Yoshida).

http://dx.doi.org/10.1016/j.jenvrad.2016.01.015

In 2008, information about radiation was added to the curriculum guideline of the Ministry of Education, Culture, Sports, Science and Technology, as part of the Japanese Government. Prior to this, education on radiation had not been part of the curriculum for 30 years. The Ministry began to draft a text for radiation education based on the curriculum guideline (Murai, 2013). Three kinds of texts were completed in October 2011. These texts were available for use in the educational process for elementary school students (MECSST, 2011a), middle school students (MECSST, 2011b, 2011c), and high school students (MECSST, 2011d, 2011e). Unfortunately, however, the Fukushima Daiichi Nuclear Power Plant accident occurred after the texts had been completed, and the texts were not able to include any reference to the accident. Following the Fukushima accident, Japanese people, including inhabitants of Fukushima Prefecture, have taken a considerable interest in radiation because of the possibility of associated health impairments (Akiba, 2012). Many phrases related to radiation were noticeable in newspapers, television, magazines, and other media. In December 2013, the Ministry created a supplementary text describing the accident and providing a detailed explanation about radiation (MECSST, 2014a, 2014b). Additionally, the Ministry of Health, Labor and Welfare published a leaflet explaining food safety for the public. The leaflet used many technical terms about radiation (MHLW, 2015).

The basis for the utilization of nuclear energy in Japan is found in the Atomic Energy Basic Act, which was enacted in 1955 (e-Gov, 2014). Subsequent to this act, the government promoted the construction of nuclear power plants, and 54 commercial nuclear power plants were erected. Following the Fukushima accident, six nuclear power plants were decommissioned, leaving a total of 48 plants in operation. However, none of these 48 nuclear power plants has resumed operations following the accident. The government is attempting to explain radiation in detail and to gain the understanding of residents for resuming the operations of the plants. The preparation of the supplementary text and leaflet described above was intended to contribute considerably to Japanese nuclear policy. However, these documents include many difficult words, addressing the topics from the viewpoint of a radiation expert, as well as many specialized technical terms seen for the first time. Thus, it was very difficult to teach the content to elementary or middle school students, who have struggled significantly to understand it. It might be the case that only a few teachers would be capable of teaching this material.

In this situation, at minimum, health care professionals, such as medical doctors, dental doctors, and nurses, who directly communicate with patients (Goto et al., 2014), should be able to understand the texts. These professionals are responsible for explaining radiation to the public in the future. To some extent, they learn about radiology in college or at university. In the Japanese dentistry curriculum, in particular, radiology is mandatory, and the number of the credits required is very high because radiation questions are always part of the national dentist examination. In dental school, radiology lectures are typically given in the fourth year, and practical training occurs in the fifth and sixth years. Together, the lectures and practical experience total 150 h on radiology before graduation. Thus, dental students should easily understand the texts on radiation published for use in the elementary, middle school, and high school curricula. Further, it is likely that, if they cannot understand these texts sufficiently, medical doctors and nurses also may not understand the texts.

We investigated dental students' understanding of the texts before and after exposure to radiation education. If their level of understanding is low, it is logical that it will be more difficult for the public, and even for university students, to understand the texts—not to mention elementary, middle school, and high school students. This means that further intervention will be necessary for the realization of Japan's nuclear policy. In that case, it may be required to improve the method of radiation education and to prepare people to teach about radiation. The aim of this study was to obtain basic data for finding an adequate method for radiation education using these supplementary texts for elementary, middle school, and high school students.

2. Materials and methods

2.1. Subjects and period

The subjects in this research were students in a national university school of dentistry in Japan. Beginning in the year following the Fukushima Daiichi Power Plant accident in March 2011, radiology lectures including all phrases used in the supplementary texts were given to fourth-year dentistry students. When these students progressed to the sixth year, a questionnaire survey about knowledge of radiation was conducted. The questionnaire was administered to first-, fourth-, and sixth-year students at approximately the same time in 2014. The first-year students had not received any lectures relating to radiation, the fourth-year students had not received a main lecture focusing on radiology in 2014, and the sixth-year students had finished the required course of lectures and practice on radiology. The subjects included 40 first-year students (26 men, 14 women), 44 fourth-year students (27 men, 17 women), and 41 sixth-year students (25 men, 17 women).

The radiology program consists of mandatory lectures and training. First-year students receive 1.5 introductory radiology lectures. A 40-h series of lectures focusing on radiology and 32 h of radiology training are given to fourth-year students. Clinical training begins in the fifth year, with 28 h allotted for fifth-year students and 56 h for sixth year students.

