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Comparison of radiation risk perception and knowledge of radiation between Indonesian and Japanese dental students

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Keywords

radiation education; risk value; Fukushima Nuclear Power Plant disaster; natural radiation; artificial radiation

Highlights

- Risk perception of X-ray in Japanese dental students decreased after lectures.
- Risk perception of X-rays in Indonesian dental students increased after lectures.
- Risk value of nuclear power in Japanese dental students dropped with rising knowledge.
- Many dental students thought natural radiation differed from artificial radiation.

Abstract

The purpose of the study was to obtain basic data to identify problems in radiation education in a situation where confidence in nuclear power has fluctuated over time and fear of nuclear power has increased globally due to nuclear power plant disasters at Chernobyl and Fukushima. We conducted a questionnaire survey on understanding and risk perception of radiation and atomic power, before and after lectures, for 107 Japanese and 137 Indonesian dental students. Thirty-six phrases were extracted from two supplementary texts about radiation created by the Japanese Ministry of Education, Culture, Sports, Science and Technology, and 30 events commonly used in research on risk perception were used. The students were asked to rate their level of understanding of 36 phrases and risk perception of 30 events. Moreover, the students were asked to answer 6 general questions about radiation. For Japanese students, understanding of radiation increased and risk perception for both nuclear power and X-rays decreased after lectures ($p<0.05$). Concerning nuclear power, the risk-value declined as the level of understanding increased ($p<0.01$). However, for Indonesian students, who had lectures on only radiation excluding nuclear power in dental radiology, risk perception increased for X-ray after lectures ($p<0.05$). This indicates that thought and custom, in the absence of knowledge, are influenced by lectures. In general, it is said that increase in knowledge will lower risk perception, but even if radiation education is imparted,

risk perception may rise if the lectures are not understood properly. It was concluded that educators need to incorporate sufficient knowledge in their teachings, and correct thinking, to mitigate the risk of future radiation education giving the opposite of the intended effect.

1. Introduction

Japan is the only country where the atomic bomb was dropped. The atomic bombs were detonated over the cities of Hiroshima and Nagasaki in August 1945, and many people were sacrificed due to the explosion and the subsequent radiation damage. Japanese people have continued to experience the fear of atomic bombs because many Japanese have been plagued by the possibility of radiation-induced carcinogens even years after the bombings. This fear of atomic energy and radiation was elevated due to the Fukushima Nuclear Power Plant (FNPP) disaster. The accident occurred due to the tsunami caused by the Great East Japan Earthquake in 2011. As a result of the accident, a large quantity of radioactive isotopes was released into the atmosphere and contaminated food, water, and soil (Fukasawa et al., 2017). Although the FNPP was shut down, the radioactive decontamination and decommissioning of the reactor are yet to be completed. Therefore, many Japanese people have come to fear nuclear energy and radiation (Kanda et al., 2012).

Electric power demand to support the Japanese economy has consistently increased over time. Currently, the main energy sources for Japan are natural gas, coal, and oil. Japan is dependent on other countries for the supply of most of these energy resources. About 60 years ago, the Japanese government plotted a far-sighted strategy and proposed to make nuclear power one of the supply sources (Nuclear Regulation Authority, 1955). After that, nuclear power generation became the pillar of Japanese energy. Although nuclear-generated electric power increased year by year, radiation education was treated as unimportant. Recently, radiation education has been re-evaluated and incorporated into compulsory education (Yoshida et al., 2018). As a part of this campaign, three radiation supplementary texts were prepared for elementary, junior-high, and high-school students (MECSST, 2011). However, just as the texts were completed and ready for use, the FNPP accident occurred. As there was no description about the accident in the texts, the texts had to be revised. Since then, two texts for elementary, junior-high, and high-school students have been newly created and distributed to all elementary and junior-high schools for radiation education (MECSST, 2014).

Because of the Great East Japan Earthquake, many volunteers, members of the Self-Defense Forces, firefighters, policemen, and others conducted relief activities. Among them, medical staff such as doctors, dentists, and nurses played an important role. They offered mental and spiritual sustenance for people by providing consultation and medical treatment. However, for the FNPP accident, most medical staff could not deal with persons exposed to radiation due to insufficient knowledge, and consequently fear, of radioactive isotopes. Medical staff routinely use X-rays in medical care. When they respond to people who are afraid of radiation, their risk perception of radiation affects their correspondence. During undergraduate studies, physicians, dentists, and radiology technologists learn radiology for many hours. However, there has been little detailed investigation into how much people in such professions fear radiation.

