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Editorial

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Influence of Radiation Education on Risk Perception in Japanese Dental Students

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Abstract

Since the Fukushima Dai-ichi Nuclear Power Plant accident in 2011, the Japanese Government has been focusing radiation education in elementary, middle and high schools to improve public understanding about the continuing existence of nuclear plants. The government developed two supplementary texts about radiation, including nuclear power, for elementary school, middle school, and high school students. The authors evaluated the content of these texts by questionnaire research and found them very difficult to understand even for dental students. After that we examined the relationship between radiation education and risk perception. The results of the present study indicate that radiation education might change students' risk perception with regard to radiation.

Keywords

Radiation education; Dental student; Risk perception

Background

Japan is the only country that has been attacked with atomic bombs. Hundreds of thousands died in the atomic bombings of Hiroshima and Nagasaki in 1945. The survivors of the bombings have suffered from ongoing radiation-related injury and illnesses. The burst of the nuclear bombs released enormous amounts of radiation. Alpha, beta, and gamma rays and neutrons were emitted by the nuclear fission of the bombs. The area affected by radiation in Hiroshima is estimated to have been 10×20 km^2. The number of deaths in Hiroshima is estimated at 140,000 out of a total population of 420,000, according to the Hiroshima City government [1]. The number of deaths in Nagasaki is published on the city's official website and as of August 9, 2016, the official number of deaths from the bombing was 172,230 [2]. An 86-page survey report detailing findings on the effects of the use of nuclear weapons in Hiroshima and Nagasaki was published in 2014 [3]. Based on data from Hiroshima and Nagasaki, it is clear that people exposed to more than a certain dose of radiation (100 mSv according to the Japanese Government) are at a significantly increased risk of cancer ($p<0.05$). There may also be genetic effects on their offspring. Even today, some people are afraid of the effects of the bombings. In general, Japanese people can be said to be strongly concerned about the effects of radiation and are very sensitive about the topic of radiation.

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Fukushima Dai-ichi Nuclear Power Plant Accident

In the postwar era, Japan has made great use of electric energy to develop industry and enjoy the amenities of life. Liquefied natural gas (LNG), oil, coal and nuclear power are considered the "four pillars" that make up the cornerstone of electric energy policy in Japan. The magnitude 9.0 Great East Japan Earthquake occurred on March 11, 2011. A huge tsunami caused by the earthquake struck the electric power equipment of Fukushima Dai-ichi Nuclear Power Plant in Fukushima Prefecture, Japan. As a result, the power plant was damaged and a large amount of radioisotope was released into the atmosphere [4]. The extent of the fallout ranged as far as the United States and Europe [5,6]. The amount of radioisotope released was estimated in a report on the accident published by the Incorporated Administrative Agency Japan Nuclear Energy Safety Organization (JNES) [7]. This report stated that the total discharge amounts from the reactors of Fukushima Dai-ichi Nuclear Power Plant were approx. 1.6×10^{17} Bq for iodine-131 and approx. 1.5×10^{16} Bq for cesium-137. Even as of 2017, the contamination from the accident has not been completely resolved, and large amounts of radioactive cesium remains in in the environment in Fukushima Prefecture.

Because of the outcry from many citizens, all nuclear power plants in Japan stopped operating after the accident. Most of these nuclear power plants still have not resumed operation today. Given these circumstances, the Japanese Government created supplementary texts to promote education on nuclear power and radiation [8,9]. There are two kinds of supplementary texts: those for elementary school students, and those for middle and high school students. However, the contents of the texts are considered to be very difficult from the standpoint of professions that work with radiation. Our evaluation of the supplementary texts has highlighted the importance of radiation education [10].