2.2. Questionnaire survey

Two supplementary texts about radiation created by the Japanese Ministry of Education, Culture, Sports and Technology in December 2013 were used in the present study (MECSST, 2014a, 2014b). One of the texts was intended for elementary school students, and the other was for middle and high school students. From each text, 25 phrases considered to be essential knowledge were extracted. For each phrase, the dental students were asked to rate their level of knowledge using a four-point scale (understanding = 3, a little knowledge = 2, having heard = 1, no knowledge = 0). Each respondent also replied to six questions on their background and demographic characteristics: 1) sex, 2) taking a physical subject in high school, 3) selection of a physical subject in the second examination of the university entrance exam, 4) reading a local news page in a newspaper, 5) getting news from the Internet, and 6) watching news on television (Table 1).

2.3. Statistical method

The above-mentioned four levels of understanding (understanding = 3, a little knowledge = 2, having heard = 1, no knowledge = 0) were employed in the statistical analysis without change. Differences of means between levels of understanding for phrases in supplementary texts for elementary school students and in those for middle and high school students were analyzed using the Mann–Whitney *U* test. The difference among the total scores for all phrases in each year group was analyzed using the Kruskal–Wallis test. When a significant difference was detected using the Kruskal–Wallis test, Steel's multiple comparison test was applied based on sixth-year students' scores, and the relationship

between the mean scores and attributes was evaluated using Hayashi's quantification method 1. Statistical add-in software for Microsoft Excel, Version 1.13 (Social Survey Research Information Co. Ltd., Tokyo, Japan) was used for all statistical analyses.

2.4. Ethics statement

A questionnaire was performed as a part of lectures to improve the future lecture and to evaluate the understanding of the lecture. After the explanation to the students, to be given consent was judged by reply of the questionnaire.

3. Results

3.1. Understanding of phrases

3.1.1. Supplementary text for elementary school students

The best understood phrase was "atomic bombing of Hiroshima and Nagasaki," with a total score of 270 (mean = 2.16). Comparing these results with those for all other phrases, there is a great difference between scores. The phrases "harmful rumor" (total score = 247, mean = 1.98) and "half-life" (total score = 243, mean = 1.94) were ranked second and third, respectively (Table 2). The least known phrases, in contrast, were "aircraft monitoring," "radioactive strontium," and "Tokai-mura nuclear accident." The total scores for these phrases were 86 (mean = 0.67), 86 (mean = 0.67), and 94 (mean = 0.75), respectively. Among all year groups, the phrase known the least was "aircraft monitoring" (Table 2).

3.1.2. Supplemental text for middle and high school students

The best understood phrases from the supplemental text for middle and high school students were "isotope" (total score = 253, mean = 2.02), "atomic nucleus" (total score = 234, mean = 1.87), and "radiation exposure" (total score = 222, mean = 1.78). The order in which these phrases were ranked was the same for all year groups. The least known phrases were "spatial dose rate" (total score = 65, mean = 0.52), "physical dose" (total score = 66, mean = 0.53), and "ICRP" (total score = 77, mean of 0.62) (Table 3).

3.2. Comparison of level of understanding between the two supplemental texts

Among first- and fourth-year students, the phrases from the text intended for elementary school students were understood significantly better than were those from texts for middle and high school students ($p < 0.05$) (Tables 1 and 2, Fig. 1). The ratio of mean scores for phrases from texts intended for elementary school students and those from texts intended for middle and high school students was 1.43:1.12 in first-year students and 1.31:0.93 in fourth-year students. There was no difference between these means (1.49:1.34) in sixth-year students.

3.3. Comparison of level of understanding by year group

The overall mean understanding reported for phrases from the text intended for elementary school students was 1.43 in first-year students, 1.31 in fourth-year students, and 1.49 in sixth-year students. There was no significant difference among the three means. However, concerning phrases from the text for middle and high school students, the sixth-year dental students (mean = 1.43) had a significantly higher level of understanding than did first-year (mean = 1.12) or fourth-year students (mean = 0.93) ($p < 0.05$) (Tables 2 and 3, Fig. 2).

3.4. Information source

Concerning information sources used to gain understanding of the relevant phrases, several significant partial correlations were observed. For first-year students, watching television was associated with level of understanding (range = 19.7, partial correlation = 0.427). For both fourth-year students (range = 18.8, partial correlation = 0.501) and sixth-year students (range = 22.5, partial correlation = 0.377), reading the newspaper was associated with level of understanding (Table 4). All of these partial correlations were significant at the 0.05 level. This indicates that first-year students who watched television and fourth- and sixth-year students who read the newspaper understood the relevant phrases significantly better than those who did not engage in these activities.