The authors of this paper have been teaching radiology as faculty of dentistry, and have been researching change in risk perception of radiation through education (Yoshida et al., 2016, 2017, 2018). It is said that risk perception decreases with the improvement of understanding, but it is unclear whether this adage can be generally applied to people in all professions or in different countries. Risk perception of radiation may be very different between Japanese and other people, and the effect of radiation education on different populations may also be different. Thus, it is important to evaluate this difference.

In Japan, after the FNPP accident, public opinion turned against nuclear power. Consequently, most existing nuclear power plants have stopped operation and there have been no new nuclear power plants constructed. Currently, the Japanese government is trying to raise public understanding of nuclear energy use by enriching radiation education in primary and secondary education. At the same time, other countries are planning to set up nuclear power plants. It is also important to know the risk perception of radiation and nuclear power of people in these countries.

Indonesia and Japan are located in East Asia and are closely related educationally and economically. Some universities have executed an inter-university academic exchange agreement, and personnel exchange programs have been established for education and research. Japanese T and Indonesian G universities, to which the authors belong, are also signing the academic exchange agreement. In addition, the IAEA (International Atomic Energy Agency) is developing a Nuclear Science Education Program for middle and high school students in the Asia-Pacific region (Iimoto et al., 2015). The IAEA Nuclear Science Education Program has already been conducted in Indonesia.

In this context, we evaluated the influence of radiation education on risk perception of radiation and nuclear power in Japanese and Indonesian dental students. A questionnaire survey was used to examine the knowledge and risk perception of radiation and nuclear power before and after lectures on radiation based on the above mentioned radiation supplementary texts for elementary, junior-high, and high-school students.

The purpose of this paper is to examine the change in the relationship between knowledge and fear of radiation and nuclear energy as a result of radiation education, and to obtain the basic information for the future radiation education.

2. Materials and Methods

2.1. Subjects

The IAEA is trying to raise public understanding of nuclear power generation by conducting radiation education for junior-high and high-school students to deepen their knowledge about radiation and nuclear power. In Asia, IAEA has selected Southeast Asia, and more specifically Indonesia, as a target area for its radiation education course. Indonesia and Japan were chosen in consideration of it. Dental students were chosen because radiology education program was compulsory and radiation related content was included in the program. A questionnaire survey was conducted for 107 dental students in Japanese T National University and 137 dental students in Indonesian G National University in 2018. The subject groups were as follows:

a) first-year students, before lecture,

b) fourth-year students, right after the lecture, and

c) sixth-year students, before graduation.

The subjects in T University included 33 first-year students, 39 fourth-year students and 35 sixth-year students. The subjects in G University included 45 first-year students, 46 fourth-year students and 46 sixth-year students.

The dental radiology education program is mandatory in both universities. In T University, a 30-hour series of lectures and 30-hour fundamental training are given to fourth-year students. Then, 60-hour clinical training is given to fifth- and sixth-year students. In G University, a 26-hour series of lectures and 20-hour fundamental training are given to fourth-year students. Then, 60-hour clinical training is given to fifth- and sixth-year students. Both universities' radiology education program included basic radiation physics, basic radiation biology, and radiation protection based on ICPR recommendations.

2.2. Questionnaire

Understanding of phrases related to radiation and atomic power, and risk perception of general events were investigated by questionnaire survey as follows. Moreover, six questions about radiation were asked to examine knowledge. The language of the questionnaire was Japanese in Japan and English in Indonesia, because Indonesian dental students were familiar with English. One Indonesian of the authors studied for over four years in Japanese T University, and the authors confirmed the content match of English and Japanese questionnaires.

2.2.1. Understanding of phrases related to radiation.

Two supplementary texts about radiation created by the Japanese Ministry of Education, Culture, Sports, Science and Technology were used (MECSST, 2014). One of the texts was intended for elementary school students, and the other was intended for middle and high school students. From each text, 36 phrases considered to be essential knowledge were extracted. The 36 phrases included almost all phrases on radiation or atomic power in the texts except those specific to Japan. Of these, twenty-four phrases were related to radiation and the remaining 12 phrases were related to atomic power. For each phrase, the dental students were asked to rate their level of understanding using a four-point scale (understanding = 3, a little knowledge = 2, having heard = 1, no knowledge = 0). The phrases used in the questionnaire were translated by the authors into English for Indonesian dental students.

