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Analysis of University Student Awareness of Radiation Exposures from Consumer Products

SeungHwan Kim* and Kunwoo Cho†
*Korean Advance Institute of Science and Technology, 373-1 Guseong-dong, Yuseong-gu, Daejeon, Republic of Korea
†Korea Institute of Nuclear Safety, 62, Gwahak-ro, Yuseong-gu, Daejeon 305-338, Republic of Korea

ABSTRACT

Background: Since the terminology 'radioactive consumer product' is not quite familiar to the public and is often considered as negative and detrimental things, the educational curriculum is essential for establishing reliability of nuclear energy related and for the development of better communication strategy of radiation risk with the public. To provide base data which is valuable for establishing efficient curriculum of education and training about radiation safety, it is necessary to apprehend the different level of awareness of radiation exposures classified by various consumer products.

Materials and Methods: On November 2014, a question investigation about asking awareness level of radiation exposure from various consumer products was done for university students who are highly educated. The object students are studied at a four-year-course universities which is located at Daejeon City.

Results and Discussion: Although the average awareness level is comparatively low, the awareness of senior students, who major in radiation, nuclear related departments and male students are relatively high. On the other hand, the awareness of freshman, sophomore, junior students, who do not major in radiation, nuclear related departments and female students are relatively low. It is necessary to provide various information to avoid unnecessary concerns and misconceptions about radiation exposure.

Conclusion: This paper will be an instrument for efficient establishment of curriculum of education and training related with radiation safety.

Correspondence to Kunwoo Cho
kwcho@kins.re.kr

Keywords: Awareness, Consumer products, Radiation exposures, University students, Education and training

1. INTRODUCTION

Korean society has experienced unexpected diversity hazard source and the public concerns from it during a rapid modernization and a process of economic growth [1]. Exposures from radiation or radioisotope could be one kind of that hazard source, but the usage of radiation or radiation isotope has been increased consistently so now the number of 37,931 institution use it at 2012 since 1958 with enactment of law [2].

Actually everything that we experience emits radiation. Foods and water, air, consumer items including house that we live, ground and even human emit a certain amount of radiation. The total amounts of natural radiation account for 82%. The biggest source of natural background radiation is airborne radon emerged from the earth's crust which contributes 55% exposure to the public. In addition, some essential elements which we should intake to maintain human body is also radioactive matter. This radioactive isotopes is mainly potassium (^{40}K) and carbon (^{14}C) and it adds significant exposure contributions with 11% of total exposure. Terrestrial radiation, largely from uranium and thorium and cosmic radiation from outer space and the sun, mainly protons, neutrons occupy 8% respectively.

Only 18% exposure is come from man-made source. Except occupational dose, which is the dose received by an individual in the course of employment, it is public knowledge that the most important source of man-made radiation is from medical procedures, such as diagnostic imaging (for example, X-rays, CT scanners), nuclear medicine (for example PET, SPECT) and radiotherapy. Medical X-rays occupy 11% of total amount of exposures to the public and nuclear medicine take possession of 4%. In spite of a competitive advantage of radiation, it is always the subject of debate because of its potential risks.

Medical uses are largely responsible for man-made source, however there are 3% of man-made source which portion is the same now as in old times and there are only a few information about it and hard for the public to find it. It is mainly originated from consumer product that can be defined as devices or materials openly used by the public at large and independent from any technical control and maintenance. Compared to medical usage, 3% is significantly small so the prominence is usually neglected. However it definitely exists. It is important for public to have a knowledge about radioactivity level of the products that we use.

A vague fear about nuclear energy and acquisition of knowledge from various ways can deepen the public's negative appreciation of it [3]. The main reason that lots of people have negative awareness about radiation is that the opportunity to get an information is limited to about contents of incidents and accidents from mass media like TV or internet. From this reason, lack or absence of understanding and experience cause fear and pessimistic awareness [4].

From the results of survey to search a source of information about radiation, the point which claims our attention is that the public has obtained the information at internet at a high rate [5]. A fact that the low rate of acquiring information from textbook has great implications for us. By considering general awareness that a knowledge from elementary, middle and high school textbook has lingered quite longer, it is urgent to prepare a confrontational strategy about textbook and curriculum of education related with radiation and its exposure [5].

Alhakami & Slovis (1994) claim that perception of risk decreases as education level increases and from this, the receptivity about nuclear energy of the public will rise [6]. As considering the rate of affirmation about benefits of radiation is higher for adults than teenager, it shows the need for radiation related education [5]. Because there are only small chances to be exposed to radiation related information at the level of compulsory education course.

In Korea there are many cases of failure for nuclear energy related policy, but these cases are usually based on the cognition that information delivery can induce attitudinal change [7]. However the stands about nuclear energy is much more influenced by previously formed awareness than new information and it is not easy to change [7]. Therefore changing the recognition about nuclear energy could be one of the best solution to establish the reliability of nuclear energy related policy.

Before building educational curriculum, it is important to search how people feel about radiation. Actually there are some papers about investigating the awareness of radiation for medical purpose, radiation food irradiation or nuclear energy, however there are no statistics and previous research about the consumer product whose occupation is small with 3%.

This paper aims to investigate acquaintance and awareness about consumer products of university student in Daejeon. For the educational challenges involved in improvement of recognition and reliability of nuclear energy related policy, university students who

Corresponding author : Kunwoo Cho, kwcho@kins.re.kr
Korea Institute of Nuclear Safety, Daejeon, Republic of Korea

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are being highly educated and who just finish compulsory education course become an object of attention. By comparing difference of acquaintance and awareness between different genders, each grade and major related with nuclear engineering and non- major students, this paper will provide supporting data which is necessary for establishing efficient curriculum of radiation exposure from consumer products.