4. Discussion

4.1. Phrases in the supplemental text for elementary school students

The phrase "atomic bombing of Hiroshima and Nagasaki" is always described in elementary school society textbooks in Japan. A memorial service for those killed by the atomic bomb is held in Hiroshima and Nagasaki each year, and this is telecast across the country. It is therefore not surprising that this was observed to be the best known phrase. The phrase "harmful rumor" was the second most known phrase. This phrase often appeared in the social issues encountered by elementary and middle school students who evacuated from Fukushima to other prefectures after the Fukushima Daiichi Nuclear Power Plant accident. These students encountered accommodation denial and faced bullying. "Half-life" became well known because of the government publication announcing that the health damage caused by iodine-131 could be ignored because its half-life was eight days, but the effect of cesium-137, which has a half-life of 30 years, had continued over several generations (Yamaguchi et al., 2014). Additionally, the storage location of spent nuclear fuel, which has a very long half-life of thousands of years, became a major social issue. Thus, the phrase "half-life" has been taken up in many television news broadcasts and newspapers, and the phrase is very popular among members of the public.

Concerning the phrases ranked lower in terms of understanding, "aircraft monitoring" is a very specific phrase. Since the beginning of the accident, the spatial dose rates of all prefectures in Japan have been measured using "aircraft monitoring," and the resultant data are routinely published on the government homepage (Saito and Onda, 2015; Lyons and Colton, 2012)]. Except for information about Fukushima, the public are not currently interested in the data and measurement method. Radioactive cesium and iodine often appear in the mass media, but "radioactive strontium" does not. The "Tokai-mura nuclear accident" was well covered by television and newspaper media at the time of the accident, but it has been forgotten over time because the effect was limited to the plant area, with the surrounding residents unaffected (Endo et al., 2001; Tsunoda, 2001). The exposure dose of people outside of a 350 m radius was estimated at less than 1 mSv (Endo et al., 2001).

4.2. Phrases in the supplemental text for middle and high school students

"Isotope" and "atomic nucleus" were the first and second most known phrases from the supplemental text for middle and high school students, because these phrases were taught in high school science classes. Television and newspaper media often reported

Table 1
Questionnaire.

What is your gender? 1. Man 2. Woman
Did you take a physical subject in high school? 1. Yes 2. No
Did you select a physical subject in the second examination of the university entrance exam? 1. Yes 2. No
Do you read a local news page in a newspaper? 1. Always 2. Often 3. Sometimes 4. No
Do you get news from the Internet? 1. Always 2. Often 3. Sometimes 4. No
Do you watch news on television? 1. Always 2. Often 3. Sometimes 4. No

	Phrase	Understanding	A little knowledge	Having heard	No knowledge
1	radiation				
2	radioactive material				
3	Fukushima Daiichi Nuclear Power Plant				
4	cesium				
5	Chernobyl Nuclear Power Plant disaster				
6	Three Mile island Nuclear Power Plant				
7	Tokaimura nuclear accident				
8	aircraft monitoring				
9	areas to which evacuation orders				
10	harmful rumor				
11	standard for radioactive material in food				
12	environmental radiation				
13	decontamination				
14	radioactivity				
15	half-life				
16	X-ray				
17	cesium 137				
18	cesium 134				
19	iodine131				
20	atomic bombing of Hiroshima and Nagasaki				
21	sievert				
22	100 millisieverts				
23	renewable energy				
24	radioactive strontium				
25	plutonium				
26	difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order				
27	radiation exposure				
28	inspection of all rice bags				
29	spatial dose rate				
30	radiation monitoring				
31	atomic nucleus				
32	isotope				
33	alpha ray				
34	beta ray				
35	neutron ray				
36	electromagnetic ray				
37	gamma ray				
38	becquerel				
39	grey				
40	absorbed dose				
41	external exposure				
42	internal exposure				
43	three principles of radiation protection against external exposure				
44	low dose exposure				
45	high dose exposure				
46	International Commission on Radiological Protection				
47	natural radiation				
48	man-made radiation				
49	physical dose				
50	carbon 14				

that the people exposed to radioactive iodine and cesium might be faced with elevated risks of thyroid cancer or leukemia in the future. The phrase "radiation exposure" also often appeared in the news.

"Difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order" is an uncommon phrase, but the phrase now also appears in the news, because most of refugees are unable to return to their homes (METI, 2014). The authorities have announced that, as of 2014, more than 100,000 people remain evacuated (ANRE, 2014). Recently, it was reported that the evacuation was associated with the risk of polycythemia and that the health condition of evacuees should be checked periodically (Sakai et al., 2014). The most unknown phrase from the text for middle and high school students was "spatial dose rate." The public are well acquainted with "dose," but not with "spatial dose rate," because the latter phrase is very specialized. People are interested only in the value of spatial dose rate, without understanding the exact meaning. The level of understanding scores for "physical dose" and "ICRP" were lowest among first- and fourth-year students. Sixth-year students had a better understanding of these phrases, because sixth-year students were in the process of studying intensely for the national examination.

4.3. Comparison of understanding level in each year group

The reason that no difference in the level of understanding was observed across the year groups for phrases intended for elementary school students is likely that most of these phrases were fundamental. A supplemental text for middle and high school students included many difficult phrases, and first- and fourth-year students who had not received a lecture on radiation were not able to understand those terms well. However, sixth-year students reported a higher level of understanding and having heard these terms, because they had learned about radiology and were in the process of studying the material again for the national examination.

4.4. Information sources

Currently, Japanese middle and high school students tend not to read newspapers, so, increasingly, university freshmen will get information from television or the Internet. A nationwide survey of people aged 18 and older is conducted by Japan Press Research Institute each year. It reported that, in 2014, the frequency of reading newspapers was lowest among those aged 18–29 years and that, from 2013 to 2014, this frequency decreased from 43% to 40% among those aged 18–19, and from 61% to 53% among those in their 20s (Japan Press Research Institute, 2014). However, university students still increasingly read newspapers to learn about social situations as they progress through the university system. A similar tendency of news illiteracy among the young generation has been observed in United States and the United Kingdom. It has been reported that the ratio of young people reading magazines in the United Kingdom decreased from 77% in 2005–57% in 2011 (Clark, 2012). The results of a 2008 NAA Foundation study of American young people also showed that television and the Internet dominated other media such as radio and newspapers. The percentage using each form of media at least weekly was 93% for television, 90% for the Internet, and 31% for newspapers (NAA foundation, 2013). These results show that, worldwide, young people no longer read as they did in the past.

Questionnaire survey data on radiation in Japan has revealed similar patterns (Hayashi, 2014; Nishitani, 2004; Okazaki et al., 2012). In a report of the "Nuclear Power, Radiation, Energy and Environmental Issues" survey of students aspiring to become teachers, it was shown that information on nuclear power generation was obtained from television (33%), newspapers (21%), and the Internet (16%). However, learning about science, basic physics, and chemistry during high school provided better information about radiation (Hayashi, 2014). Another study demonstrated that university students obtain information about radiation and radioactivity from lessons and from television (Nishitani, 2004). In terms of acceptance of the information provided, another report found that the public trust television coverage and newspapers, assigning the reliability of television, newspapers, and the Internet at the same level as that of doctors, whereas medical students trust the Internet most in Japan (Okazaki et al., 2012).

For radiation education, it is very important to teach basic science during university as well as high school, and it should be compulsory in medical education in particular. Public health nurses and general nurses also are appropriate possibilities to explain a radiation risks to health, because they have many opportunities to communicate with regional inhabitants. Moreover, people with sufficient knowledge about radiation health risks are required in the fields of elementary and secondary education. The Science Council of Japan has proposed compulsory science education on radiation health risks in medical education. They have also proposed that this education be extended to students in science courses in the faculty of education and those related to medicine, such as dentistry, pharmacy, nursing, and health sciences, because it is thought that they should take responsibility for the larger society (SCRPRM, 2014). However, the number of teachers engaging in education and research related to basic radiology and radiobiology is insufficient, and the course time allotted to radiation education has been shortening in Japan. According to the results of a survey of 10 medical schools that had basic radiology departments, the average course time for radiology was 38.8 h (37.3 h for 12 cases, across two institutions). However, there were large differences between the participating medical schools: In 46 schools lacking a full-time radiation-related teacher, the average time spent on radiology courses was found to be 7.4 h (SCRPRM, 2014; Kondo et al., 2009). In the field of nursing education, very few class hours are spent on radiation (15 or 30 h in total) (Ohno and Kaori, 2011).