2.2.2. Risk perception of radiation and medical care

Thirty events commonly used in research on risk perception were used (Slovic et al., 1979, Slovic, 1996). Dental students were asked to rate their risk perception using a seven-point scale -the maximum risk was 7 and the minimum risk was 1 (Table 3). The risk-value of 30 events was ranked based on the average of each grade. Two events related to radiation, "X-rays", and "nuclear power"; and 3 events related to medical care, "vaccinations", "surgery", and "prescription antibiotics"; were selected. The differences in the risk ranking and the average risk-value assigned by each grade were evaluated. Moreover, the results were compared with risk perception by American risk experts.

2.2.3. Knowledge about the nature of radiation

The students were asked to answer six questions about radiation. These questions were from a past questionnaire survey for high school students in Asia including Japan and Indonesia (Japan Atomic Industrial Forum, 2003). The language of the questionnaire was translated into English and distributed to each country. The questions were answered with "yes" or "no". The correct answer rate was calculated, and the results of the two countries were compared.

2.3. Statistical methods

The difference in the average score of understanding before and after lectures was compared. The correlation between understanding and risk-value was also evaluated. The Mann-Whitney U test or Kruskal-Wallis test was used to evaluate the difference of the averages between the two countries. Moreover, Steel multiple comparison was added. A regression analysis was performed on the correlation coefficient and slope of the regression line. The statistical software of Excel Statistics (ver.12, BellCurve, Tokyo, Japan) and Excel 2010 (Microsoft Japan, Tokyo) were utilized for the analysis. The significance level was set to 0.05.

2.4. Ethics statement

A questionnaire was performed as a part of lectures to help improve future lectures and to evaluate the understanding of lectures by Indonesian and Japanese students. After the questionnaire was explained to students, student consent was judged as the completion of the questionnaire.

All procedures in this study were approved by the Ethical Committee of Faculty of Dentistry, Universitas Gadjah Mada No.001327/KKEP/FKG-UGM/EC/2018 and complied with the Code of Ethics of the World Medical Association (Declaration of

Helsinki).

3. Results

3.1. Understanding of phases

3.1.1. Phrases related to radiation

In Japan, the average score on a 3-point scale, with 3 representing complete understanding, was 1.18 for before-lecture first-year students. The scores after lectures of fourth-year students (2.42) and sixth-year students (1.71) were significantly higher ($p<0.01$). In Indonesia, the average score of before-lecture first-year students was 1.05. The scores after lectures of fourth-year year-students (2.09) and sixth-year students (1.56) were significantly higher ($p<0.01$). In both universities, the average score of fourth-year students was the highest ($p<0.01$). Among fourth-year students, the average score of Japanese students was higher than that of Indonesian students ($p<0.01$).

Concerning understanding of the 24 phrases, understanding of the phrases “radiation”, “X-ray”, “isotope”, “radioactivity”, and “atomic nucleus” were at the top in both Japan and Indonesia. There was no significant difference between the two universities. The score of “half period” was better in Japan and there was significant difference in understanding of this phrase between first-year students of the two universities ($p<0.01$).

3.1.2. Phrases related to atomic power

Based on comparison of the average scores of the various subject groups, the average score of fourth-year students was the highest in both universities ($p<0.01$).

Based on a comparison between the two universities, there was no difference in the average score of first-year students, but the average score of Japanese fourth-year and sixth-year students was higher than that of Indonesian fourth-year and sixth-year students ($p<0.01$).

Understanding scores for the phrases “atomic bombing of Hiroshima and Nagasaki”, “radioactive material”, and “renewable energy” were the highest at both universities' students. For Indonesian students, the number of phrases with an average score less than 1, which essentially indicates unfamiliarity with the phrase, was 7 for first-year students and 10 for fourth-year and sixth-year students; the number was 0 for all Japanese students.

3.2. Risk perception

In the Japanese university, the risk ranking for “nuclear power” was the highest for first-year students, but the average risk-value significantly decreased for fourth-year- and sixth-year students after lectures ($p<0.01$). Concerning “X-rays”, the ranking decreased from 8^{th} to 14^{th} after lectures and the average risk-value significantly decreased for fourth-year students after lectures ($p<0.05$). The ranking of “surgery”, “prescription antibiotics”, and “vaccination”, related to medical care, also decreased for fourth-year students, and the average risk-value significantly decreased ($p<0.05$).