2. THEORETICAL BACKGROUND

A number of products in daily use contain low levels of radionuclides. Some of these items contain low levels of naturally occurring radioactive materials (NORM), which potentially includes all radioactive elements found in the environment. But the great number of consumer products consist of radioactive substance. To utilize chemical and radioactive properties of radioactive material, it is deliberately added to consumer products [8].

It is hard to give a clear definition of consumer product, and there are a number of different ways to categorize it. There are one way to define consumer product as a manufactured product or appliance, or many kinds of source where radioactive material is deliberately or intentionally added and which member of public can easily take without special control [9]. By defining consumer product as above, building materials, spa waters, minerals and foodstuffs are not included in the scope of consumer product [9].

There is a preceding report, Radiation Protection 146 (2007) studying various types of consumer products by J. Shaw, J. Dunderdale and R. A. Paynter of NRPB Occupational Services Department in European Commission. In Radiation Protection 146, all available quantitative data about the number of different types of consumer product are investigated and collected.

Not all consumer products contain radioactive materials. The types of radioactive consumer products refer to the consumer products that the radioactivity are added either intentionally or unintentionally and treated particularly for specific purpose. In this paper, the types of consumer products which will be used at questionnaire is based on data from the Radiation Protection 146. Commonly used consumer products which contain or are composed of radioactive material to be distinguished from levels of environmental background radiation are summarized as follows. The questions about asking awareness of consumer products in the survey are composed on the basis of this 12 items.

2.1 Ionization chamber smoke detectors

The air filled in the chamber between the electrodes is ionized by a radioactive source. The radioactive source is americium-241 which is an alpha emitter and cause very low external dose rates [9].

2.2 Radioluminous products

In radioluminous products, tritium gas and painting of radium-226 or promethium-147 are used as the major two sources for illuminating and highlighting in the dark [9].

2.3 Fluorescent lamp starters

For the initial ionization of the arc to emit visible light, some fluorescent lamps contain small quantities of radioactive materials [9].

2.4 Electronic devices

To make initial ionization or current, electronic devices contain some electronic components which contains small amount of radioactive materials [9].

2.5 Anti-static devices

Some anti-static devices combined with alpha particle emitters may be used by amateur photographers or record collectors to get rid of dust from device such as camera lenses [9].

2.6 Thoriated incandescent gas mantles

Gas mantles impregnated with thorium nitrate can produce thorium oxide in the process of heating to make incandescence [9].

2.7 Thoriated lenses

To changer optical properties of lenses, thorium compounds are added at lenses [9].

2.8 Thoriated tungsten welding electrodes

To enhance the durability of electrode, we sometimes use tungsten inert gas (TIG) welding techniques which includes thorium [9].

2.9 Glassware, tableware, jewellery and ceramic tiles incorporating uranium

To vary color or to make fluorescent and iridescent glass, Uranium compound is used by adding or plastering on surface of the glass [9].

2.10 Dental products incorporating uranium

Uranium compounds with cerium have been used to make antique porcelains for better exterior of false teeth [9].

2.11 Irradiated gemstones

For commercial purpose, sometimes gemstones are irradiated to change its color. Neutron, electron, gamma ray are used to change the structure of gemstones. With changed color, consequentially there are significant activation [9].

2.12 Antique products

When humankind had lack of knowledge about radiation protection, Radium-226 was frequently used for its beneficial effects. After effects of radiation is divulged, we can find it as antique because of production suspension [9].

3. METHODS OF STUDY

There are no previous research paper that search the Korean people's awareness of radiation exposure from only consumer products. Although 3% occupation is relatively small compared to medical purpose usage, ignorance about this field can also be another fear and become negative recognition for nuclear energy. To make an educational curriculum to lower the negative perception and to establish a reliability for policy, first of all we should know current condition that how many people have ever heard about radiation from each consumer product. So the survey in this paper focuses on the awareness about consumer product which accounts for only 3%, someone might neglect.

Although surveying only for Daejeon has a limitation that it is hard to consider as total awareness of Korean university students compared to complete enumeration survey, but Chungcheong Province and Daejeon city are one of the regions where the greatest number of universities resides in Republic of Korea. Therefore this paper could aid to better people's understanding partially.

A survey to examine the acquaintance and awareness about radioactive consumer products by university students in Daejeon area who have a higher education for the educational challenges can be used as a representative indicator of general awareness level by university students and will serve as a good reference for the development of effective education and training program for public awareness of radiation exposure.

The subject of study is students of 4-year universities which are located in Daejeon, Chungnam National University, Hanbat National University, Hannam University, Konyang University, Korea Advanced Institute for Science and Technology (KAIST), Woosong University, total 7 Universities. From 24th November 2014 to 30th November 2014, for 7 days, all students of the universities have done the investigation by utilizing paper questionnaire and online questionnaire provided by Google as investigators.

The total number of students who participated in the survey is 502 students. The available sampling number from among these is 483 students (96.21%) which is used in analysis. There are 16 students who have studied at different universities mentioned above did a survey. There are one student who didn't respond some questions. Lastly there are 2 paper questionnaires that are impossible to recognize. Consequently total 19 paper questionnaires (3.79%) are not included in analysis.