4.5. Radiation risk and nuclear power plants

Two main types of radiation risk are from medical imaging and from nuclear power generation. Research on risk perception has found that, from 30 activities and technologies associated with risks, including the radiological risks of nuclear power and X-rays, radiological technology experts judged the risk for nuclear power as almost safe (ranking 20th of the 30) and X-rays as fairly dangerous (ranking 7th). In contrast, the general public, such as women voters and college students, judged nuclear power as the most dangerous (ranking first of the 30 possibilities), whereas X-rays were thought to be appreciably safer (ranking 22nd for women and 17th for students). The researchers concluded that the concept of risk meant different things to different people (Slovic, 1987).

Another study on perceived radiation risks among radiation workers, medical doctors, and the general population in Romania found that the level of anxiety toward radiation was significantly lower among radiation workers and that lower levels were found among medical university graduates than among university graduates or non-university graduates. The study concluded that higher educational background and deeper the knowledge of radiation was linked to lower anxiety about radiation (Mihai et al., 2005). A questionnaire administered by Nagasaki University in an area where an atomic bomb was dropped in Japan yielded similar results. This study showed that the risk perception for radiation was high among nurses, staffs, graduated students, and doctors, and it concluded that the level of specialist knowledge was associated

Table 2
Dental students' scores on phrases extracted from a supplemental text for elementary school students.

	Phrase	Scores in each year group			
		First	Fourth	Sixth	Total
		n = 40	n = 44	n = 41	n = 125
1.	atomic bombing of Hiroshima and Nagasaki	97	95	78	270
2.	harmful rumor	83	83	81	247
3.	half-life	74	88	81	243
4.	radiation	74	80	82	238
5.	Fukushima Daiichi Nuclear Power Plant	78	78	78	232
6.	radioactivity	71	78	73	222
7.	radioactive material	71	70	79	220
8.	X-ray	65	74	78	217
9.	Chernobyl Nuclear Power Plant disaster	77	70	68	215
10.	decontamination	69	64	67	200
11.	Areas to which evacuation orders	69	64	64	197
12.	sievert	58	64	69	191
13.	cesium	63	57	64	184
14.	renewable energy	69	65	45	179
15.	environmental radiation	58	58	50	166
16.	100 millisieverts	55	47	60	162
17.	standard for radioactive material in food	56	53	51	160
18.	plutonium	51	49	53	153
19.	Three Mile island Nuclear Power Plant accident	40	38	52	130
20.	iodine 131	33	29	55	117
21.	cesium 137	33	31	48	112
22.	cesium 134	32	31	49	112
23.	Tokai-mura nuclear accident	19	34	41	94
24.	radioactive strontium	23	24	34	86
25.	aircraft monitoring	8	20	23	56
Total score		1431	1442	1528	4401
Average score		1.43	1.31	1.49	1.41

Table 3
Dental students' scores on phrases extracted from a supplementary text for middle and high school students.

	Phrase	Scores in each year group			
		First	Fourth	Sixth	Total
		n = 40	n = 44	n = 41	n = 125
1.	isotope	92	87	74	253
1.	atomic nucleus	85	78	71	234
2.	radiation exposure	75	76	71	222
3.	difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order	73	72	57	202
4.	electromagnetic ray	62	59	67	188
5.	beta ray	54	56	65	175
6.	Alpha ray	54	56	64	174
7.	gamma ray	52	55	64	171
8.	becquerel	47	49	65	161
9.	internal exposure	52	44	65	161
10.	external exposure	48	41	64	153
11.	neutron ray	42	44	64	150
12.	absorbed dose	30	28	67	125
13.	natural radiation	37	33	54	124
14.	man-made radiation	38	32	48	118
15.	gray	30	21	61	112
16.	radiation monitoring	33	34	40	107
17.	carbon14	45	26	33	104
18.	high dose exposure	33	21	46	100
19.	inspection of all rice bags	28	31	37	96
20.	low dose exposure	32	18	45	95
21.	three principles of radiation protection against external exposure	18	15	45	78
22.	International Commission on Radiological Protection (ICRP)	20	16	41	77
23.	physical dose	18	11	37	66
24.	spatial dose rate	19	17	29	65
Total score		1117	1020	1374	3511
Average score		1.12	0.93	1.43	1.12

with risk perception (Miura et al., 2008). In the case of the Fukushima Nuclear Power Plant accident, it has been reported that a radiation seminar was helpful for reducing anxieties (Tsubokura et al., 2013). It has also been reported that medical students who have recently learned about biological radiology reported feeling less anxiety than did other citizens and doctors (Okazaki et al., 2012; Kohzaki et al., 2015).

