The Radiation Unit is Difficult for the General Public toUnderstand – An Easier Alternative Unit is Required - 17223

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ABSTRACT

One of the difficult things to explain about nuclear power and/or radiation to the public is the 'radiation unit'. Especially after the Fukushima accident, many people are concerned about radiation, but over 70% of public who responded to the survey do not understand what the Bq(Becquerel)refers to. Changing the SI unit(International System of Units) is not easy, and instead, auxiliary units can be used. We considered several auxiliary units: one using an index number (like that for earthquakes), one that makes a comparison to general drug risk, one that makes a comparison to an amount of foodstuff (like BED), an introducing index comparing annual dose limit, using number compared to the background, and colorizing (i.e, red, green, blue). KHNP-CRI surveyed the public about radiation and radiation unit indexesto determine which was easiest to understand. For the question 'Do you know what the radiation unit Becquerel(Bq) is?', over 70% answered 'No'. When asked,'Do you think radioactivity is contagious and can be transmitted through a person’s respiratory system or via skin contact?', over 47% answered 'It is definitely or possibly contagious'. When asked, 'Which would you prefer as an easier to understand radiation auxiliary unit, if it were to be changed?', over 70% preferred 'colorizing or figure'. It is interesting that men prefer figureswhereas women prefer colorizing. The sample population of the survey was 500 adult men and women in Korea. The sampling error was based on random sampling, a confidence interval of 95%, and a standard maximum allowable sampling error of ± 4.4% point. The survey method was 'Computer Aided Telephone Interview'. (CATI)

INTRODUCTION

While public concerns about radiation heightened after the Fukushima nuclear power plant accident, the radiation units were too difficult for the general public to understand, so an easily-explained alternative was needed. It is not easy to explain radiation units even to citizens with engineering knowledge, and the reality is that people usually think of the nuclear power plant explosion accident when they hear ′radiation,′and have a vague fear. In accordance with this, the Central Research Institute of Korea Hydro & Nuclear Power Co. Ltd. sought to help citizens overcome their vague fears and have a better understanding about radiation by proposing a new radiation unit or auxiliary index that the general public can easily grasp.

However, in order to develop a new international standard radiation unit, the complicated process of going through international agreement of confirmation has to take place, which is in no way an easy task. Looking back at the past process of switching from conventional units (Rad, Rem, Ci) to SI units (Gy, Sv, Bq), one can see how difficult this is. A tremendous amount of time is needed to change the indicator displays of various devices, guidebooks, procedures, and habits, and the cost is prohibitive as well.

In order to increase citizens′ understanding of radiation, various attempts have been made through research, academia, and industry, but even these explanation guides for radiation feel complicated and unfamiliar to the general public, so a new attempt that can be comprehended bythe general publicwas deemed necessary. As a result, the Central Research Institute attempted to gather opinions with the participation of experts from various fields, including not only radiation-related experts but also risk, toxicity, and humanities experts, educational institutes, and civil associations.

This analysis, based on opinions of experts from such diverse fields, derived what may be appropriate as auxiliary radiation index types, and conducted a factual survey on the preference and understanding of units through professional public poll agencies.

METHODOLOGY

In order to collect expert opinions on radiation units, there were a series of consultation from diverse fields, including radiation experts within and outside of the company, as well as from risk/toxicity analysis, medical, psychology, and education experts, civil associations, and press experts. [1]

After that,a survey for general public was conducted with 500 men and women participants throughout the country on the aforementioned derived display methods of radiation units. The survey was commissioned to a professional survey organization. Sample extraction was done through random extraction after population-proportional allocation based on region, gender, last name, and age (based on registered population as of August 2014), and assuming a random sample extraction, the maximum tolerance sampling error was ± 4.4% points based on a 95% confidence interval. The survey method was a computer aided telephone interview (CATI). The gender of respondents was 49.2% male and 50.8% female, and for education, 47% were high school graduates and below, and 51% were junior college graduates and above.The survey introduction and questionnaire is shown in Table 1 and 2.

Apart from the survey for the general public, a separate survey was conducted for employees of our company. The survey introduction and questionnaire is shown in Table 3.

Table 1.Hankook Research survey population and survey introduction

Category	Content		
Population	Adult males and females over the age of 19 living throughout the nation		
Sample Size	500 (Valid Sample)	Gender	Male 246
			Female 254
		Age	Ages 19-29 : 86
			Ages 30-39 : 92
			Ages 40-49 : 113
			Ages 50-59 : 100
			Ages 60 and over: 109
Sample Extraction	Random sample extraction after population-proportion allocation based on region, gender, and age * Based on registered population as of August 2014		
Sampling Error	Assuming random sample extraction, maximum tolerance sampling error of ± 4.4% points based on confidence interval of 95%		
Survey Method	Computer Aided Telephone Interview (CATI)		
Survey Period	October 22~23, 2014		
Survey Organization	Hankook Research, Inc.		

Table 2.Survey questionnaire (General Public)

Q1. What comes to mind first when you hear the word ‘radiation’?
1) Nuclear bomb
2) Cancer treatment
3) Disease diagnosis
4) Nuclear power plant
5) Fukushima accident
6) Other ( )

Q2. Do you think the effects of radiation are contagious, like HPAI or AIDS?
1) It is contagious
2) It could be contagious
3) It is not contagious
4) Unsure

Q3. How well do you know about radiation measurement units?
1) I know about milli-Sievert (mSv)
2) I know about Becquerel (Bq)
3) I know about both Sievert (Sv) and Becquerel (Bq)
4) I have heard about Sievert (Sv) and Becquerel(Bq) but I don’t know much about them.
5) I don’t know any

Q4. What do you think about radiation units (Sievert, Becquerel)?
1) They are too difficult to understand, so I want them to be easier
2) They are a bit difficult, but I will get used to them if I use them often
3) They are a bit difficult, but it doesn’t matter
4) There is no problem using them, so no change is needed

Q5. Have you ever received education related to radiation (including school)?
1) I have received it and I remember the content
2) I have received it but I don’t remember the content
3) I have not received it but if I have
4) I have not received it, and I don’t feel the need to know about it in the future