In the Indonesian university similarly to the Japanese university, the ranking of “nuclear power” was the highest for all grades. However, in contrast with the Japanese university, the average risk-value for fourth-year students was the highest. Concerning “X-rays”, the ranking increased from 10^{th} to 5^{th} after lectures and the average risk-value significantly increased for fourth-year- and sixth-year students after lectures ($p<0.05$). There was no significant change in ranking for “surgery”, “prescription antibiotics”, and “vaccination”.

In contrast to the risk perception of American risk perception experts for “nuclear power”, the results of the two universities were relatively high. There was no clear difference for other events.

Concerning correlation between understanding and risk-value for “X-rays”, there was no different between the students of the two universities. However, the study found a correlation between the risk-value of “nuclear power” and the average understanding of 12 phrases related to atomic power in Japanese students ($p<0.01$). The correlation was expressed by the following equation.

$y=-1.0x+7.1$, where x is the average of understanding and y is risk-value. The range of 95% confidence intervals for regression coefficient and intercept were -1.6 to -0.5 and

6.2 to 8.0. The equation shows that the risk-value dropped by 1 point with every 1-point increase in the understanding score (Fig. 1).

3.3. Knowledge

Concerning the 6 questions about radiation (Table 4), the average correct answer rate was highest for fourth-year students was in the Japanese university ($p<0.01$) (Table 5). In the Indonesian university, there was no difference in the rate between grades.

Comparing the correct answer rate between the same grades in both universities, the rate for Indonesian students was higher in the first grade. On the other hand, the rate for Japanese students was higher in the fourth-year grade ($p<0.01$).

Concerning the correct answer rate of fourth-year and sixth-year students after lectures, the rates of questions 4 and 5 (Table 4) were significantly lower in the Japanese university ($p<0.01$). In the Indonesian university also, the correct answer rate of question 5 was significantly lower ($p<0.01$).

The results showed that students at both universities did not know the fact that natural radiation is the same as artificial radiation.

4. Discussion

4.1. Difference of the subjects

The subjects of this questionnaire were dental students at national universities in Japan and Indonesia. There are 29 universities of dentistry (11 national, 1 public and 17 private) with faculty in Japan and 30 universities (15 national and 15 private) in Indonesia. According to world university rankings of 2018, Japanese T University is ranked 200th and the Indonesian G University is ranked between 201 to 250 among Asian universities (The world university rankings, 2018). In both countries, the academic ability of students entering the field of dentistry is quite high and it is believed that there is no considerable difference in academic the ability of students from the two countries. Therefore, the difference in results from this questionnaire is not a reflection of academic ability but a reflection of the primary and secondary education, social background, habits, and the quality of teachers.

4.2. Difference in understanding of phrases

Concerning understanding of 24 phrases related to radiation, the average score for fourth-year and sixth-year students after lectures increased compared with that of first-year students before lectures in both universities. This shows that understanding clearly increased after lectures. There was a difference in the average score of fourth-year students at the two universities. This was due to the low score for "becquerel", "gray", "man-made radiation", and "natural radiation" among others. Interestingly, 36 of 46 students of Indonesian G University did not know the word "becquerel". This shows that the students were not taught the word in the lectures because the word was not included in Indonesian radiology program. The program of radiation is similar in both universities because there are no significant differences in the average score in the sixth-year before graduation.

Most phrases related to atomic power are not included in the general dental radiology lectures. However, in Japanese T University, atomic power was explained in the lecture after the FNPP accident. In Indonesian G University, atomic power was not covered in lectures. Consequently, the students answered that they did not know more than half of the phrases. As a result, in fourth-year and sixth-year students, the study revealed a clear difference in understanding between the students of the two Universities. In the previous research, understanding level of phrases related to radiation for Japanese dental students was examined (Yoshida, et al., 2016), but the result did not show whether the result was specific to Japanese students, In this research it was shown that similar radiation education had similar effects in different countries.

The Japanese government is trying to raise public understanding of atomic power use because of its policy to make nuclear power one of the pillars of electric power in Japan. To support this effort, supplementary texts about radiation were made, and a plan was implemented to teach radiation education from primary school. However, this plan is yet to be fully implemented. Consequently, the first-year students' understanding of radiation is low. However, the improvement in understanding of radiation after lectures on radiology shows that the students' understanding of radiation by the time of university entrance will increase with an increase in the penetration of radiation education.

When a self-enumeration method is adopted in a questionnaire survey encompassing regions with different thought, educational background, and language; the result may be influenced by these factors. In addition when understanding of phrases like those presented in this questionnaire is evaluated through a self-enumeration method, the score tends to be higher when there is an energetic thinking and lower when there is an unobtrusive thinking. Regardless of the level of understanding, there may be a significant difference in the score between the former and the latter. One countermeasure to this inherent bias is to conduct objective testing at the same time as the survey questionnaire and to evaluate the differences.