Concerning nuclear power plants, it has been reported that the

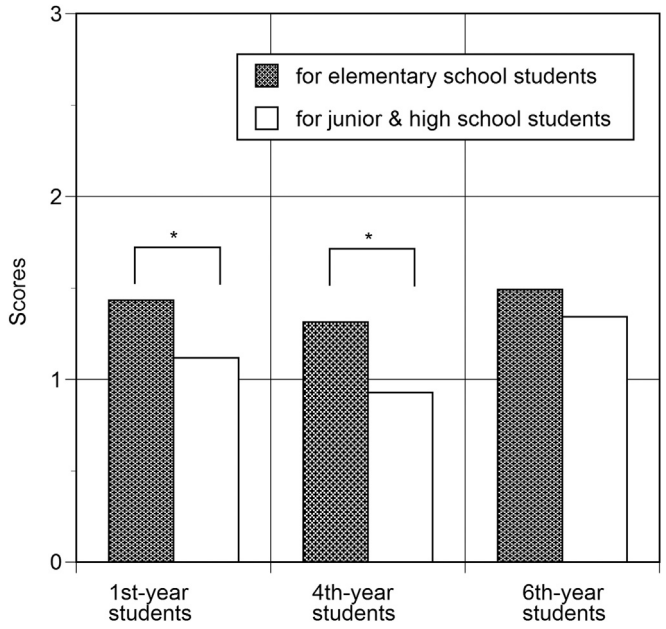

Fig. 1. Comparison of average scores for two supplemental texts by year in dental school.*: $p < 0.05$.

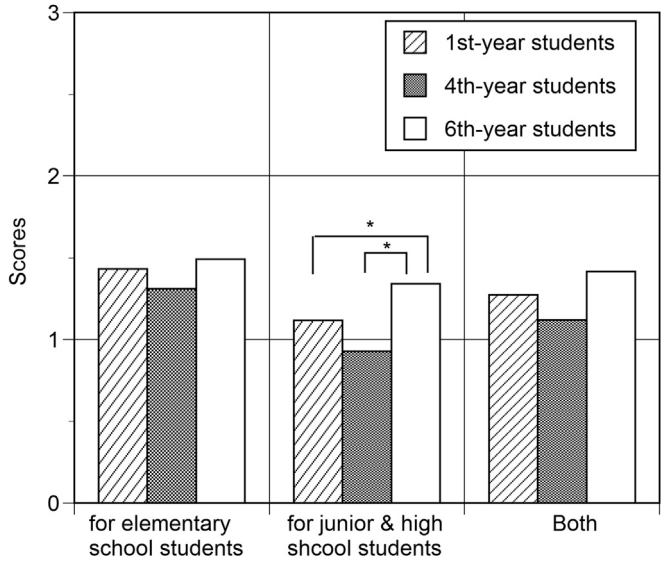

Fig. 2. Comparison of average scores for supplemental texts by text level and year in dental school.*: $p < 0.05$.

was proposed after the Fukushima Nuclear Power Plant accident (Slovic, 1987; Kohzaki et al., 2015; Inoue, 2014). The Fukushima Nuclear Power Plant accident influenced public opinion as far away as the United Kingdom, where public support for the nuclear program temporarily dropped after the accident (Nuclear Industry Association, 2013). Structured education about nuclear energy and radiation is not currently provided even in higher education in Japan, and it is very important to provide this education using video material in elementary schools (Saito and Kusama, 1992). Japanese people are highly sensitive to nuclear power and radiation, and this tendency has increased significantly following the Fukushima Nuclear Power Plant accident (Inoue, 2014).

5. Conclusion

Japan's atomic energy policy has been disturbed by the Fukushima Nuclear Power Plant accident in 2011. A problem of electric power supply is often taken up in many fields because all nuclear power plants have been stopping until last year. At this late date, only one plant begins to resume operation. However, the resume operation of other plants is not yet determined. The most important point is whether the consent of the local residents in the area where the nuclear power plant was built can be obtained or not. Most of citizens have little knowledge of radiation as well as atomic power generation and they consider radiation is very dangerous. In fact, Fukushima prefecture citizens have been enough troubled with damage caused by harmful rumors even now. After the Fukushima Daiichi Nuclear Power Plant accident, the Japanese government created new two supplemental texts on radiation education reflecting the accident to have citizens know radiation including atomic power well. One is for elementary school students and another is for middle and high school students. The supplemental texts have many advantages for improving the public understanding of radiation use, especially nuclear power generation from the point that everyone should be provided with an environment where they can learn about radiation. In these situations, the authors evaluated the understanding level of dental students for the phrases used in the texts. Though the dental students must learn radiation for many times to utilize it in the future, they could hardly understand the phrases. The result indicates that it is very difficult for even middle and high school students as well as elementary school students to learn the texts so that radiation education method may need to be changed. Thus, it is concluded that it is very important to give many school hours on radiation in elementary school and to cultivate the educator who can teach the content of the texts. Therefore, it will be able to achieve the understanding of citizens regarding future radiation use including atomic power generation.