Q6. Have you ever explained radiation to other people? If you have, did you have any difficulty?
1) I have never explained it
2) I have explained it, and I have felt difficulty
3) I have explained it, and I didn’t feel any difficulty

Q7. If radiation measurement units are changed to be easier to understand, which one would you prefer?
1) Express with numbers 1, 2, 3, 4 like burns or earthquakes
2) Express with color like blue, yellow, or red depending on the strength of radiation
3) Compare as 1/10, 1/5, 1/2 of radiation allowed for general public
4) Set major regions of Korea and compare in terms of how much for those regions
5) Express as life expectancy reduction index of radiation exposure (ex: smoking)

Q8. Do you trust measurement results from professional radiation measurement organizations?
1) I trust them
2) I somewhat trust them
3) Sometimes I trust them and sometimes I don’t
4) I cannot trust them somewhat
5) I cannot trust them

Q9. Do you trust press announcements about radiation risks?
1) I trust them
2) I somewhat trust them
3) Sometimes I trust them and sometimes I don’t

the chance, I want to learn about it	4) I cannot trust them somewhat 5) I cannot trust them

Table 3. Employee survey

Category	All 12 operators of a nuclear power plant radiation measuring instrument
Questions	6 questions including experience using units, unit index preference, etc.
Survey Period	August 28, 2014

Q1. Personal information: Year of entry ( ) 1) Less than 5 years ago 2) 5 year ~ 10 years ago 3) Over 10 years ago Q2. Personal information: Major ( ) 1) Nuclear engineering, physics, radiation 2) Others (Not above) Q3. Have you ever felt difficulty explaining 'radiation' to the general public due to units? 1) Yes 2) No ==> Question 5 Q4. If there was any difficulty using radiation units, what was it? 1) Difficulty explaining the meaning of the radiation unit itself 2) Difficulty explaining whether exposure to radiation is safe 3) Others ( ) Q5. Is there any inconvenience when using the current standard radiation units of mSv, Bq? 1) It was unfamiliar at first, but now I am used to it and have no difficulty 2) Pronunciation is difficult and the engineering meaning does not come through, so it needs to be changed 3) Others ( )	Q6. If using auxiliary index of radiation amount along with standard units, what would be the priority? (- - - -) 1) Several times BKG, determining the radiation background of major regions in Korea 2) 1/100, 1/10, 1/5 of dose limit (1mSv for an ordinary person) 3) Express range of dose limit in numbers from 1~10 (ex: burns) 4) Express in colors: green (normal), blue (caution), yellow (warning), red (serious) 5) Number of consumable animals and plants: 1, 2, 3 carps/day, or 10, 20, 30 bananas/day…

RESULT AND DISCUSSION

1. Cases of radiation units and auxiliary indices

The SI was started at the 10th General Conference on Weight and Measures (CGPM) in 1954 by selecting a consistent unit system based on a total of 6 units comprising 4 basic units of MKSA-type and temperature and luminous intensity, and the overall details of measurement units were prepared at the 11th CGPM in 1960 by determining rules for derived units.

The radiation units belong to 22 derived units, and are comprised of the 3 units of radioactivity, absorbed dose, and dose equivalent. The Becquerel (Bq), indicating the amount of radioactivity, is expressed as s^{-1}, and the absorbed dose and dose equivalent (Sv) are expressed as J/kg. Currently, international units (SI) of gray (Gy), Sievert (Sv), and Becquerel (Bq) are used throughout the world, but some people still use previous units like Rad, Rem and Ci.

Table 4. Radiation Units

Unit	Definition
Gray (Gy)	The amount of radiation energy absorbed by matter
Sievert (Sv)	The radiation energy absorbed in the body expressed as the level of biological damage
Becquerel (Bq)	The degree to which the atomic nucleus changes per unit time
[Application]	Based on the above basic units, man·Sv is used as the unit for collective dose, Bq/cm^2 for surface contamination, and Bq/cm^3 for volume contamination

Various auxiliary indices have been developed and used to help the general public understand radiation units, which include Randall Munroe's Radiation Dose Chart, BBC Guardian Datablog's Radiation Dosage Chart, the DOE Dose Index Chart, and the KINS Radiation Comprehension Chart. The concept of the 'Banana Equivalent Dose (BED)' was proposed among radiation safety experts in the U.S. in 1995, where 1 BED was equal to the dosage caused by K-40 when eating 150g of banana, which roughly corresponds to 0.1uSv of dosage. [2] (Figure 1)