By classifying grade, there are 103 freshman students (21.32%), 188 sophomore students (38.92%), 149 junior students (30.85%), 35 senior students (7.25%) and 8 students (1.66%) more than 4th grade who did questionnaires. The reason to classify results with grade is that university students are the first students who just finish compulsory education course. So the acquired information or experience until high school can be judged from the data of the freshman. Furthermore, we can identify how much information is provided directly or indirectly in the curriculum of college from freshmen to senior.

By classifying major field of study, there are 38 major students (7.87%) and 445 non – major students (92.13%) who did questionnaires. Students' major field of study is classified by major of treating radiation, nuclear engineering and majors of the rest of the department. From this result, the impact of education during university course could be shown.

By classifying gender, there are 250 male students (51.76%) and 233 female students (48.24%) who did questionnaires. The reason to classify results with gender is to know radiation related interest based upon gender. This result would be necessary of educational curriculum to complement for certain gender.

A tool of this paper is questionnaire. The contents of questionnaire ask subjects about general characteristics (university, grade, gender, major) of subjects and 12 questions about radiation exposures from 12 kinds of consumer products. The results of questionnaire will be compared by grade, gender and major to understand tendency and to compare the awareness classified by products. For each questions, there are 4 choices asking degrees of knowledge. The choice for the people in the best know is counted as 4 points and on the contrary to this, the choice for the people who do not know is counted as 1 points.

The collected result is counted to get number, percentage, average and standard deviation through calculation by using Excel as a tool. As there are no statistical data which question Korean university students on the awareness of radiation from consumer products, so this survey would be the first attempt to investigate the awareness of it.

4. QUESTIONNAIRE RESULTS

Each 12 questions about consumer products have 4 choices, A: have never heard, therefore have no idea, B: have a familiar sound, but do not know, C: have a general knowledge, D: know well even radiation source. The results of survey which is sorted on the basis of grade, major and gender is shown in Annex Table.

5. INTERPRETATION

5.1 Differences in the awareness of radiation exposures from various consumer products according to grades.

From the results which is analyzed for each grade, the result of students more than 4th grade is excluded for analysis. Because the sample of questionnaire is rather small (total 8 students) compared to other grades, it is judged that the credibility is not secured. Therefore the comparison is done from freshman to senior.

After scoring every choices that students select, it is able to confirm that senior students get the highest scores for all kinds of 12 consumer products in comparison with other grades. Also total average of all kinds of 12 consumer products is also the highest score. In the case of freshman and sophomore, the level of awareness for all kinds of 12 consumer products are almost similar. The difference of total average score is 0.002 points which can be interpreted as equivalence. In the case of junior, scores for all kinds of 12 consumer products are definitely separated, relatively higher than freshman and sophomore. In conclusion, there are a tendency that the level of awareness and acquaintance rises to higher level with increasing of grades.

For freshman, the awareness of all kinds of 12 consumer products in descending order is fluorescent lamp starters (1.398±0.6437), electronic devices (1.398± 0.6586), radioluminous products (1.281±0.5646), anti-static devices (1.223±0.5733), irradiated gemstones (1.184±0.4776), ionization chamber smoke detectors (1.165±0.3965), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.165±0.4641), dental products incorporating uranium (1.155±0.4570), antique products (1.136±0.3953), thoriated tungsten welding electrodes (1.136±0.4191), thoriated lenses (1.126±0.4553), thoriated incandescent gas mantles (1.116±0.4014).

For sophomore, the awareness of all kinds of 12 consumer products in descending order is fluoresecent lamp starters (1.537±0.6792), radioluminous products (1.345±0.5767), electronic devices (1.340±0.6111), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.186±0.5283), dental products incorporating uranium (1.180±0.4604), anti-static devices (1.175±0.4903), ionization chamber smoke detectors (1.164±0.3851), antique products (1.159± 0.4682), irradiated gemstones (1.148±0.4485), thoriated tungsten welding electrodes (1.101±0.3503), thoriated lenses (1.095±0.3593), thoriated incandescent gas mantles (1.079±0.3405).

For junior, the awareness of all kinds of 12 consumer products in descending order is fluorescent lamp starters (1.610±0.7019), electronic devices (1.577± 0.7524), radioluminous products (1.523±0.7471), anti-static devices (1.429±0.6681), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.402±0.7411), dental products incorporating uranium (1.382±0.6814), irradiated gemstones (1.355±0.6861), ionization chamber smoke detectors (1.315±0.6029), thoriated incandescent gas mantles (1.288±0.5591), antique products (1.255±0.5694), thoriated lenses (1.234±0.5231), thoriated tungsten welding electrodes (1.228±0.5449).

For senior, the awareness of all kinds of 12 consumer products in descending order is electronic devices (1.914±0.8060), radioluminous products (1.914± 0.8741), antique products (1.857±0.8329), dental products incorporating uranium (1.771±0.7959), fluorescent lamp starters (1.742±0.9053), thoriated incandescent gas mantles (1.657±0.8261), ionization chamber smoke detectors (1.628±0.7591), anti-static devices (1.600± 0.7634), thoriated lenses (1.542±0.8050), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.542±0.6904), irradiated gemstones (1.485± 0.7317), thoriated tungsten welding electrodes (1.457±0.6477).

For university students in object universities, radiation exposures from ‘fluorescent lamp starters’ among all kinds of consumer products is the most well-known (for 3 grades). For university students in object universities, radiation exposures from ‘thoriated tungsten

welding electrodes' and 'thoriated incandescent gas mantles' among all kinds of consumer products are the least well-known (for 2 grades of each).