4.3. Difference of risk perception

It is known that laypeople and experts have different judgment criteria for perceiving risk (Slovic et al., 1979, Slovic., 1996, Perko., 2014, Yoshida et al., 2017). Experts of risk perception decide the degree of risk by the mortality rate caused by the event. The risk perception of laypeople is affected by the actual number of deaths, not the mortality rate. That is, when the actual mortality rate is low, it is perceived to be high, and vice-versa (Slovic et al., 1979). For instance, in the case of deaths due to motor vehicle accidents, alcohol, smoking, and handguns, laypeople underestimate the number of deaths when compared to the actual. Conversely, the number of deaths caused by vaccination is small but the number of deaths as estimated by the average lay-person is much greater than the actual number. This difference between the actual number of deaths and the estimated number of deaths illustrates the difference in risk perception between laypeople and experts.

Concerning X-ray related events, the actual number of deaths (about 2000) is large but the estimated deaths number (about 90) is very small (about 20:1). Similarly, the actual number of deaths (about 100) due to nuclear power related events is very small but the estimated number of deaths number (about 20) is smaller (Slovic et al., 1979). Risk is judged on two factors of unknown and dread (Slovic., 1987, 1996, Yoshida et al., 2017). If either factor rises, the risk-value rises. Nuclear related events including "nuclear weapons fallout", "nuclear reactor accident", and "nuclear weapons (war)" are higher for dread risk. On the other hand, "diagnostic X-ray", "pesticides", and "oral contraceptives" are higher for unknown risk. Dread risk is defined as "perceived lack of control, catastrophic potential, inequitable distribution of risks and benefits, or involuntary". Unknown risk is defined as "not observable, effects are delayed, little scientific knowledge on the risk, unknown by those people exposed, or new risk" (Slovic., 1987). Nuclear power events have both unknown and dread risk, but "diagnostic X rays" has only unknown risk; most people do not exactly know the influence of X-rays but they do not feel much fear towards its medical use. As a result, in the results of the questionnaire, the risk score for "X-ray" may be lower than that of "nuclear power".

A decrease in the unknown factor due to improvement in understanding through education is considered to be the reason why Japanese students' risk score of nuclear power declined after lectures. The risk ranking method used in the previous research did not revealed the educational effect on risk perception (Yoshida, et al., 2017), but it was shown that the method using risk score was useful to assess the effect. On the other hand, residual fear from knowledge of the atomic bombing of Hiroshima / Nagasaki is considered to be the reason why Indonesian student's nuclear risk ranking is higher than that of Japanese students. The risk ranking of nuclear power did not change for all Indonesian students as there was no lecture on the subject. This tendency is the same for American students (Table 3). In the United States, fear of nuclear power is thought to be prevalent as a result of the possibility of a catastrophe at Three Mile Island nuclear plant (United States Nuclear Regulatory Commission, 2018).

Concerning "X-ray", the opposite trend was seen among both universities' students. Lectures lowered risk perception of Japanese students but increased risk perception of Indonesian students. The risk ranking was similar in first-year students in both universities. It is expected that because Japan has experienced the atomic bombing and the FNPP accident, first-year Japanese students are very sensitive to radiation.

Thus, the risk ranking of "X-ray" will be higher among Japanese students. However, it is expected that increase of knowledge through lectures decreased the unknown risk, and hence the overall risk perception. On the other hand, Indonesian people have not experienced the same fear of radiation as Japanese people. However, the Indonesian students learned in lectures that even small amount of radiation can have negative impacts including increased risk of severe disorders such as cancer. It is considered that this contributed to the fact that there was an increase in the risk ranking of "X-ray" after lecture among Indonesian students.

These results show that increasing knowledge can reduce risk perception, but may also increase fear if the content of the education is not presented with the appropriate context. Thus, it is important to keep the results of this study in mind when designing radiation education for people who are unaware of or uninterested in radiation. Moreover, it is important that radiation education not be biased towards either the risks or the benefits of radiation.