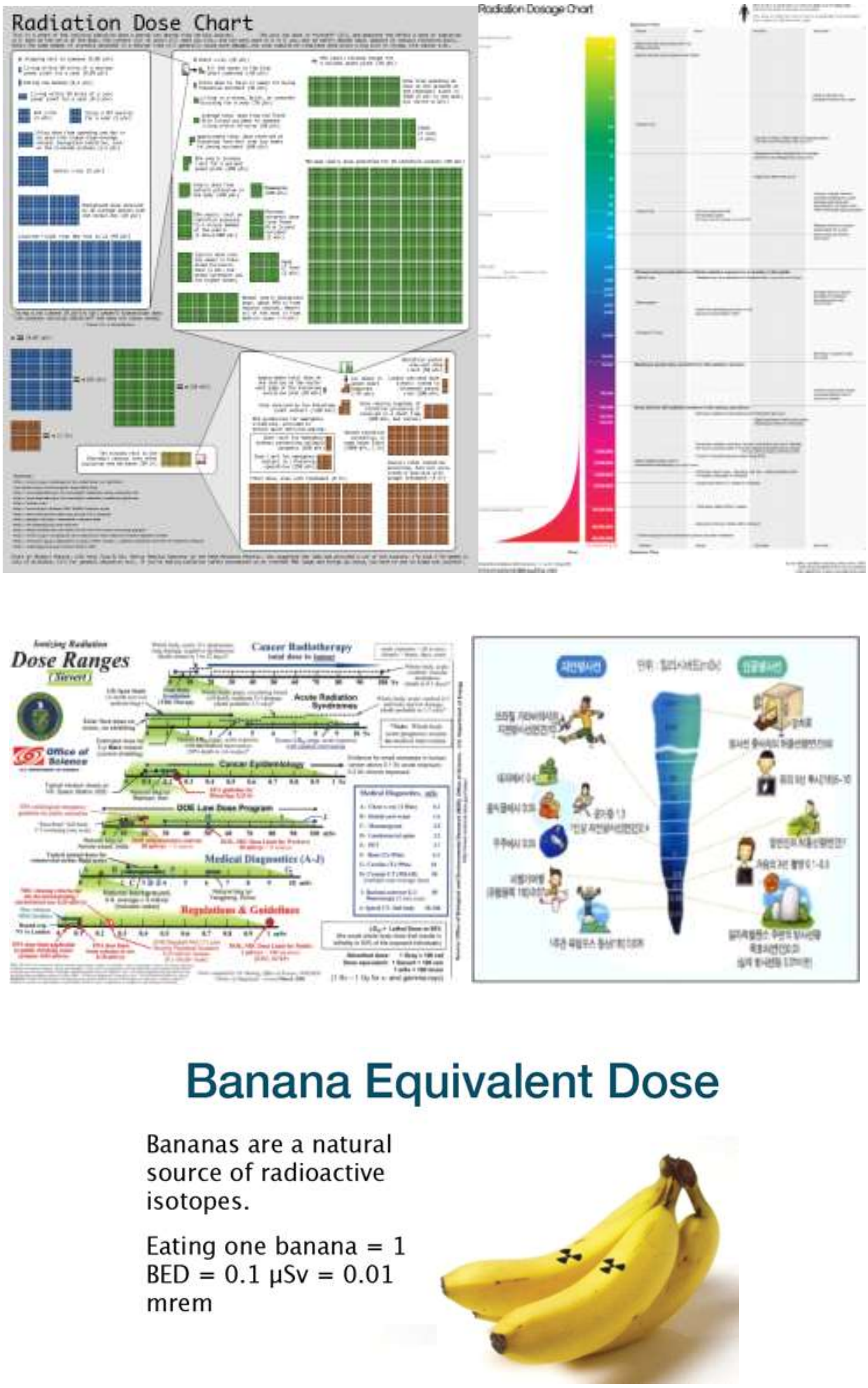


Figure 1. Radiation auxiliary indices (Randall Munroe's Radiation Dose Chart, BBC Guardian Datablog's Radiation Dosage Chart, DOE Dosage Index Chart,

KINS Dosage Chart, BED)

2. Cases in other fields

Looking at the indices of various fields we encounter in our lives may help in increasing understanding of radiation units. For agricultural food products, the recommended daily intake or allowance is displayed in percentages (%) so that the general public can easily identify their effect when purchasing or consuming products. International organizations commonly control heavy metals in food, mainly cadmium, mercury, and lead.

In the U.S. all states use various methods to promote the safety of consumed fish, centered on the U.S. EPA. For example, promotional material for proper consumption amount (depending on the type of contaminant) is distributed using an image showing the safety of freshwater fish caught in Lake Michigan. (Figure 2)

It is written that the channel catfish is contaminated with PCB, with a warning not to consume it regardless of size. The Chinook salmon, although also contaminated with PCB, is said to be okay to consume about once a month. It also tells people that rainbow trout under 22 inches in length should be consumed once a week, while trout over 22 inches should be consumed only once a month.

Figure 2. Safety guide for fish caught in Lake Michigan, Illinois

The amount of radiation can also be explained in comparison to internal medicine often used in our daily lives. For example, by limiting exposure to radiation dosessimilar to how medications like sleeping pills, painkillers, and blood pressure medication are limited. Also, it can be explained in comparison to human life expectancy; for example, in terms of how many years life is shortened for people smoking a pack of cigarettes every day or for a certain percentage of obesity. It can also be explained in comparison to burns, as the severity of burns is classified into first, second, third, and fourth degree depending on the depth and area of the burn.

Table 5. Types of burns

Depth	Damaged Tissue	Appearance	Symptom	Healing Period	Scar
1st Degree	Epidermis, horny layer	Flare, congestion	Pain, heat	From 5~10 days	None
2nd Degree (Light)	Epidermis, shallow dermal layer	Blister, flare, swelling, moisture	Severe pain, burning sensation, dull sensation	From 2~3 weeks	Almost none
2nd Degree (Severe)	To deep dermal layer	Blister, flare, swelling, moisture, gradual whitening	Less pain, significantly dulled sensation	From 3~8 weeks	Easy to form
3rd Degree	All of dermal layer, subcutaneous tissue	Necrosis, carbonization, dry, whitening	No pain, no sensation	No natural healing (skin graft required)	Formed
4th Degree	All of dermal layer, subcutaneous tissue, fat, muscle, bone	Necrosis, carbonization, dry, whitening	No pain, no sensation	No natural healing (amputation required), epithelium of skin not regenerated	Formed

It is also meaningful to see how the risk of radiation is being perceived from the perspective of cognitive psychology. It is said that risk does not specifically exist but is a subjectively formed concept. The thought process that intervenes when assessing risk is diverse, and while the cognitive processing procedure was emphasized during early days, emotions or feelings are highlighted as more important in recent times. Individual world views also have a huge influence, so for example, people supporting a hierarchical social order perceive risk as lower and have a favorable attitude toward nuclear energy compared to people supporting equality. They also easily reject the risk analyses of scientists (even if theyare experts) if they have different world views or cannot be trusted for other reasons. For such reasons, information about risk delivered through the media can have a big influence on attitudes toward risk, and there is a high possibility of having influence on the direction of strengthening existing ideas instead of changing previous opinions.

The public tends to be difficult onmathematical and statistical information. Notable cases of public misunderstanding include ignoring the denominator, misunderstanding the concept of %, and misunderstanding of statistics, such as ignoring the base rate or the confusion of conditional probability. Between the cases of there being 1 straw out of 10 draws, and there being 9 straws out of 100 draws, a considerable number of people select the latter as representing a higher percentage. In order to solve this issue, the U.S. and Europe teach children probability, and use visual auxiliary means or develop tools to aid in the comprehension of the concept of probability, in order to increase literacy in risk.