5.2 Differences in the awareness of radiation exposures from various consumer products according to major

After scoring every choices that students select and classifying students with major and non- major students, it is able to confirm that, in every kinds of 12 consumer products, students who major in treating radiation, nuclear engineering get higher scores compared to students who do not major in treating radiation, nuclear engineering. The minimum difference is 0.262 at 'thoriated lenses' and the maximum difference is 0.901 at 'irradiated gemstones'. As a result, the total average score of representing an awareness for major students is also higher than non-major students with 0.5856 points.

For students who major in treating radiation, nuclear engineering, the awareness of all kinds of 12 consumer products in descending order is fluorescent lamp starters (2.263±0.8486), electronic devices (2.184± 0.7899), radioluminous products (2.157±1.0888), irradiated gemstones (2.078±0.9835), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.973±1.0634), dental products incorporating uranium (1.947±0.9986), antique products (1.789±0.8632), thoriated incandescent gas mantles (1.657±0.8668), ionization chamber smoke detectors (1.605±0.9043), anti-static devices (1.552±0.8174), thoriated tungsten welding electrodes (1.447±0.7846), thoriated lenses (1.421±0.7480)

For students who do not major in treating radiation, nuclear engineering, the awareness of all kinds of 12 consumer products in descending order is fluorescent lamp starters (1.487±0.6622), electronic devices (1.413±0.6601), radioluminous products (1.370± 0.5955), anti-static devices (1.280±0.5842), ionization chamber smoke detectors (1.222±0.4716), dental products incorporating uranium (1.222±0.4993), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.220±0.5287), antique products (1.186± 0.4869), irradiated gemstones (1.177±0.4570), thoriated lenses (1.159±0.4636), thoriated incandescent gas mantles (1.157±0.4421), thoriated tungsten welding electrodes (1.152±0.4282).

For university students in object universities, radiation exposures from 'fluorescent lamp starters' among all kinds of consumer products is the most well-known. The Radiation exposures from 'thoriated lenses' among all kinds of consumer products is the least well-known for majoring students and 'thoriated tungsten welding electrodes' among all kinds of consumer products is the least well-known for non-majoring students.

5.3 Differences in the awareness of radiation exposures from various consumer products according to gender

After scoring every choices that students select and classifying students with gender, it is able to confirm that male students get slightly higher scores compared with female students except for 'fluorescent lamp starters' that female students get more 0.117 points than male students. As a result, the total average score of representing an awareness is slightly high with 0.1 points for male students. The minimum difference is 0.024 at 'radioluminous products' which is almost similar and the maximum difference is 0.159 at 'glassware, tableware, jewellery and ceramic tiles incorporating uranium' which also shows not that large difference.

For male students, the awareness of all kinds of 12 consumer products in descending order is electronic devices (1.524±0.7439), fluorescent lamp starters (1.492±0.7112), radioluminous products (1.444± 0.7422), anti-static devices (1.376±0.7004), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.356±0.7023), dental products incorporating uranium (1.348±0.6594), irradiated gemstones (1.324± 0.6595), ionization chamber smoke detectors (1.296± 0.5936), antique products (1.272±0.5916), thoriated incandescent gas mantles (1.256±0.5783), thoriated lenses (1.252±0.6103), thoriated tungsten welding electrodes (1.240±0.5499).

For female students, the awareness of all kinds of 12 consumer products in descending order is fluorescent lamp starters (1.609±0.7039), radioluminous products (1.420±0.6102), electronic devices (1.420± 0.6511), anti-static devices (1.223±0.4831), ionization chamber smoke detectors (1.206±0.4448), dental products incorporating uranium (1.206±0.4907), glassware, tableware, jewellery and ceramic tiles incorporating uranium (1.197±0.5113), antique products (1.193± 0.5002), irradiated gemstones (1.167±0.4465), thoriated incandescent gas mantles (1.133±0.4084), thoriated tungsten welding electrodes (1.107±0.3607), thoriated lenses (1.103±0.3177).

For university students in object universities, radiation exposures from 'electronic devices' is the most well-known for male students and 'fluorescent lamp starters' among all kinds of consumer products is the most well-known for female. For university students in

object universities, radiation exposures from 'thoriated tungsten welding electrodes' is the least well-known for male students and 'thoriated lenses' among all kinds of consumer products is the least well-known for female students.

6. CONCLUSION

The awareness of radiation exposures from various consumer products which is usually neglected because of relatively small quantity compared to medical radiation exposure is low, less than 2 point. The low level of awareness about radiation exposures can cause unnecessary concern and misconception. A risk of which scientific knowledge is unfamiliar to general public makes people feel fear significantly [10].

As the grades of students get higher, we can find that the awareness of radiation exposures from consumer products also rises to higher level. This result can be understood that the university students obtain some information about radiation exposure from various channels regardless of their major, after entering the university.

For the students who major in treating radiation, nuclear engineering, we can find that the awareness of radiation exposures from consumer product is explicitly higher than students who do not study radiation or nuclear engineering. This result shows that the frequency of accommodating information by taking the classes about nuclear and radiation engineering is relatively higher than the frequency for students who do not take any courses about nuclear and radiation. Therefore, for non-major students, it is important that various kinds of information about benefit and harm of radiation exposure should be offered repeatedly through various ways and means.

The result of this study also shows that male students has a slightly higher level of awareness about radiation exposure from consumer products compared to female students.