4.4. Planning of nuclear power plant and public opinion regarding the plan in Indonesia

In Indonesia, industries have developed economically, and energy demand is rising. During the First Long Term Development Program (LTDP-I) from 1969 to 1994, energy consumption rose 9.4% per year on average, and it is estimated that there will be more energy consumption in the second LTDP from 1994 to 2019 (Soentono, 1997). Nuclear power plants are planned to be installed for electricity supply. In 2012, it was announced that 4% of electricity in Indonesia will depend on nuclear power by 2025 (SNSMEACWG, 2013). However, there is not unanimous public support in Indonesia for the nuclear power plant promotion project. According to the survey of 3,000 people in 2010 in the areas of Java, Madura, and Bali, 59.7% agreed and 26.1% opposed the utilization of nuclear power plants. However, according to the national survey of 3.000 people in 2011 after the FNPP accident, 49.5 % agreed and 35.5% opposed. That is, after the FNPP, the agreement rate decreased, and the opposition rate increased (IAEA, 2014). This result clearly shows that the change in thinking is due to fear caused by the FNPP accident. If radiation education permeates the public in the future, the public's understanding of atomic power will increase, and risk perception will change.

The IAEA conducts the project of enriching radiation education in support of installation of nuclear power plants. In the preparatory stage of the education program, experts in radiation education were dispatched from Japan to teach middle and high school teachers in the Asian region (Iimoto et al., 2015). Indonesia was one of the target countries. In the next stage, about 10,000 high school students received radiation education from the Indonesian trained teachers using English text. The teaching material used in the Indonesian IAEA project was the first English-translated supplementary text on radiation created for junior high school students by the Japan

Atomic Energy Agency (JAEA) (Watanabe et al., 2015). The original of the text was the supplementary text about radiation for junior high school students among the first three texts created by the Japanese Ministry of Education, Culture, Sports, Science and Technology as mentioned above (MECSST, 2011). As the project progresses, future university students in Indonesia will understand nuclear power well. Currently, the IAEA is trying to make the supplementary text a teaching material for radiation education around the world, and plans are being developed to use it for radiation education in various countries around the world. Thus, the supplementary text will become a world standard text of radiation education in the future. Since the results obtained in this questionnaire cover the content of the supplementary text, this survey is considered to provide very effective basic information for fulfilling radiation education.

4.5. Difference in knowledge of radiation

The correct answer rate of question 5 was the lowest at both universities. Especially at G University, most students answered incorrectly with a correct answer rate of only 10% for all grades. This shows that the students understood the wrong thing to be correct. In Indonesian high school students also, the correct answer rate was only 8.4%. Thus, there is a high possibility that the Indonesian students understood the wrong thing to be correct due to inadequate education. In to a questionnaire survey of

Japanese junior high school teachers, many said that they did not conduct radiation education because radiation was quite difficult to be understood (Yoshida et al., 2018). The details of radiation were not taught in Indonesia either. As a result, in question 2, the correct answer rate among Indonesian fourth-year students decreased by about 25% after lectures. Conversely, the increase in the correct answer rate among Japanese fourth-year students indicates that lectures were effective because the material was taught. Since it is difficult to ascertain what is understood and what is not understood by the students through a questionnaire survey alone, it is necessary to give a simple true-false test. Based on the results, it is recommended to focus educating on the common place of errors among students. However, it has been pointed out that wording influences the correct answer rate, so it is necessary to pay careful attention to make problem sentences (Suzuki., 2014).

The correct answer rates among second-year students in high school in both countries were under 50%, but those were largely improved at both universities (Japan Atomic Industrial Forum, 2003). Because the academic ability of students of both universities is within the top 20% among all university students. Radiation education in Japanese high schools is conducted in the basic-physics and physics courses. Easy, fundamental radiation is taught in the basic-physics course, but advanced content, including elementary particles and nuclear power, is taught in the physics course. Physics is a an elective course, and most of the high schools do not teach advanced radiation in the physics course because radiation-related problems are hardly given on university entrance examinations. In Indonesian high schools, one course on physics, chemistry, and biology is mandatory. Radiation is taught in each course. Radioisotope is taught in the physics and chemistry courses, and somatic effects of ionizing radiation are taught in the biology course. The difference in the first-year students of both universities may be due to the fact that top Indonesian high school students who received radiation education entered G University.

5. Conclusions

It is known that risk perception decreases with increasing knowledge. However, the fact that the previous claim is not always correct was clarified by surveying the relationship between risk perception and knowledge of radiation among Japanese and Indonesian dental students. Moreover, it was shown that factors such as the subject's background and the degree of interest may lead to the opposite result. We need to consider this in radiation education. In addition, an education that does not give biased teachings to the students is necessary.