Risk Perception

The risk of nuclear power plants can be considered by reviewing the Fukushima accident. It is necessary to think about how much risk society should accept because benefits and risks always coexist in scientific technology. Cars are indispensable in the modern world, despite the fact that many people's lives are lost annually to car accidents. The reason for this is that society has judged the profit brought about by the use of cars (benefit) to be greater than the loss to people caused by cars (risk). Starr studied the relationship between benefit and risk [11]. He used monetary value and death rate as yardsticks of benefit and risk, respectively, and evaluated various activities and technologies. The results showed that the more benefit increased, the more risk increases, and the acceptability of the risk appeared to approximately proportional to the third power of the benefit. It was also found that the public was willing to accept voluntary risks (e.g., the risks incurred in skiing or swimming) 1000 times as high as they were willing to accept for involuntary risks (e.g., the risks of food preservatives or nuclear power). Lichtenstein et al. examined people's estimates of the frequency of death from various causes, and indicated that there were two kinds of bias in these estimates. One was a tendency to overestimate small frequencies and underestimate larger ones, and the other was a tendency to exaggerate the frequency of some specific causes and to underestimate the frequency of others

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[12]. Slovic also performed a similar experiment, and added more experiments on rating the risks of 30 activities and technologies by four different representative groups [13]. The groups consisted of 30 college students, 40 members of the League of Women Voters, 25 business and professional members of the "Active Club", and 15 persons selected nationwide for their professional involvement in risk assessment (experts). It was showed that the laypeople overestimated when the actual deaths were smaller and underestimated when they were larger Figure 1. Furthermore, a pronounced difference between the risk rating of laypeople and that of experts was observed because the increase of knowledge reduced risk perception Table 1. Further research revealed that experts estimated the magnitude of on the basis of the probability and degree of results, but laypeople formed their estimates on the basis of the two factors of dread risk and unknown risk Figure 2 [14,15]. Moreover, it was also found that even experiments had different risk judgments because of the positions or roles of experts.

There are various definitions of risk. At present, two evaluation methods are generally used. One is "risk assessment" which evaluates risk scientifically and objectively. The other is "risk perception" which

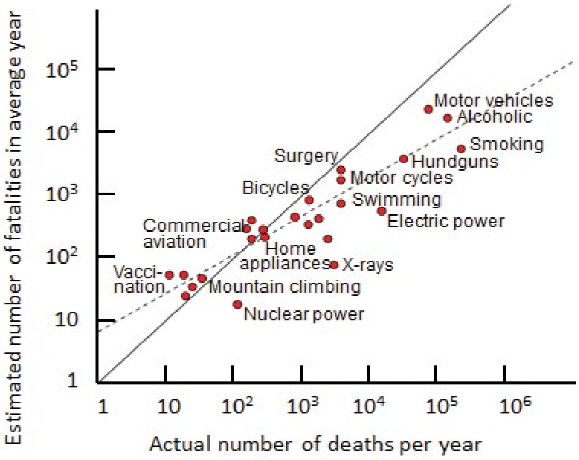

Figure 1: Relationship between estimation and the actual number of deaths.

Laypeople's judgments of the number of fatalities in an average year plotted against the best estimates of annual fatalities for 25 activities and technologies. The solid and dashed lines indicate accurate judgment and the best fit of data points, respectively. The figure is cited from Slovic et al (1979).

Table 1: Ordering of perceived risk.

	Japanese		American #	
	Dental students in 2016			
	Fourth-year (Before education) (37)	Fifth-year (After education) (38)	College students (30)	Experts (15)
Handguns	1	1	2	4
Nuclear power	2	2	1	20
Smoking	3	3	3	2
Motorcycles	4	4	6	6
Fire fighting	5	5	10	18
X-rays	6	16	17	7
Surgery	7	7	11	5
Motor vehicles	8	9	5	1
Large construction	9	6	14	13
Hunting	10	8	18	23
Mountain climbing	11	11	22	29
Pesticides	12	10	4	8
Police work	13	12	8	17
High school & college football	14	13	26	27
Contraceptives	15	15	9	11
General (private) aviation	16	14	15	12
Skiing	17	19	25	30
Vaccinations	18	21	29	25
Alcoholic beverages	19	18	7	3
Prescription antibiotics	20	20	21	24
Food preservatives	21	22	12	14
Food coloring	22	23	20	21
Power mowers	23	17	28	28
Bicycles	24	25	24	15
Electric power	25	27	19	9
Commercial aviation	26	26	.16	16
Spray cans	27	24	13	26
Railroads	28	28	23	19
Swimming	29	29	30	10
Home appliances	30	30	27	22

American data were cited from Slovic (1979).