One thing that must not be forgotten in risk recognition is that transparency must be secured by releasing the risk assessment process or procedure to the public and having the public participate in its formation. Risk recognition can be amplified socially to influence policymakers, and develop into an independent political force. As decisions related to risk recognition can have a long-term effect on the lives of the public anyway, securing transparency not only at the policymaking phase but starting from the risk assessment procedure is important in increasing trust between related parties.

After the Fukushima nuclear plant accident, visitors to the Korean National Radiation Emergency Medical Center (including Japanese visitors, workers in radiation-related fields, and the general public) increased for counseling. An operation manual has been developed and used as a tool to provide quick and professional counseling to clients and provide consistent and standardized counseling.

For counseling based on a vague fear of radiation, pursuing the emotional stability of clients by providing appropriate information and emotional support is important. At the early stages of counseling by phone,with a call made due to simple anxiety, if there is enough sympathy about the anxiety during the counseling the anxiety is often reduced so much that clients once wishing to come to the clinic can have their on-site doctor withdrawn. This shows that due to the diverse information available thanks to the development of media such as the internet, distorted information has increased, causing pan-national anxiety as well.

Consultation calls are a great tool as a channel for the general public to relieve their fear of radiation. As the media has a tendency to focus on problems and worries when reporting accidents, citizens encountering such news can have increased anxiety and confusion. At this point, consultation calls serve a role as a window for people to reduce their anxieties. Clients express satisfaction at being able to discriminate between predictability and actual situations by themselves through consultation, having their anxieties subside, or by verifying that they have correctly understood the announcement made by public institutions.

Especially concerning is that the curiosity and anxiety citizens have regarding exposure to daily radiation and medical radiation, but not nuclear power generation, is just as big as the matters above. There have been many cases where people resorted to consultation calls because they didn’t know where to ask, and were looking on the internet, worrying about the alarming stories floating around without clear evidence. Communicating with the general public and resolving their distress by explaining to them about daily radiation in friendly terminology, and about the things they want to know, appears to be another role that consultation calls need to continuously play.

According to a study, approximately 30% of students who were actually studying radiology chose the wrong answer about Sv, a radiation unit. As for whether they received professional education about the units, over 50% of the students answered that they had not received the education. From these results, the need for education about international standard units can be verified. The reality is that students in Korea have virtually few opportunities to learn about radiation in the regular education curriculum at school.

Well-controlled nuclear energy and radiation greatly contribute to humanity, but can also lead to catastrophe if uncontrolled, so it should be debated whether the workers in the radiation field who overly concentrate on the safe and positive parts in education, aren't actually having a negative effect.

The reality is that most radiation-related education consistently teaches that nuclear power generation is a safe and clean method of energy production, and that the exposure to radiation from around nuclear power plants is safe because it is much less than the exposure resulting from daily natural radiation. However, the fact that the minds of people who have seen pictures of the damage done by Chernobyl, Fukushima, and the Hiroshima bombing cannot be moved shows that it serves as a chance to strongly hammer home that radiation is dangerous. Also, people get a strong impression that radiation emitted from nuclear power generation is very dangerous when they see workers repairing equipment wearing protection suits sometimes displayed by the press. In reality, radiation is highly dangerous, depending on its strength, but is highly useful when it is being properly controlled.

There seems to be a gap between the safety education provided to radiation workers and the general public. It is possible that misunderstandings are occurring because workers are taught to be careful about certain factors in order to prevent risk, but the general publicand students are only taught that it is safe.

In education theses related to radiation, writers have the tendency to only emphasize positive aspects of radiation, and this should be rectified. For research, the right method seems to be to evenly expose the duality of radiation and then pursue a change of perception. Thus, future researchers will have to think a lot about how to approach the risk aspect of education. If people are prejudiced about the negative aspects of radiation, change of perception is not easy, and if an accident occurs because the positive aspect was emphasized, then the irreversible would happen. By letting people know that as there is a small amount of risk, there are various efforts being made to prevent even small accidents from occurring, a true change of perception would be able to take place.

The reason why many people have a negative perception on radiation can be attributed to a lack of understanding and experience of radiation, as the opportunity for them to encounter related information is limited only to when accidents and incidents occur and are announced through public media such as TV or internet. The best way for this situation not to happen is for accidents not to occur. Unfortunately, this is not a problem limited to a single country. Because accidents related to nuclear power have a tremendous influence throughout the world if even one occurs, education has the biggest influence when all countries of the world consider safety as the foremost value and prevent accidents from occurring.

It is highly important to communicate with citizens from the perspective of consumers and resolve the general public’s vague anxieties about radiation. The labeling system (color, number, etc.) for radiation can be an alternative. Carbon emission amount, energy efficiency and food safety labels could be referenced, and the Special Act on Safety Management of Children’s Dietary Lifestyle and food traffic light labeling system can be particularly good examples. For instance, the food traffic light labeling system is implemented by the Ministry of Food and Drug Safety to prevent youth obesity by encouraging children to select healthier foods when choosing snacks, and it labels the nutrition information of products using the colors of green (low), yellow (normal), and red (high) and has shapes like circles for children and consumers to easily recognize the amounts of sodium, sugars, saturated fat, and fat which have a high risk if they are consumed in excess.[3]