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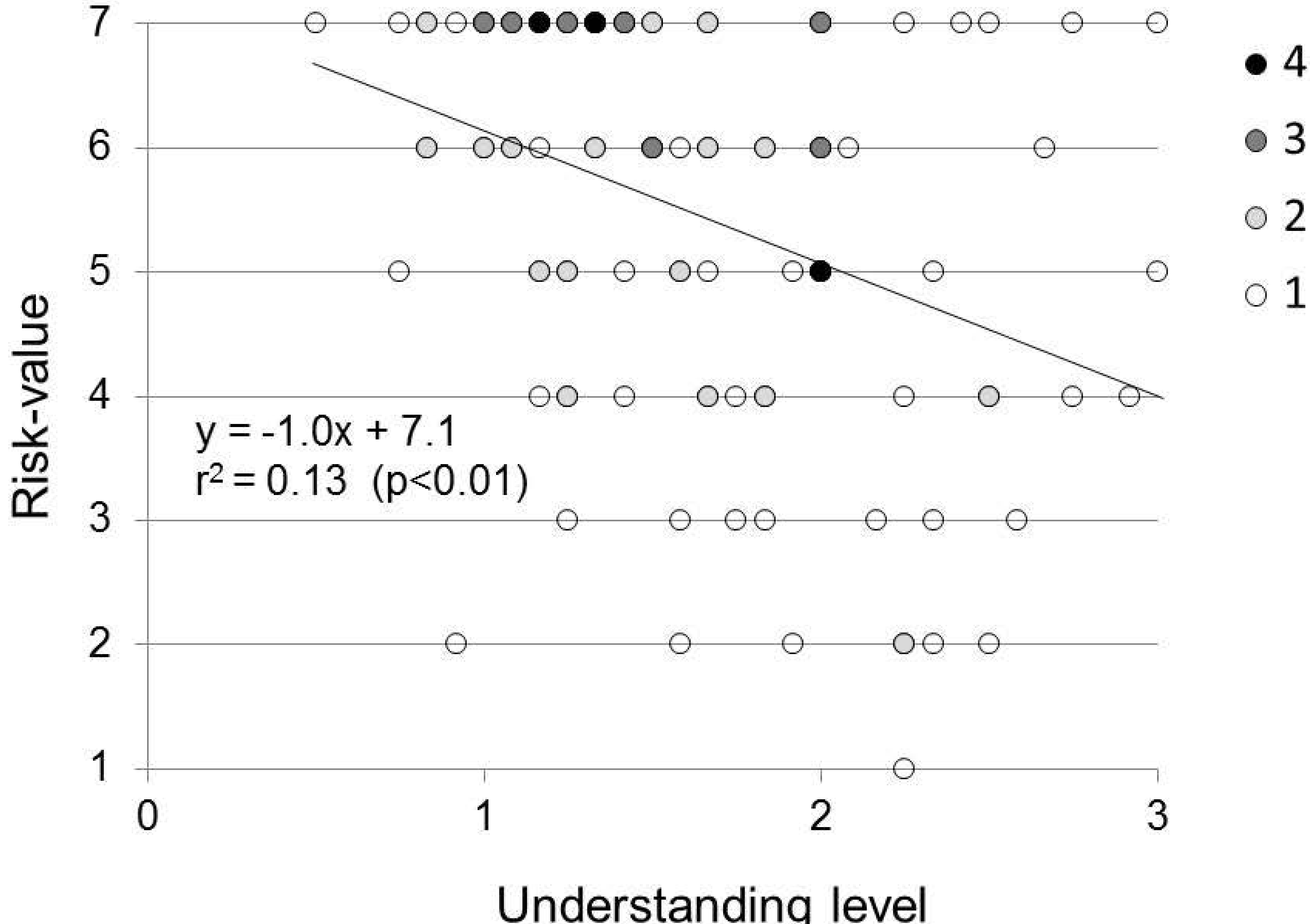
Figure caption

Relationship between risk-value and understanding level for atomic power among 104 Japanese dental students.

Number of legends shows the number of cases because the data is the same.