Although the total exposure quantity from consumer products is relatively and largely small compared with those from the usage for medical purpose, it is important to have appropriate information. To do that, it is necessary to provide related knowledge from radiation safety curriculum at university. We can see that the overall awareness fall short of expectations, although junior and senior students, major students and male students have relatively higher awareness for radiation exposures from each consumer product. Consequently, the major target groups for the provision of knowledge on radiation exposure should be freshman, sophomore, non-major students and female students for increasing the level of awareness.

It can be expected that in the process of designing education program which is related with radiation exposure from consumer product to enhance awareness, the results of this paper will be useful for effective recognition improvement by helping us to understand the characteristics of each group.

Invigoration of industry applying radiation technology is high in socio-economic value from the viewpoint of the enhancement of national competitiveness and improvement of the quality of life of the people. For the stages of investigation and development of a strategy at a national level, the top priority is the understanding on the acceptance of its value by the members of a society [10]. As radiation exposure is difficult theme of access by the general public, efficient and effective program of education and curriculum to help proper and sound understanding of radiation exposure is needed [11].

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Annex Tables

Annex Table 1. Understanding About Radiation Exposures from Various Consumer Products of University Students by Each Grade

Division		Grade					Total
		1st	2nd	3rd	4th	More than 4th	
Ionization chamber smoke detectors	A	87 (84.5%)	158 (84.0%)	111(74.5%)	19 (54.3%)	5 (62.5%)	380 (78.7%)
	B	15 (14.6%)	29 (15.5%)	31 (20.8%)	10 (28.6%)	2 (25.0%)	87 (18.0%)
	C	1 (0.9%)	1 (0.5%)	5 (3.3%)	6 (17.1%)	0	13 (2.7%)
	D	0	0	2 (1.4%)	0	1 (12.5%)	3 (0.6%)
Radioluminous products	A	80 (77.7%)	133 (70.7%)	90 (60.4%)	13 (37.1%)	5 (62.5%)	321 (66.5%)
	B	17 (16.5%)	45 (23.9%)	44 (29.5%)	14 (40.0%)	1 (12.5%)	121 (25.1%)
	C	6 (5.8%)	10 (5.4%)	11 (7.4%)	6 (17.1%)	2 (25.0%)	35 (7.2%)
	D	0	0	4 (2.7%)	2 (5.8%)	0	6 (1.2%)
Fluorescent lamp starters	A	71 (68.9%)	107 (56.9%)	77 (51.7%)	19 (54.3%)	5 (62.5%)	279 (57.8%)
	B	23 (22.3%)	61 (32.5%)	53 (35.6%)	7 (20.0%)	0	144 (29.8%)
	C	9 (8.8%)	20 (10.6%)	19 (12.7%)	8 (22.8%)	3 (37.5%)	59 (12.2%)
	D	0	0	0	1 (2.9%)	0	1 (0.2%)
Electronic devices	A	72 (69.9%)	137 (72.9%)	86 (57.7%)	13 (37.1%)	3 (37.5%)	311 (64.4%)
	B	21 (20.4%)	39 (20.7%)	41 (27.5%)	12 (34.3%)	4 (50.0%)	117 (24.2%)
	C	10 (9.7%)	11 (5.9%)	21 (14.1%)	10 (28.6%)	1 (12.5%)	53 (11.0%)
	D	0	1 (0.5%)	1 (0.7%)	0	0	2 (0.4%)
Anti-static devices	A	87 (84.5%)	163 (86.7%)	99 (66.4%)	20 (57.1%)	4 (50.0%)	373 (77.2%)
	B	10 (9.7%)	18 (9.6%)	37 (24.8%)	9 (25.7%)	3 (37.5%)	77 (16.0%)
	C	5 (4.9%)	6 (3.2%)	12 (8.1%)	6 (17.2%)	1 (12.5%)	30 (6.2%)
	D	1 (0.9%)	1 (0.5%)	1 (0.7%)	0	0	3 (0.6%)
Thoriated incandescent gas mantles	A	94 (91.3%)	177 (94.1%)	113 (75.8%)	20 (57.1%)	7 (87.5%)	411 (85.1%)
	B	6 (5.8%)	7 (3.7%)	30 (20.1%)	7 (20.0%)	0	50 (10.4%)
	C	3 (2.9%)	4 (2.2%)	5 (3.4%)	8 (22.9%)	1 (12.5%)	21 (4.3%)
	D	0	0	1 (0.7%)	0	0	1 (0.2%)
Thoriated lenses	A	94 (91.3%)	173 (92.0%)	120 (80.5%)	22 (62.9%)	7 (87.5%)	416 (86.1%)
	B	6 (5.9%)	13 (7.0%)	24 (16.1%)	8 (22.9%)	0	51 (10.6%)
	C	2 (1.9%)	1 (0.5%)	4 (2.7%)	4 (11.3%)	1 (12.5%)	12 (2.5%)
	D	1 (0.9%)	1 (0.5%)	1 (0.7%)	1 (2.9%)	0	4 (0.8%)
Thoriated tungsten welding electrodes	A	92 (89.3%)	172 (91.5%)	123 (82.5%)	22 (62.9%)	7 (87.5%)	416 (86.1%)
	B	8 (7.8%)	13 (6.9%)	19 (12.8%)	10 (28.6%)	0	50 (10.4%)
	C	3 (2.9%)	3 (1.6%)	6 (4.0%)	3 (8.5%)	1 (12.5%)	16 (3.3%)
	D	0	0	1 (0.7%)	0	0	1 (0.2%)
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	A	90 (87.4%)	164 (87.2%)	109 (73.2%)	20 (57.2%)	6 (75.0%)	389 (80.5%)
	B	9 (8.7%)	14 (7.5%)	23 (15.4%)	11 (31.4%)	0	57 (11.8%)
	C	4 (3.9%)	9 (4.8%)	14 (9.4%)	4 (11.4%)	2 (25.0%)	33 (6.9%)
	D	0	1 (0.5%)	3 (2.0%)	0	0	4 (0.8%)
Dental products incorporating uranium	A	91 (88.3%)	160 (85.1%)	108 (72.5%)	15 (42.9%)	7 (87.5%)	381 (78.9%)
	B	8 (7.8%)	22 (11.7%)	26 (17.4%)	14 (40.0%)	1 (12.5%)	71 (14.7%)
	C	4 (3.9%)	6 (3.2%)	14 (9.4%)	5 (14.3%)	0	29 (6.0%)
	D	0	0	1 (0.7%)	1 (2.8%)	0	2 (0.4%)
Irradiated gemstones	A	88 (85.4%)	167 (88.8%)	111 (74.5%)	22 (62.9%)	5 (62.5%)	393 (81.4%)
	B	11 (10.7%)	14 (7.5%)	26 (17.5%)	10 (28.6%)	3 (37.5%)	64 (13.3%)
	C	4 (3.9%)	7 (3.7%)	9 (6.0%)	2 (5.7%)	0	22 (4.5%)
	D	0	0	3 (2.0%)	1 (2.8%)	0	4 (0.8%)
Antique products	A	91 (88.3%)	166 (88.3%)	121 (81.2%)	14 (40.0%)	7 (87.5%)	399 (82.6%)
	B	10 (9.8%)	14 (7.4%)	18 (12.1%)	13 (37.1%)	1 (12.5%)	56 (11.6%)
	C	2 (1.9%)	8 (4.3%)	10 (6.7%)	7 (20.0%)	0	27 (5.6%)
	D	0	0	0	1 (2.9%)	0	1 (0.2%)