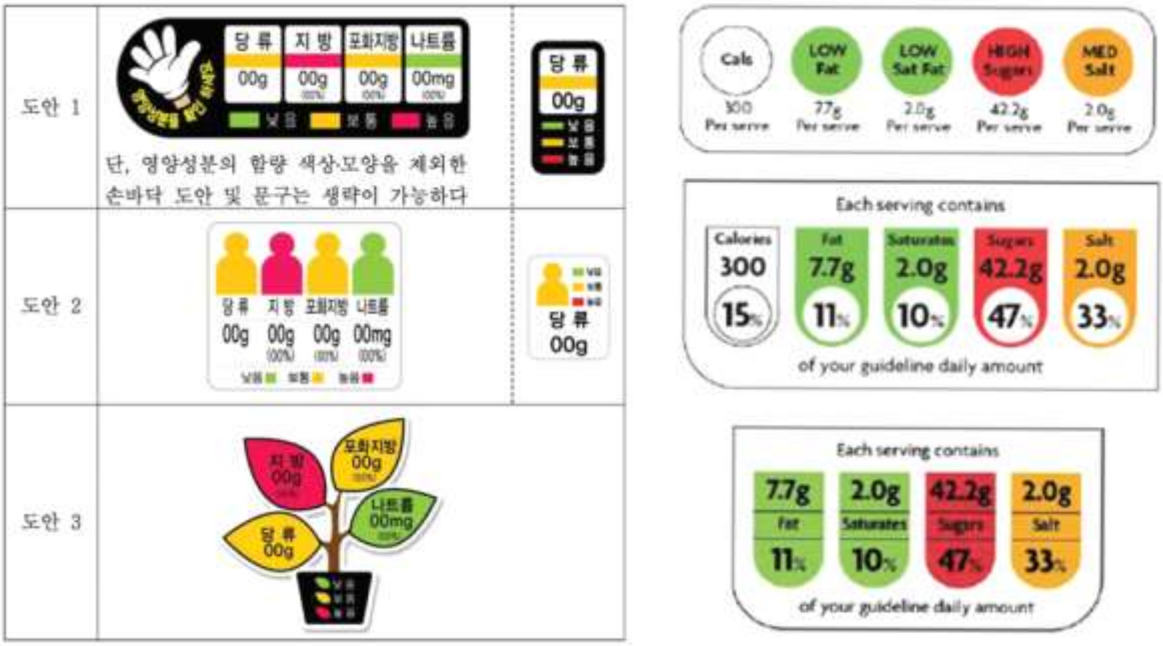


Figure 3. Food traffic light labeling system (Left: Korea, Right: U.K.)

Another example is the air pollution map provided by Korea Environment Corporation. The Korea Environment Corporation provides the air pollution degree of 5 atmospheric environment standard matters (sulfurous acid gas, carbon monoxide, nitrogen dioxide, fine dust, ozone) for each time period, and day of the week.This is done by combining the expression methods of the air pollution clock and air pollution calendar, and providing air pollution status expressed in 5 easily recognizable levels and colors by applying an integrated atmospheric environment index reflecting the effect on the human body and experienced pollution level.[4]

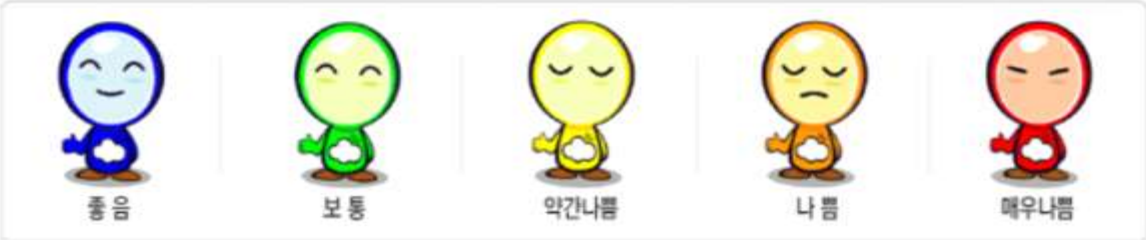


Figure 4. Air pollution level display method by Korea Environment Corporation

3. Collection of expert opinion to derive auxiliary radiation unit index

In order to collect expert opinions on radiation units, surveys were collected from diverse fields, including radiation experts within and outside of the company, as well as from risk/toxicity analysis, medical, psychology, and education experts, civil associations, and press experts. [4]The following were derived as the main implications:

○The subjects of application of the units need to be approached after being divided into two groups:

- Group I: Nuclear power workers, residents near a nuclear power plant (relatively high understanding)
- Group II: General public (most have worries about radiation exposed by consumption through food)

○ As measures to develop radiation units as an auxiliary index, the following were proposed:

- Rather than comparing X-ray diagnosed exposure amount, recommend use of other risk indices (avoid same system of radiation unit)
- Regularly analyze the residual radioactivity of agricultural and marine products for each region, and show the number of consumable products (ex: number of freshwater fish) using an image
- Quantify by comparing as 1/2, 1/5, 1/10, etc. of the yearly dose limit
- Quantify by selecting conservative references such as natural radioactivity (reference with little change)
- Display by indexing from 1～10
  . Need to determine whether to limit to a small scope or to apply to the entire range
  . It may be efficient to index by separating the low-dose area for the general public and high-dose in the case of an accident
- Show coefficients of reduction of life expectancy (refer to cases of smoking, obesity, etc.)
- The residual pesticide label for food can be applied to the amount of radioactivity in the case of nuclear power plant accident

○ Application plans of radiation unit indices

- The risk must be known first and a strategy to let people determine how to act by themselves is needed (using informed decision concept)
- Divide radiation into normal/warning/serious levels referencing the fine dust index and electricity supply meter and label the levels with colors of

blue/yellow/red

○ Risk is a subjectively formed concept and is selective rather than systematic, so it is more sensitive to particular information, and certain information can be ignored.

- Experts have the tendency to emphasize benefits and neglect risks whereas environmental organizations tend to emphasize risks and neglect social benefits
- It is assumed that normal people use only 10% of their brains, but this is not true
- There is a prejudice that natural coloring is always good, but the cochineal natural coloring extracted from cacti has greater toxicity than artificial coloring

○ The public is only interested in results and dislikes lengthy explanations

○ Regular radiation measurement is probably mostly ND(Non Detectable), so there is a question of effectiveness

○ There are medical students who think that the Fukushima radiation leak damage can be spread like HPAI or AIDS, so experts are saying that the medical curriculum must be changed

○ Civil environmental organizations also recognize that easily understood radiation units are necessary, but they must not infringe on the citizens' right to know

○ It is not important to explain in units with certain names but to approach safety so that it can easily be learned by consumers

Based on the consultation with experts, the following alternatives for delivering the SI radiation unit (Sv) are proposed as Table 6.

Table 6. Auxiliary index alternatives

Measure	Application example
◦ Display the natural radiation reference level using colors	*Green (normal), Blue (caution), Yellow (warning), Red (serious)*
◦ Display radiation influence using index of 1~10 by size (dimensionless)	*1 (normal), 2 (warning), …, 10 (serious)* *※Similar to index of burns and earthquakes*
◦ Display as percentage of general public dose limit (1mSv)	*1/100, 1/10, 1/5, 1/2, etc. of yearly limit*
◦ Coefficient based on environmental radiation of major regions in Korea	*1BKG, 1.5BKG, 2BKG, etc.*

◦ Assess residual radiation of regional agricultural and marine products to display the number of consumable products	*Display picture warning about number of fish in areas where fishing is permitted near nuclear power plants*

Apart from the above alternatives, the following are still other alternatives, and these are deemed to have a small amountof risk or to be unrealistic at the current time.

