APPLICATIONS OF IONIZING RADIATION – DISCLOSURE IS NECESSARY

F. SANTOS
Escola Carlos Drummond de Andrade
Rua Tomás Fonseca, nº 650, Nova Iguaçu, RJ - Brazil

E. MACHADO
Instituto Federal de Educação, Ciência e Tecnologia – IFRJ
R. Cel. Delio Menezes Porto, nº 1045, Nilópolis, RJ - Brazil

M. ALVES, G. DE PAULA
Escola SESC de Ensino Médio
Avenida Ayrton Senna, nº 5677, Rio de Janeiro, RJ - Brazil

F. FAMA, A. A. da SILVA, A. REIS
Instituto de Radioproteção e Dosimetria
Avenida Salvador Allende, s/nº, Recreio dos Bandeirantes, RJ - Brazil

ABSTRACT

Even though the increasing of the application of ionizing radiation in areas such as medicine, industry, safety and research, the general population remains unaware of its applications, risks and benefits. Generally, the terms radiation and nuclear energy are associated with the atomic bomb, cancer, or mutation. Thus, it is observed that people construct their own concepts, influenced by military applications, accidents or even superhero movies or cartoons, where radioactivity is regarded as something extremely dangerous that causes damage to the people and to the environment. Consequently, there is a cultural aversion over the peaceful use of ionizing radiation and their applications in various sectors of society. Since the use of IRs is increasing, misconceptions about radioactivity can harm society causing difficulties in implanting new technologies that involve ionizing radiation as well as panic in the face of a radiation emergency, as small as may it be, which can hinder the response to the emergency. Therefore, it is necessary to demystify radioactivity. This can be done in schools through the dissemination of the applications of IRs in various practices and associated radiological protection. The aim of this work was to evaluate the level of knowledge regarding IRs of students in the last year of high school, as well as present to them a response for radiation emergency and the various applications of IRs. The students answered a quiz with 10 questions in various applications of ionizing radiation, namely, nuclear medicine, food irradiation, computed tomography, industrial radiography, radioactive tracers, irradiation sterilization, radiotherapy and nuclear meters. The questions consisted of statements with the following options: right, wrong or I do not know. After the quiz, two lectures were presented: Radiological Accident in Goiânia and Ionizing Radiation Applications. The number of correct answers was small, confirming that most students are unaware of the applications of ionizing radiation, which could explain the phobia observed when addressing the topic. During the presentation of lectures, students clearly demonstrated their fascination with the themes, asking many questions and expressing surprise to know in which ways ionizing radiation is present in everyday life. Teachers were also very interested and participative. Partnerships are being signed with the schools so that this disclosure occurs annually in order to arouse young people's interest in the nuclear area.

1. Introduction

Applications of ionizing radiations (IRs) are increasing in world. Too many benefits are obtained to society by using radiations in different areas as engineering, industry, research, security, construction and mainly in medicine. But, these applications seem to be unknown by the population which generally associate the radiation with bomb, mutation or cancer. It is observed that people construct their own concepts, influenced by military applications, accidents or even superhero movies or cartoons, where radioactivity is regarded as something extremely dangerous that causes damage to the people and to the environment. Consequently, there is a cultural aversion over the peaceful use of ionizing radiation and their applications in various sectors of society.

Although Brazilian educational legislation requires issues as nuclear energy and radiation applications should be taught in high school, it is easy to find many points that hinder such law requirements. A research in Brazilian publications shows many difficult pointed by teachers to present radiations issues in high school: small numbers of scholar books presenting this issue; students have previous misconceptions about this issue; teachers themselves have previous misconceptions about the issue that prevent them to talk about it without own opinion [1].

A lesson learnt from radiological accident in Goiânia – Brazil put in evidence that people did not know the minimum about radioactivity, causing several difficult in the communication with public. Psychological, economic and commercial effects, as panic, stigmatizing, and shunning people were increased by the lack of knowledge. A psychologist who worked in Goiânia accident strongly recommends clarifying the population about applications of ionizing radiation as well as their risks and their benefits [2].

The need of talk about radiation threats and safety to community was pointed out by Ansari [3] in a book directed to professionals and to population. Using a common language, the author explains natural occurrence of radiation and tells to community how to protect themselves in a situation of radiation emergency. Impacts from a radiation emergency can be reduced by actions taken and by how the population reacts to such situation.

After Fukushima, some studies were carried out and they suggest a new approach about radiation needs to be addressed in schools [4, 5]. The demands for education on radiation subjects increased not only by professionals but also by students. The NIRS (National Institute of Radiological Sciences) is visiting school to conduct classes on radiation basics [6]. Authors conclude that the school visits significantly changed the students' feelings toward radiation from "fear" to "interest" and are helpful for school teachers because they do not have enough knowledge to teach about radiation.

A study carried out with elementary, middle and high school students' evaluated changes in the levels of their perception, knowledge, and attitude for each sector that uses radiation [7]. A communicating strategy was developed to form a consensus on the use of radiation and nuclear power and to improve public understanding. The authors found that the levels of perception, knowledge, and attitude increased highly for sectors that use radiation after the radiation class. They suggest that classes should be provided continuously once positive behavioural changes are expected.