Annex Table 2. Understanding about Radiation Exposures from Various Consumer Products of University Students Majoring Nuclear Engineering and Non-nuclear Related Studies

Division		Major students	Non-major students	Total
Ionization chamber smoke detectors	A	24 (63.1%)	356 (80.0%)	380 (78.7%)
	B	7 (18.4%)	80 (18.0%)	87 (18.0%)
	C	5 (13.2%)	8 (1.8%)	13 (2.7%)
	D	2 (5.3%)	1 (0.2%)	3 (0.6%)
Radioluminous products	A	15 (39.5%)	306 (68.8%)	321 (66.5%)
	B	7 (18.4%)	114 (25.6%)	121 (25.1%)
	C	11 (28.9%)	24 (5.4%)	35 (7.2%)
	D	5 (13.2%)	1 (0.2%)	6 (1.2%)
Fluorescent lamp starters	A	9 (23.7%)	270 (60.7%)	279 (57.8%)
	B	11 (28.9%)	133 (29.9%)	144 (29.8%)
	C	17 (44.7%)	42 (9.4%)	59 (12.2%)
	D	1 (2.7%)	0	1 (0.2%)
Electronic devices	A	8 (21.1%)	303 (68.1%)	311 (64.4%)
	B	16 (42.1%)	101 (22.7%)	117 (24.2%)
	C	13 (34.2%)	40 (9.0%)	53 (11.0%)
	D	1 (2.7%)	1 (0.2%)	2 (0.4%)
Anti-static devices	A	24 (63.1%)	349 (78.4%)	373 (77.2%)
	B	8 (21.1%)	69 (15.5%)	77 (16.0%)
	C	5 (13.2%)	25 (5.7%)	30 (6.2%)
	D	1 (2.6%)	2 (0.4%)	3 (0.6%)
Thoriated incandescent gas mantles	A	22 (57.9%)	389 (87.4%)	411 (85.1%)
	B	8 (21.1%)	42 (9.4%)	50 (10.4%)
	C	7 (18.4%)	14 (3.2%)	21 (4.3%)
	D	1 (2.6%)	0	1 (0.2%)
Thoriated lenses	A	27 (71.1%)	389 (87.4%)	416 (86.1%)
	B	7 (18.4%)	44 (9.9%)	51 (10.6%)
	C	3 (7.9%)	9 (2.0%)	12 (2.5%)
	D	1 (2.6%)	3 (0.7%)	4 (0.8%)
Thoriated tungsten welding electrodes	A	27 (71.1%)	389 (87.4%)	416 (86.1%)
	B	6 (15.8%)	44 (9.9%)	50 (10.4%)
	C	4 (10.5%)	12 (2.7%)	16 (3.3%)
	D	1 (2.6%)	0	1 (0.2%)
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	A	19 (50.0%)	370 (83.1%)	389 (80.5%)
	B	4 (10.5%)	53 (11.9%)	57 (11.8%)
	C	12 (31.6%)	21 (4.8%)	33 (6.9%)
	D	3 (7.9%)	1 (0.2%)	4 (0.8%)
Dental products incorporating uranium	A	18 (47.4%)	363 (81.6%)	381 (78.9%)
	B	6 (15.8%)	65 (14.6%)	71 (14.7%)
	C	12 (31.6%)	17 (3.8%)	29 (6.0%)
	D	2 (5.2%)	0	2 (0.4%)
Irradiated gemstones	A	13 (34.2%)	380 (85.4%)	393 (81.4%)
	B	13 (34.2%)	51 (11.5%)	64 (13.3%)
	C	8 (21.1%)	14 (3.1%)	22 (4.5%)
	D	4 (10.5%)	0	4 (0.8%)
Antique products	A	19 (50.0%)	380 (85.4%)	399 (82.6%)
	B	8 (21.1%)	48 (10.8%)	56 (11.6%)
	C	11 (28.9%)	16 (3.6%)	27 (5.6%)
	D	0	1 (0.2%)	1 (0.2%)