Numbers in parentheses indicate the number of respondents.

evaluates risk simply and subjectively. Risk assessment is used by evaluating the risk of numerous things such as nuclear power plants, fires, explosions, pesticide use, and genetically modified organisms. It has been shown as knowledge increases, perceived risk decreases. Risk perception can be explained as the subjective probability that an undesirable event will take place, or recognition of uncertainty. It has also been shown that that judgment sometimes becomes irrational when a risk related to one's own health problems is perceived [16].

Radiation Education

Based on the experimental results of Slovic et al., the authors decided to evaluate whether radiation education could change the risk perception in Japanese subjects. We chose dental students because we belong to the Department of Oral and Maxillofacial Radiology in a national university, and because these students are considered sensitive to the topic of radiation, particularly since the Fukushima accident. Dental students at Tokushima University were targeted.

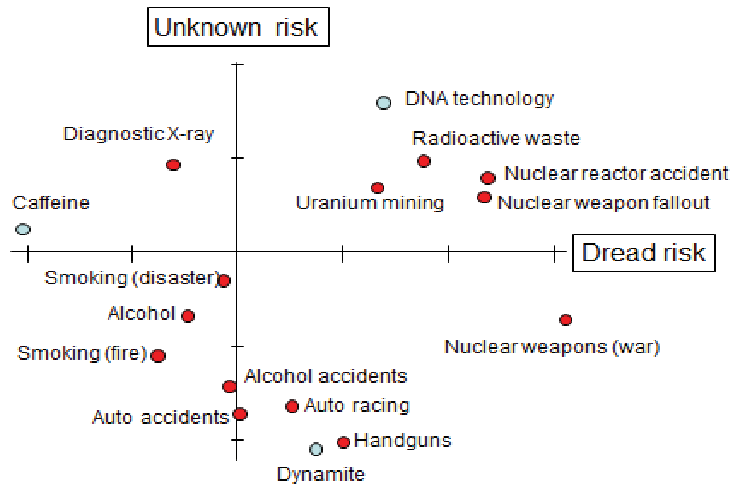

Figure 2: Location of hazards on dread risk and unknown risk.

Only hazards related to higher risk (handguns, nuclear power, smoking ,motorcycles and X-ray) in table 1 are plotted (red points) although 81 hazards is plotted in the original graph base on factor analysis. The highest and the lowest unknown risk and the lowest dread risk also are plotted (blue points). The horizontal line indicates dread risk which is defined at its high (right hand) end by perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits. The vertical line indicates unknown risk which is defined at its high end by hazards judged to be an observable, unknown, new, and delayed in their manifestation of harm. The figure is cited from Slovic P (1987) and modified.

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

Phrase		Japanese dental students in 2014	
		Fourth-year (Before education) (40)	Sixth-year (After education) (41)
1	Atomic bombing of Hiroshima and Nagasaki	2.16	1.90
2	Half-life	2.00	1.98
3	Harmful rumor	1.89	1.98
4	Radiation	1.82	2.00
5	Fukushima Daiichi Nuclear Power Plant	1.77	1.90
6	Radioactivity	1.77	1.78
7	X-ray	1.68	1.90
8	Radioactive material	1.59	1.93
9	Chernobyl Nuclear Power Plant disaster	1.59	1.66
10	Renewable energy	1.48	1.10
11	Sievert	1.45	1.68
12	Decontamination	1.45	1.63
13	Areas to which evacuation orders	1.45	1.56
14	Environmental radiation	1.32	1.33
15	Cesium	1.30	1.56
16	Standard for radioactive material in food	1.20	1.24
17	Plutonium	1.09	1.29
18	100 millisieverts	1.07	1.46
19	Three Mile Island Nuclear Power Plant accident	0.86	1.27
20	Iodine 131	0.66	1.34
21	Tokai-mura nuclear accident	0.77	1.00
22	Cesium 134	0.70	1.20
23	Cesium 137	0.70	1.17
24	Radioactive strontium	0.55	0.83
25	Aircraft monitoring	0.45	0.56
	Average	1.49	1.31

Numbers in parentheses indicate the number of respondents.