○ Develop a life expectancy reduction index for radiation exposure, like for smoking or obesity

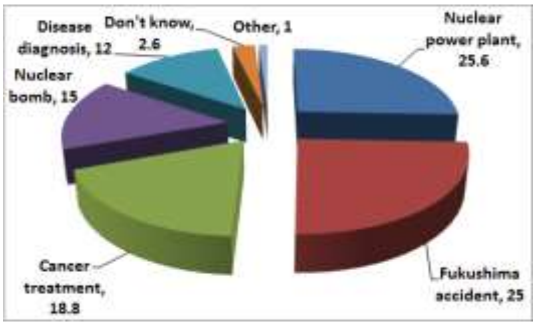
○ Compare the side effects of taking medication such as sleeping pills or Tylenol, consuming pesticide, etc.

○ Compare with the danger levels of car accidents, fires, etc.

4. Survey results

The survey result for general public showed that for the question of what comes to mind first when hearing the word 'radiation,' 25.6% answered nuclear power plants and 25% answered the Fukushima nuclear power plant accident, showing an overall negative sentiment.

For the question, 'Do you think radiation is contagious through respiratory or skin contact with people exposed to radiation?' 47.4% said that it is contagious, showing an urgent need for education.



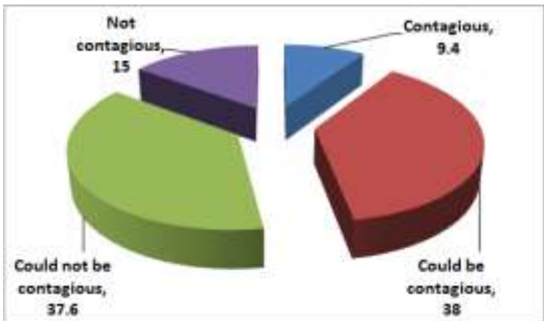


Figure5.What comes to mind firstFigure6. Opinion on the contagiousness when hearing the word 'radiation'?(Q1)of radioactivity (Q2)

For the question about how much they know about milli-Sievert (mSv) and Becquerel(Bq), 65.8% answered that they didn't know about milli-Sievert (mSv), 73.8% answered that they didn't know about Becquerel (Bq), showing an urgent need for education in this aspect as well. For opinions on changing radiation measurement units, 51.8% answered that they want them to be easier, and 23.8% answered that they don't use it often so it doesn't matter.

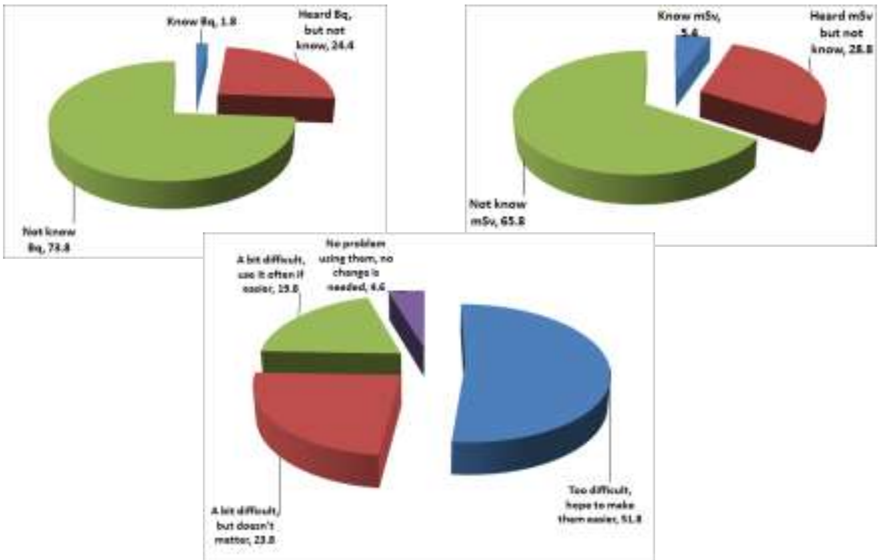


Figure 7. Recognition of radiation measurement units and opinion on measurement units (Q3, Q4)

For the question about whether they had received education related to radiation including school education, 80.2% answered that they had not. For the question, 'Have you ever explained information, accidents, or articles related to radiation to other people?' 14.4% answered that they had explained it, and for the question, 'How was it to explain it?' 59.7% answered that there was no difficulty, and 40.3% answered that it was difficult to explain.

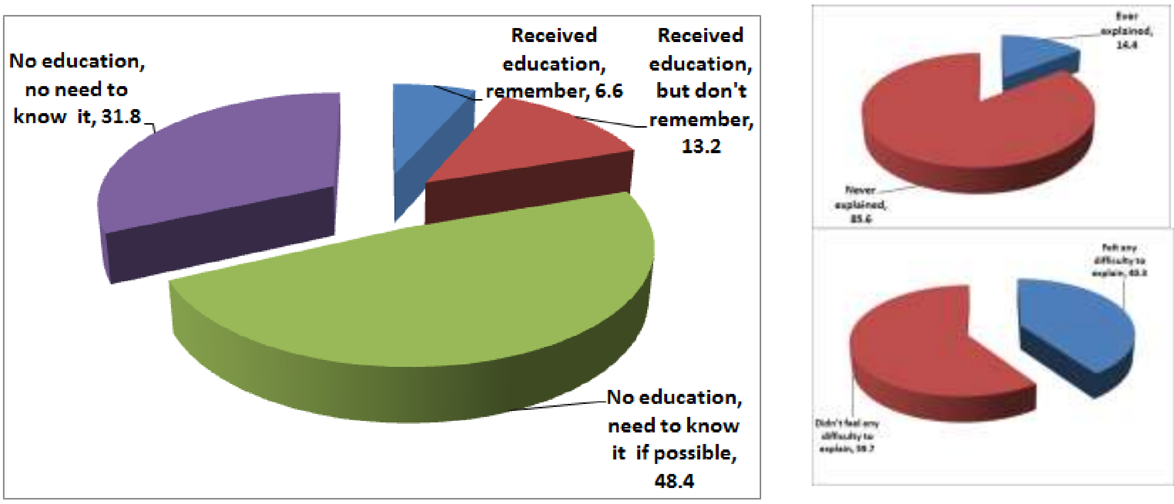


Figure8. Experience education and explaining about radiation (Q5, Q6)

For the question about which method is preferred if the radiation measurement units were to be changed to be easier to understand, 35.6% answered that expressing them in numbers or colors would be good. What was interesting was that males preferred numbers, while females preferred colors.