Table 4
Influence of information source.

Item	First-year students		Fourth-year students		Sixth-year students	
	Range	Partial correlation	Range	Partial correlation	Range	Partial correlation
Physics	7.81	0.220	5.85	0.181	2.31	0.077
Newspaper	4.70	0.129	18.81	0.501*	22.45	0.377*
Television	19.67	0.427*	14.51	0.226	8.94	0.261

*: $p < 0.05$.

proportion of nuclear power generation opponents increased and the proportion of supporters decreased after the Tokai Nuclear Accident (Tsunoda, 2001). The importance of radiation education

Conflicts of interest

The authors have declared that no competing interests exist.

Acknowledgments

This study was supported by a Grant-in-Aid for Science Research Project (#25462919) from the Ministry of Education, Culture, Sports, Science and Technology in Japan.

References

Agency for Natural Resources and Energy (ANRE), 2014. Annual Energy Report in 2014. www.enecho.meti.go.jp/about/whitepaper/2014gaiyou/whitepaper2014pdf_h25_nenji.pdf (Japanese) visited 2015 Sep. 12.

Akiba, S., 2012. Epidemiological studies of Fukushima residents exposed to ionizing radiation from the Fukushima Daiichi Nuclear Power Plant prefecture – a preliminary review of current plans. J. Radiol. Prot. 32, 1–10.

Clark, C., 2012. Children's and Young People's Reading Today. Findings from the 2011 National Literacy Trust's Annual Survey. National Literacy Trust, London, UK. www.literacytrust.org.uk/assets/0001/4543/Young_people_s_reading_FINAL_REPORT.pdf. visited 2015 Sep. 12.

e-Gov, 2014. The Atomic Energy Basic Act. http://law.e-gov.go.jp/htmldata/S30/S30HO186.html (Japanese) visited 2015 Sep. 12.

Endo, A., Yamaguchi, Y., Sakamoto, Y., Yoshizawa, M., Tsuda, S., 2001. External doses in the environment from the Tokai-mura criticality accident. Radiat. Prot. Dosim. 93, 207–214.

Goto, A., Rudd, R., Lai, A., Yoshida, K., Suzuki, Y., Halstead, D., Yoshida-Komiya, H., Reich, M., 2014. Leveraging public health nurses for disaster risk communication in Fukushima City: a qualitative analysis of nurses' written records of parenting counseling and peer discussions. BMC Health Serv. Res. 14, 129–137.

Hayashi, W., 2014. The survey "Nuclear power, Radiation, Energy and Environmental Issues" for students who want to become teachers. Tokaigakuen Univ. Repos. 19, 179–194. http://repository.tokaigakuen-u.ac.jp/dspace/bitstream/11334/406/1/kiyo_w019_14.pdf (Japanese) visited 2015 Sep. 12.

Inoue, H., 2014. What should the radiation education in Japan in the future be like? Yakugaku Zasshi 134, 163–168 (Japanese).

Japan Press Research Institute, 2014. Fifth National Poll about the Media in 2014. www.chosakai.gr.jp/notification/pdf/report5.pdf (Japanese) visited 2015 Sep. 12.

Kohzaki, M., Ootsuyama, A., Moritake, T., Abe, T., Kubo, T., Okazaki, R., 2015. What have we learned from a questionnaire survey of citizens and doctors both inside and outside Fukushima? Survey comparison between 2011 and 2013. J. Radiol. Prot. 35, N1–N17.

Kondo, T., Kai, T., Tsuzuki, T., 2009. Medical radiation and radiation education. Radiat. Biol. Res. Commun. 44, 93–105 (Japanese).

Lyons, C., Colton, D., 2012. Aerial measuring system in Japan. Health Phys. 102, 509–515.

Matsuda, N., Morita, N., Miura, M., 2014. Assessment and control of health risk caused by the radiological accident at the TEPCO Fukushima Daiichi nuclear power plant. Yakugaku Zasshi 134, 135–142 (Japanese).