The data are cited and modified from Starr (1969).

There are 29 dental universities (11 national, 1 public and 17 private) in Japan, and Tokushima University is intermediately ranking among national universities. Students are given a total of about 150 hours of radiology lectures and practical experience before graduation. Thus, they should easily understand the supplemental texts on radiation published for use in the elementary, middle school, and high school curricula. We used a questionnaire survey to examine the educational effect of radiation education given to 4th-year students. The survey was conducted in 6th-year students after they finished radiation education. The understanding level of phrases regarding radiation in the supplemental texts was evaluated using a four-point scale (understanding=3, a little knowledge=2, having heard of it=1, no knowledge=0). The results showed that the phrases used in the texts were too difficult despite having been made for elementary school, middle school, and high school students, and only a partial educational effect was observed Tables 1 and Table 2, Figure 3 [8]. Another analysis was performed in 2015. The phrases were classified into radiation and nuclear power, and were further classified by difficulty level Tables 4 and 5. The results showed that radiation education increased the understanding level of more difficult phrases Figure 4. Subsequently, we researched the relationship between risk perception and radiation education. The results showed that the risk ranking of "X-rays" dropped greatly after radiation education, and the ranking became similar to estimated given by American students Table 1. This indicated that the risk perception of X-rays could be changed by education in Japanese students. However, it is unknown

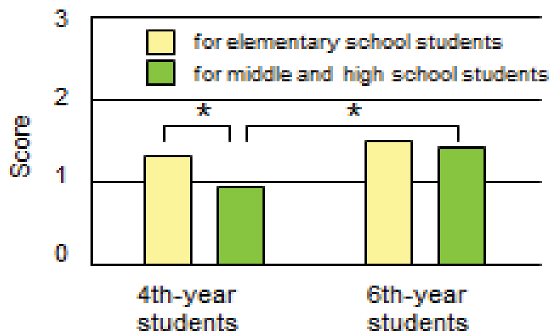

Figure 3: Average score on phrases for elementary school, middle school, and high school students.

Dental students' average score on phrases extracted from a supplemental text for elementary school students, and middle and high school students. There is a significant difference in the score between the two supplemental texts in 4th-year students, and between 4th- and 6th-year students in supplemental text for middle- and high school students (p<0.05).

Table 3: Dental students' average score on phrases extracted from a supplemental text for middle and high school students.

Phrase		Japanese dental students in 2014	
		Fourth-year (Before education) (40)	**Sixth-year (After education) (41)**
1	Isotope	1.98	1.80
2	Atomic nucleus	1.77	1.73
3	Radiation exposure	1.73	1.73
4	Difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order	1.64	1.39
5	Electromagnetic ray	1.34	1.63
6	Beta ray	1.27	1.59
7	Alpha ray	1.27	1.56
8	Gamma ray	1.25	1.56
9	Becquerel	1.11	1.59
10	Internal exposure	1.00	1.59
11	Neutron ray	1.00	1.56
12	External exposure	0.93	1.56
13	Radiation monitoring	0.77	0.98
14	Natural radiation	0.75	1.32
15	Man-made radiation	0.73	1.17
16	Inspection of all rice bags	0.70	0.90
17	Absorbed dose	0.64	1.63
18	Carbon 14	0.59	0.80
19	Gray	0.48	1.49
20	High dose exposure	0.48	1.12
21	Low dose exposure	0.41	1.10
22	Spatial dose rate	0.39	0.71
23	International Commission on Radiological Protection (ICCRP)	0.36	1.00
24	Three principles of radiation protection against external exposure	0.34	1.10
25	Physical dose	0.25	0.90
	Average	0.93	1.43

Numbers in parentheses indicate the number of respondents.