Annex Table 3. Understanding about Radiation Exposures from Various Consumer Products of University Students Classified by Gender

Division		Gender		Total
		Male	Female	
Ionization chamber smoke detectors	A	191 (76.4%)	189 (81.1%)	380 (78.7%)
	B	47 (18.8%)	40 (17.2%)	87 (18.0%)
	C	9 (3.6%)	4 (1.7%)	13 (2.7%)
	D	3 (1.2%)	0	3 (0.6%)
Radioluminous products	A	171 (68.4%)	150 (64.4%)	321 (66.5%)
	B	53 (21.2%)	68 (29.2%)	121 (25.1%)
	C	20 (8.0%)	15 (6.4%)	35 (7.2%)
	D	6 (2.4%)	0	6 (1.2%)
Fluorescent lamp starters	A	158 (63.2%)	121 (51.9%)	279 (57.8%)
	B	62 (24.8%)	82 (35.2%)	144 (29.8%)
	C	29 (11.6%)	30 (12.9%)	59 (12.2%)
	D	1 (0.4%)	0	1 (0.2%)
Electronic devices	A	155 (62.0%)	156 (67.0%)	311 (64.4%)
	B	61 (24.4%)	56 (24.0%)	117 (24.2%)
	C	32 (12.8%)	21 (9.0%)	53 (11.0%)
	D	2 (0.8%)	0	2 (0.4%)
Anti-static devices	A	185 (74.0%)	188 (80.7%)	373 (77.2%)
	B	39 (15.6%)	38 (16.3%)	77 (15.9%)
	C	23 (9.2%)	7 (3.0%)	30 (6.3%)
	D	3 (1.2%)	0	3 (0.6%)
Thoriated incandescent gas mantles	A	203 (81.2%)	208 (89.3%)	411 (85.1%)
	B	31 (12.4%)	19 (8.1%)	50 (10.4%)
	C	15 (6.0%)	6 (2.6%)	21 (4.3%)
	D	1 (0.4%)	0	1 (0.2%)
Thoriated lenses	A	206 (82.4%)	210 (90.1%)	416 (86.1%)
	B	29 (11.6%)	22 (9.5%)	51 (10.6%)
	C	11 (4.4%)	1 (0.4%)	12 (2.5%)
	D	4 (1.6%)	0	4 (0.8%)
Thoriated tungsten welding electrodes	A	204 (81.6%)	212 (91.0%)	416 (86.1%)
	B	33 (13.2%)	17 (7.3%)	50 (10.4%)
	C	12 (4.8%)	4 (1.7%)	16 (3.3%)
	D	1 (0.4%)	0	1 (0.2%)
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	A	190 (76.0%)	199 (85.4%)	389 (80.5%)
	B	35 (14.0%)	22 (9.4%)	57 (11.8%)
	C	21 (8.4%)	12 (5.2%)	33 (6.9%)
	D	4 (1.6%)	0	4 (0.8%)
Dental products incorporating uranium	A	187 (74.8%)	194 (83.3%)	381 (78.9%)
	B	41 (16.4%)	30 (12.9%)	71 (14.7%)
	C	20 (8.0%)	9 (3.8%)	29 (6.0%)
	D	2 (0.8%)	0	2 (0.4%)
Irradiated gemstones	A	192 (76.8%)	201 (86.3%)	393 (81.4%)
	B	39 (15.6%)	25 (10.7%)	64 (13.2%)
	C	15 (6.0%)	7 (3.0%)	22 (4.6%)
	D	4 (1.6%)	0	4 (0.8%)
Antique products	A	200 (80.0%)	199 (85.4%)	399 (82.6%)
	B	33 (13.2%)	23 (9.9%)	56 (11.6%)
	C	16 (6.4%)	11 (4.7%)	27 (5.6%)
	D	1 (0.4%)	0	1 (0.2%)

Annex Table 4. Differences in the Awareness (rating) of Radiation Exposures from Various Consumer Products of University Students by Each Grade