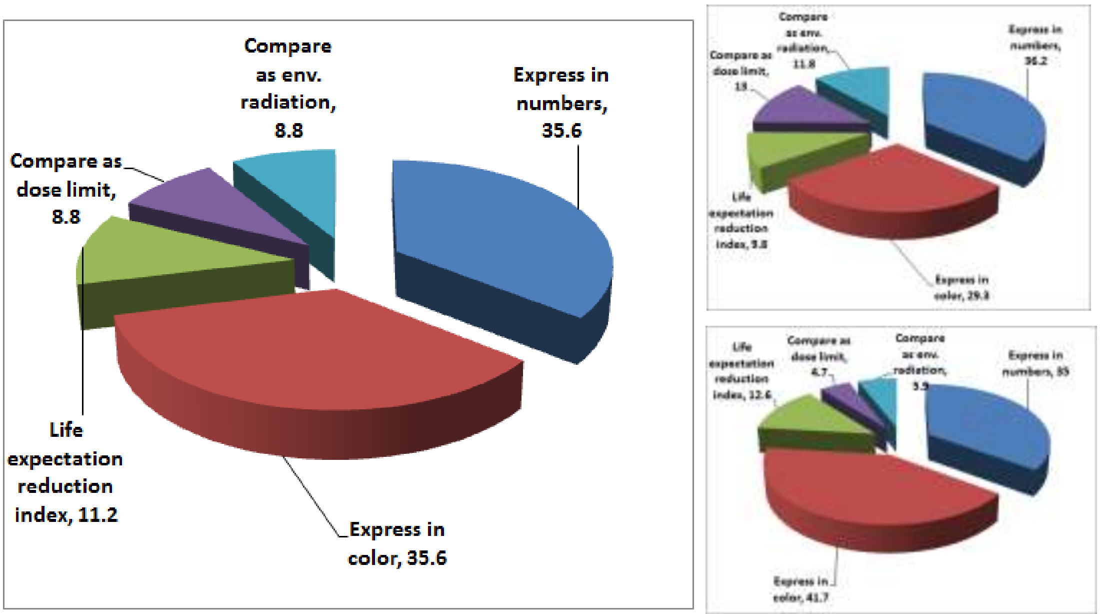


Figure9. Preference of radiation auxiliary unit(Left: All, Top Right: Males, Bottom Right: Females) (Q7)

For the question asking about trusting radiation measurements and press reporting, 28.4% trusted and 31% mistrusted measurement results from professional radiation measurement institutions like national public agencies, while 40.6% sometimes trusted and sometimes did not, showing a widespread distrust. However, for press reports about radiation risks, 32.2% trusted and 29.2% mistrusted, while 38.6% trusted depending on the case.

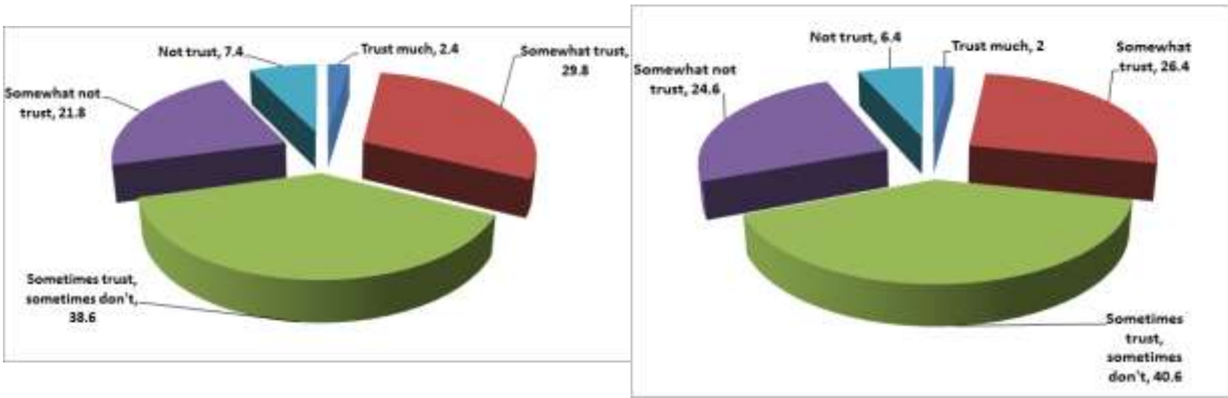


Figure 10. Trust for radiation measurement results from national public agencies (Left: Public Agency, Right: Press Report) (Q8, Q9)

The following were received as other suggestions for the survey. (Table 7)

Table 7. Total opinions on survey result

1. Promotion and education through broadcast media and related facilities is needed	37
2. Related terminology and explanation need to be easier to Understand	25
3. Transparent disclosure of information is needed	16
4. Radiation-related facilities need to be managed well	6
5. Early education regarding radiation needs to be conducted at institutions like schools	6
6. Regular and constant disclosure of information is needed	5
7. Excessive reporting by the press needs to be restrained	1
8. I don't know/no answer	10
Total	106

The survey result for employee showed that 58% of employees joined the company less than 5 years ago, 17% joined 5-10 years ago, and 33% majored in a topic related to radiology while 67% did not. When explaining radiation to the general public, 83% felt difficulty, and among these, 53% answered that they had difficulty explaining the units. 75% answered that they were unfamiliar with standard units but had gotten used to it, contrasting with the survey for the general population. For the use of auxiliary index, 25% was the majority, preferring to express units in dose limit percentages, and 23% followed, preferring to express units in colors.