7
6
5
4
3
2
1
0
1
2
3
Risk-value
Understanding level
y = -1.0x + 7.1
r2 = 0.13 (p<0.01)
4
3
2
1

Table 1

Understanding of 24 phrases related to radiation

Phrase	Japan			Indonesia		
	1st	4th	6th	1st	4th	6th
radiation	1.79	2.49	2.06	2.44	2.98	2.72
X-ray	1.76	2.69	1.89	2.42	2.89	2.41
isotope	2.42	2.59	1.97	2.16	2.20	1.61
radioactivity	1.64	2.38	1.97	1.80	2.63	2.11
atomic nucleus	2.33	2.54	1.94	1.71	1.98	1.67
half period	2.24	2.72	2.03	1.04	2.15	1.50
alpha ray	1.82	2.46	1.83	1.58	2.30	1.41
beta ray	1.82	2.49	1.83	1.53	2.26	1.37
gamma ray	1.70	2.46	1.80	1.62	2.17	1.33
electromagnetic ray	1.73	2.38	1.86	1.38	2.28	1.41
neutron ray	1.36	2.44	1.83	1.29	2.15	1.28
external exposure	0.70	2.59	1.77	0.64	2.02	1.91
internal exposure	0.67	2.59	1.69	0.60	1.93	1.85
absorbed dose	0.48	2.31	1.86	0.24	2.50	1.72
natural radiation	0.45	2.36	1.60	1.29	1.80	1.54
high dose exposure	0.24	2.36	1.14	0.58	2.39	2.09
low dose exposure	0.24	2.33	1.20	0.58	2.37	2.04
Sievert	1.39	2.38	1.83	0.11	2.09	0.72
100 millisieverts	1.18	2.36	1.69	0.09	1.96	0.72
grey	0.67	2.23	1.83	0.40	1.48	1.28
man-made radiation	0.45	2.34	1.40	0.98	1.48	1.13
three principles of radiation protection against external exposure	0.03	2.59	1.20	0.18	2.00	1.72
International Commision on Radiation Protection (ICRP)	0.21	1.85	1.03	0.42	1.80	1.43
becquerel	1.06	2.26	1.80	0.22	0.30	0.50
Average	1.18	2.42	1.71	1.05	2.09	1.56

Table 2

Understanding of 12 phrases related to atomic power

Phrase	Japan			Indonesia		
	1st	4th	6th	1st	4th	6th
atomic bombing of Hiroshima and Nagasaki	2.67	2.69	2.11	2.38	2.65	1.76
radioactive material	1.73	2.44	1.97	2.00	2.76	2.11
renewable energy	2.09	2.23	1.54	1.91	2.00	0.93
Fukushima Nuclear Power Plant disaster	1.94	2.33	1.89	1.02	0.83	0.52
Chernobyl Nuclear Power Plant disaster	1.42	2.13	1.69	0.49	0.87	0.83
iodine131	0.52	2.44	1.31	0.67	0.85	0.85
plutonium	0.94	2.05	1.49	0.49	0.83	0.65
radioactive strontium	0.58	1.64	1.34	0.38	1.26	0.93
cesium 137	0.58	2.41	1.29	0.56	0.63	0.46
cesium 134	0.58	2.41	1.26	0.47	0.63	0.41
spatial dose rate	0.21	1.69	1.23	0.27	1.22	0.98
Three Mile island Nuclear Power Plant disaster	0.61	1.46	1.37	0.18	0.28	0.39
Average	1.15	2.16	1.54	0.90	1.23	0.90

Table 3

Ranking of risk perception of 30 events

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

Table 4 Questions about the nature of radiation

1. Radioactive materials exist in nature since the earth was formed
2. Radiation from radioactive materials intensity does not change with time.
3. Radiation also emits from ordinary food although it is a very small amount.
4. The direction of radiation depends on strong wind.
5. Natural radiation and artificial radiation have different properties.
6. Radiation always emits from the body although it is a very small amount.

Table 5 Correct answer rate of knowledge on the nature of radiation (%)

	Dental students						High school students #	
	Japan			Indonesian			Japan	Indonesia
Question	1th	4th	6th	1th	4th	6th		
1	75.8	97.4	97.1	93.3	100	89.1	62.7	80.8
2	81.8	97.4	94.3	84.4	60.9	69.6	64.2	46.1
3	87.9	100	91.4	86.7	73.9	63.0	49.0	28.9
4	42.4	56.4	54.3	75.6	91.3	80.4	50.3	34.7
5	21.2	38.5	25.7	11.1	15.2	13.0	19.3	8.4
6	63.6	100	77.1	88.9	69.6	84.8	41.9	53.8
Average	62.1	81.6	73.3	73.3	68.5	66.7	47.9	42.1

Correct answer: 1, 3, 6 are "true", and 2, 4, 5 are "false".

The number of question corresponds to the number of Table 4.

#: The data are cited by reference "Japan Atomic Industrial Forum, 2003"