Division	Grade	Number	Average ± standard deviation
Ionization chamber smoke detectors	freshman	103	1.165±0.3965
	sophomore	188	1.164±0.3851
	junior	149	1.315±0.6029
	senior	35	1.628±0.7591
	More than 4th grade	8	1.625±0.9921
Radioluminous products	freshman	103	1.281±0.5646
	sophomore	188	1.345±0.5767
	junior	149	1.523±0.7471
	senior	35	1.914±0.8741
	More than 4th grade	8	1.625±0.8569
Fluorescent lamp starters	freshman	103	1.398±0.6437
	sophomore	188	1.537±0.6792
	junior	149	1.610±0.7019
	senior	35	1.742±0.9053
	More than 4th grade	8	1.750±0.9682
Electronic devices	freshman	103	1.398±0.6586
	sophomore	188	1.340±0.6111
	junior	149	1.577±0.7524
	senior	35	1.914±0.8060
	More than 4th grade	8	1.750±0.7071
Anti-static devices	freshman	103	1.223±0.5733
	sophomore	188	1.175±0.4903
	junior	149	1.429±0.6681
	senior	35	1.600±0.7634
	More than 4th grade	8	1.625±0.6959
Thoriated incandescent gas mantles	freshman	103	1.116±0.4014
	sophomore	188	1.079±0.3405
	junior	149	1.288±0.5591
	senior	35	1.657±0.8261
	More than 4th grade	8	1.250±0.6614
Thoriated lenses	freshman	103	1.126±0.4553
	sophomore	188	1.095±0.3593
	junior	149	1.234±0.5231
	senior	35	1.542±0.8050
	More than 4th grade	8	1.250±0.6614
Thoriated tungsten welding electrodes	freshman	103	1.136±0.4191
	sophomore	188	1.101±0.3503
	junior	149	1.228±0.5449
	senior	35	1.457±0.6477
	More than 4th grade	8	1.250±0.6614
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	freshman	103	1.165±0.4641
	sophomore	188	1.186±0.5283
	junior	149	1.402±0.7411
	senior	35	1.542±0.6904
	More than 4th grade	8	1.500±0.8660
Dental products incorporating uranium	freshman	103	1.155±0.4570
	sophomore	188	1.180±0.4604
	junior	149	1.382±0.6814
	senior	35	1.771±0.7959
	More than 4th grade	8	1.125±0.3307
Irradiated gemstones	freshman	103	1.184±0.4776
	sophomore	188	1.148±0.4485
	junior	149	1.355±0.6861
	senior	35	1.485±0.7317
	More than 4th grade	8	1.375±0.4841
Antique products	freshman	103	1.136±0.3953
	sophomore	188	1.159±0.4682
	junior	149	1.255±0.5694
	senior	35	1.857±0.8329
	More than 4th grade	8	1.125±0.3307

Annex Table 5. Differences in the Awareness (rating) of Radiation Exposures from Various Consumer Products of University Students Majoring Nuclear Engineering and Non-nuclear Related Studies

Division		Number	Average ± standard deviation
Ionization chamber smoke detectors	Major students	38	1.605±0.9043
	Non-major students	445	1.222±0.4716
Radioluminous products	Major students	38	2.157±1.0888
	Non-major students	445	1.370±0.5955
Fluorescent lamp starters	Major students	38	2.263±0.8486
	Non-major students	445	1.487±0.6622
Electronic devices	Major students	38	2.184±0.7899
	Non-major students	445	1.413±0.6601
Anti-static devices	Major students	38	1.552±0.8174
	Non-major students	445	1.280±0.5842
Thoriated incandescent gas mantles	Major students	38	1.657±0.8668
	Non-major students	445	1.157±0.4421
Thoriated lenses	Major students	38	1.421±0.7480
	Non-major students	445	1.159±0.4636
Thoriated tungsten welding electrodes	Major students	38	1.447±0.7846
	Non-major students	445	1.152±0.4282
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	Major students	38	1.973±1.0634
	Non-major students	445	1.220±0.5287
Dental products incorporating uranium	Major students	38	1.947±0.9986
	Non-major students	445	1.222±0.4993
Irradiated gemstones	Major students	38	2.078±0.9835
	Non-major students	445	1.177±0.4570
Antique products	Major students	38	1.789±0.8632
	Non-major students	445	1.186±0.4869

Annex Table 6. Differences in the Awareness (rating) of Radiation Exposures from Various Consumer Products of University Students Classified by Gender

Division		Number	Average ± standard deviation
Ionization chamber smoke detectors	Male	250	1.296±0.5936
	Female	233	1.206±0.4448
Radioluminous products	Male	250	1.444±0.7422
	Female	233	1.420±0.6102
Fluorescent lamp starters	Male	250	1.492±0.7112
	Female	233	1.609±0.7039
Electronic devices	Male	250	1.524±0.7439
	Female	233	1.420±0.6511
Anti-static devices	Male	250	1.376±0.7004
	Female	233	1.223±0.4831
Thoriated incandescent gas mantles	Male	250	1.256±0.5783
	Female	233	1.133±0.4084
Thoriated lenses	Male	250	1.252±0.6103
	Female	233	1.103±0.3177
Thoriated tungsten welding electrodes	Male	250	1.240±0.5499
	Female	233	1.107±0.3607
Glassware, tableware, jewellery and ceramic tiles incorporating uranium	Male	250	1.356±0.7023
	Female	233	1.197±0.5113
Dental products incorporating uranium	Male	250	1.348±0.6594
	Female	233	1.206±0.4907
Irradiated gemstones	Male	250	1.324±0.6595
	Female	233	1.167±0.4465
Antique products	Male	250	1.272±0.5916
	Female	233	1.193±0.5002

Annex Table 7. Differences in the Awareness (total rating) of Radiation Exposures from Various Consumer Products of University Students According to General Characteristics

Division		Research	
		Number	Average ± standard deviation
Grade	freshman	103	1.207±0.0959
	sophomore	188	1.209±0.1276
	junior	149	1.383±0.1252
	senior	35	1.675±0.1549
	more than 4th year	8	1.437±0.2253
Major	Major students	38	1.839±0.2869
	Non-major students	445	1.253±0.1065
Gender	Male	250	1.348±0.0913
	Female	233	1.248±0.1471