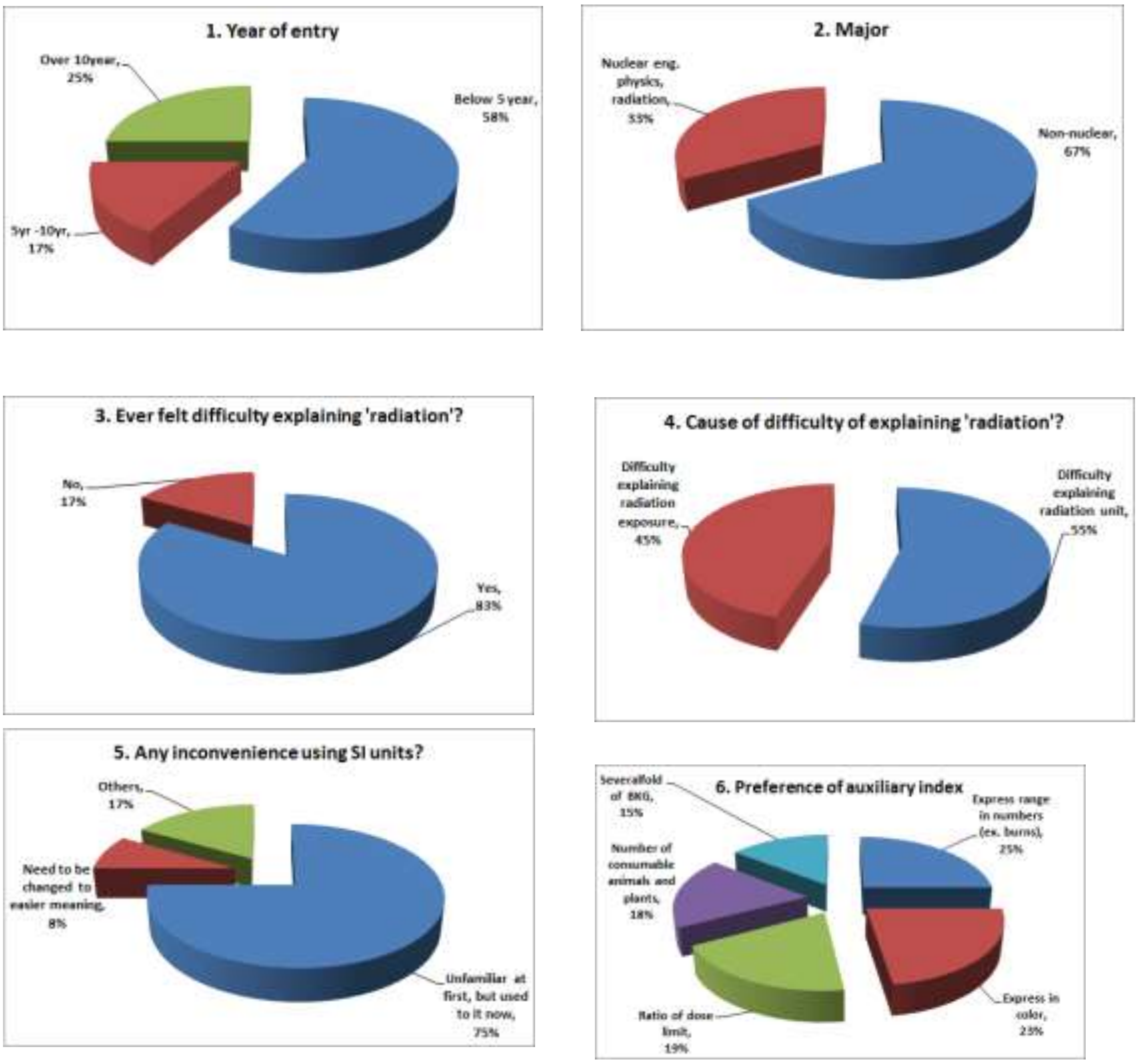


Figure11. Results of employee survey

CONCLUSION

Following the Fukushima accident, the general public's cognizance of radiation has slightly increased, but the reality is that a lot of citizens have difficulty understanding the current SI radiation units. According to survey results, there is a strong need for education of elementary, middle, and high school students. In particular, of great significance is the fact that there are even medical students who think that radiation is contagious in a manner similar to that of HPAI or AIDS, , that 30% of radiology students in Korea answered wrong on the Sv unit, and 50% were not educated,. Also, as a result of consultation, there are the following implications.

○ Field study was proven to have a significant effect (natural radiation measurement, etc.)

○ Recovery of trust in nuclear power plant personnel is crucial: when the Fukushima accident occurred, Japanese citizens trusted information from the U.S. more than the Japanese government

○Scientifically explaining radiation units is no longer effective, and the psychological fear that citizens have must be resolved

○The public is only interested in results and dislike lengthy explanations

The following is a summary of this study based on the study results thus far:

First, we must consider a mid- to long-term plan to break away from explaining radiation units within the existing engineering frame, and continuously do research on radiation units and radiation unit auxiliary indices that citizens are sympathetic to.

Second, for the development of radiation units as an auxiliary unit, it is necessary to express the degree in numbers as in earthquakes/fires or in colors of blue, red, and green. In this case, details may need to be added on the side or additional explanations given in order not to infringe on citizens' right to know. Setting indices that are familiar to the public, such as dose experienced duringa flight, environmental radioactivity in major regions, and assessment of residual radioactivity in regional agricultural and marine products, are important.

Third, as it was shown that 80% of the citizens had not received education about radiation, it was found that measures were needed to conduct education for elementary, middle, and high school students, as well as on teachers.

Fourth, standard units based on engineering are also thought to require long-term research in cooperation with international organizations. In this case, the problems of the existing units will have to be rectified, such as integrating the units or transitioning them into figures that are more in harmony with daily life.

Even outside the field of radiation, the fact that the spread of incorrect information on social media could cause astronomical losses implies a great deal to us. Even radiation could be 'dangerous' rather than 'unconditionally safe.' However, when encountering this kind of situation, a strategy is needed to help people determine for themselves what to do.

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