Mihai, L.T., Milu, C., Voicu, B., Enachescu, D., 2005. Ionizing radiation -understanding and acceptance. Health Phys. 89, 375–382.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011a. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/11/04/1313005_01_2.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011b. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/11/04/1313005_04_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011c. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/11/04/1313005_05_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011d. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/11/04/1313005_09_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2011e. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/11/04/1313005_09_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2014a. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2014/03/03/1344729_1_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Education, Culture, Sports, Science and Technology (MECSST), 2014b. Japan. www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2014/03/03/1344729_2_1.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Health, Labour and Welfare (MHLW), 2015, Japan. www.mhlw.go.jp/shinsai_jouhou/dl/leaflet_120329.pdf, (Japanese) visited 2015 Sep 12.

Ministry of Economy, Trade and Industry (METI), 2014. About "Difficult-to-return": Support Team for Residents Affected by Nuclear Incidents, Cabinets Office. www.meti.go.jp/earthquake/nuclear/pdf/kokudou6gou_press.pdf (Japanese) visited 2015 Sep. 12.

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

Murai, K., 2013. The current state of radiation education in schools and results of the opinion survey on radiation. INSS J. 20, 28–37 (Japanese).

Newspaper association of America foundation (NAA foundation), 2013. Youth Media DNA in Search of Lifelong Readers: Arlington, VA. www.americanpressinstitute.org/wp-content/uploads/2013/09/NIE_Youth-media-DNA.pdf. visited 2015 Sep. 12.

Nishitani, M., 2004. Effect of school education on students' perception of radiation. Jpn. Soc. Radiol. Technol. 60, 1555–1563 (Japanese).

Nuclear Industry Association, 2013. The UK Nuclear Industry. A Report for the Japan Atomic Industrial Forum and the Japan Electrical Manufacturers' Association by the NIA. 2013. www.jema-net.or.jp/Japanese/nps/pdf/20130702english.pdf. visited 2015 Sep. 12.

Ohno, K., Kaori, T., 2011. Effective education in radiation safety for nurses. Radiat. Prot. Dosim. 147, 343–345.

Okazaki, R., Ootsuyama, A., Abe, T., Kuto, T., 2012. A questionnaire survey about public's image of radiation after the Fukushima Daiichi nuclear power plant accident. J. UOEH 34, 91–105 (Japanese).

Saito, K., Onda, Y., 2015. Outline of the national mapping projects implemented after the Fukushima accident. J. Environ. Radioact. 139, 240–249.

Saito, S., Kusama, T., 1992. Perception of radiations and radioactivities of general public. Jpn. J. Health Phys. 27, 23–26 (Japanese).

Sakai, A., Ohira, T., Hosoya, M., Ohtsuru, A., Satoh, H., Kawasaki, Y., Suzuki, H., Takahashi, A., Kobashi, G., Ozasa, K., Yasumura, S., Yamaashita, S., Kamiya, K., Abe, M., The Fukushima Health Management Survey Group, 2014. Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: the Fukushima Health Management Survey. BMC Public Health 14, 1318. http://dx.doi.org/10.1186/1471-2458-14-1318, 2014.

Sectional committee on radiation protection and risk management (SCRPRM), 2014. Science Council of Japan. Recommendation on 4 September 2014. www.scj.go.jp/ja/info/kohyo/pdf/kohyo-22-t197-3.pdf. visited 2015 Sep 12. (Japanese).

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

Tominaga, T., Hachiya, M., Tatsuzaki, H., Akashi, M., 2014. The accident at the fukushima daiichi nuclear power plant in 2011. Health Phys. 106, 630–637.

Tsubokura, M., Kato, S., Nihei, M., Sakuma, Y., Furutani, T., Uehara, K., Sugimoto, A., Nomura, S., Hayano, R., Kami, M., Watanobu, H., Endo, Y., 2013. Limited internal radiation exposure associated with resettlements to a radiation-contaminated homeland after the fukushima daiichi nuclear disaster. PLOS ONE 8, e81909.

Tsunoda, K., 2001. Public response to the tokai nuclear accident. Risk Anal. 21, 1039–1046.

UNSCEAR, 2013. Report, 2014, vol. 1. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations, New York, pp. 25–46.

Yamaguchi, M., Kitamura, A., Oda, Y., Onishi, Y., 2014. Predicting the long-term 137-Cs distribution in Fukushima after the Fukushima Dai-ichi nuclear power plant accident: a parameter sensitivity analysis. J. Environ. Radioact. 135, 135–146.