The data are cited and modified from Starr (1969).

Table 4: Classification of radiation-related phrases by understanding level.

1.	Higher understanding group (11 phrases) a) Phrases from supplemental text for elementary school (7 phrases) Atomic bombing of Hiroshima and Nagasaki, Half-life, Radiation, Radioactivity X-ray, Radioactive material, Environmental radiation b) Phrases from supplemental text for middle and high school (4 phrases) Isotope, Atomic nucleus, Radiation exposure, Electromagnetic ray
2.	Middle understanding group (11 phrases) a) Phrases from supplemental text for elementary school (4 phrases) Sievert, Plutonium, 100 millisieverts, Carbon 14 b) Phrases from supplemental text for middle and high school (7 phrases) Beta ray, Alpha ray, Gamma ray, Becquerel, Internal exposure, Neutron ray External exposure
3.	Lower understanding group (11 phrases) a) Phrases from supplemental text for elementary school (1 phrase) Iodine 131 b) Phrases from supplemental text for middle and high school (10 phrases) Natural radiation, Man-made radiation, Absorbed dose, Gray, High dose exposure Low dose exposure, Spatial dose rate, International Commission on Radiological Protection (ICRP)Three principles of radiation protection against external exposure, Physical dose

Table 5: Classification of nuclear power-related phrases by understanding level.

1.	Higher understanding group (9 phrases) a) Phrases from supplemental text for elementary school (8 phrases) Harmful rumor, Fukushima Dai-ichi Nuclear Power Plant, Chernobyl Nuclear Power Plant disaster, Renewable energy, Decontamination, Areas to which evacuation orders, Cesium Standard for radioactive material in food b) Phrases from supplemental text for middle and high school (1 phrase) Difficult-to-return, residence restriction and zone in preparation for the lifting of the evacuation order
2.	Lower understanding group (8 phrases) a) Phrases from supplemental text for elementary school (6 phrases) Three Mile island Nuclear Power Plant accident, Tokai-mura nuclear accident Cesium134,Cesium137,Radioactive strontium, Aircraft monitoring b) Phrases from supplemental text for middle and high school (2 phrases) Radiation monitoring, Inspection of all rice bags

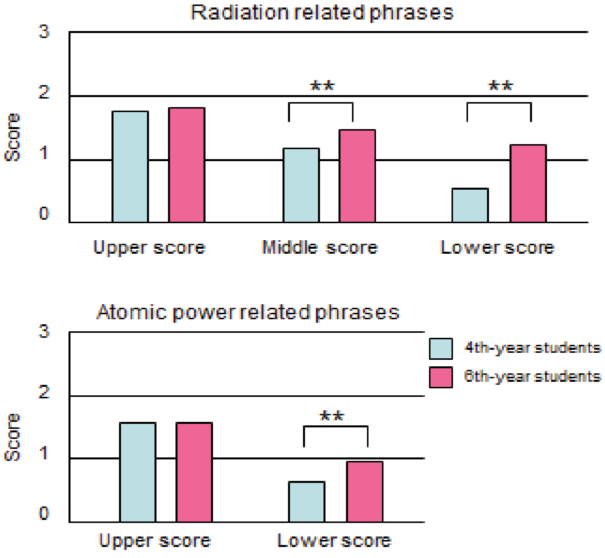

Figure 4: Average score on radiation related phrases.

Dental students' average score on radiation or nuclear power-related phrases extracted from a supplemental text. Lower and middle scores (understanding level) for radiation-related phrases increased significantly after radiation education (p<0.01). Lower scores (understanding level) for nuclear power-related phrases increased significantly after radiation education (p<0.01). The number of respondents was 83 for 4th-year students and 72 for 6th-year students in 2014 - 2015.

whether this result can be applied to Japanese people in general because dental students will become dentists and accordingly must be familiar with X-rays. Moreover, it is uncertain whether radiation education can change risk perception of nuclear power because no difference in risk ranking was observed. The authors believe that it is very important to enhance radiation education from childhood onward, and to train radiation educators for the future of Japan.

Acknowledgements

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