Considering that there is a misconception about radioactivity, this can harm directly the society causing difficulties in implanting new technologies that involve the use of ionizing radiation. The lack of knowledge how to handle safely the radiation usually cause panic to the people about the possibility of any accident with radioactivity. Therefore, it is necessary to demystify what is radioactivity. This can be done in schools, in different levels, through the dissemination the concepts about this subject including several demonstrations of the peaceful applications of the ionizing radiation associated radiological protection.

The aim of this work was to evaluate the level of knowledge of students in the last year of high school regarding ionizing radiation, to clarify the misunderstanding concepts, to present the practices related to a response for radiation emergency and to show the several peaceful applications of ionizing radiation. The students answered a quiz with 10 questions about various applications of IRs.

2. Methodology

As the objective was to evaluate the level of knowledge regarding IRs of students in the last year of high school, a quiz with 10 questions on various applications of ionizing radiation, namely, nuclear medicine, food irradiation, computed tomography, industrial radiography, radioactive tracers, irradiation sterilization, radiotherapy and nuclear meters. The questions consisted of statements with the following options: right, wrong or I do not know.

The 50 students in this study did not have a special class on ionizing applications including quiz statements. The objective was to evaluate their knowledge with the regular classes from the school without any additional improvement in their knowledge. The students were encouraged to be extremely sincere; they had not the obligation to get a good score in the quiz. It was empathized to the students that the most import was to show what they actually known about ionizing radiation applications.

After the quiz, two lectures were addressed about the Radiological Accident in Goiânia - Brazil and The Ionizing Radiation Applications. After the class, the students evaluated their answers to the questions made previously.

3. Results and discuss

The answers percentages are presented in Table 1. The gray cells are the percentages of right answers.

From statement (a) answers, 37% of students recognize nuclear medicine. In statement (c) 36% seems to recognize that patient receive a radiation dose when undergo to this procedure and 51% seem to recognize the same in mammography and radiotherapy as can be seen in statement (f) and (g), respectively. As medicine presents the highest increasing of ionizing radiation applications, these concepts should be better discussed with students considering radiation dose received and risk-benefit relationship.

Statement (g) is a real case occurred about ten years ago. At that time, the conclusion was: the airline lost money! Only 22% of students considered that the airline decision has been wrong.

Tab 1. Percentage (%) results from quiz answered by last year high school students.

Statements	True	False	I do not know
a) Radioactive material can be injected in patient body to do an image exams or clinical treatment.	37	41	22
b) Foods as meals and fruits exposed to ionizing radiation increase the shelf life. These foods can be consumed without damage to health.	6	78	16
c) Computed Tomography is an exam with high resolution image which allows evaluating the health conditions and, the advantage is that patient does not receive radiation dose.	31	36	33
d) Some radioactive elements, in small amounts, are added to beverages to alter the colouring. As the amount of radioactive material is low, these drinks can be consumed freely.	24	37	39
e) In medicine, radiography is used to evaluate a broken arm. In industry, the radiography is used to evaluate manufacturing defects of an aircraft turbine or in a steering column of a car.	53	12	35
f) Mammography is a test recommended for women in order to diagnose early possible breast cancer cases and it reduces the mortality rates in certain age group; however, women who undergo this exam receive a dose of ionizing radiation in the breasts.	51	22	27
g) An airline has refused to carry medical equipment because it carries a radiation sterilization certificate. The airline had a correct attitude because this material could cause damage to the health of passengers during the flight.	31	22	47
h) Paper documents can be longer lasting if irradiated. One technique for conserving books, pictures, maps, photographs is to disinfect such documents by applying a significant dose of ionizing radiation.	16	23	61
i) Radiation therapy is a method capable of destroying tumour cells using bundles of ionizing radiation. A dose of radiation is applied at a given time to a volume of tissue encompassing the tumour, seeking to eradicate all tumour cells.	51	14	35
j) One of the applications of ionizing radiations in the industry are nuclear meters. An example is the density meter in a paper mill, which consists of positioning the source of radioactivity on one side of the paper and the radiation detector on the opposite side. When the radiation passes through the paper it is possible to evaluate the density of the paper.	27	10	63

Food irradiation had the minimum right answers (6% only!). This result is similar to other from students of other schools. Our results may be in accordance with HAN *et al* [7], who said: *"… if accurate information on irradiated food and nuclear power is not provided, (…) then students are expected to vote in opposition to nuclear power and avoid purchasing and consuming irradiated food.*"

The percentages of right answers in the statements (b), (g) and (h) indicate the need to present the use of irradiation in foods, sterilizing and disinfecting.

The major number or right answers was for industrial radiography (statement (f)). The analogy with medicine should be considered.

Statement (d) received 37% of right answers, which considering not possible to add radioactive material in beverages to change the coloring. It indicates that justification and risk-benefit relationship need to be addressed in presentations to students.

Nuclear meters have important applications in industry, but this application of ionizing radiation has to be presented with details to the students as can be observed from Table 1 in statement (j). A detailed presentation has to include issues as radiation properties, penetrating of ionizing radiation, etc.

Answers of the quizzes are presented in the Figure 1. The right answers percentage was 34%. The major number of answers was "*I DO NOT KNOW*", which corroborates the need to addressing the radiation issue in high school.

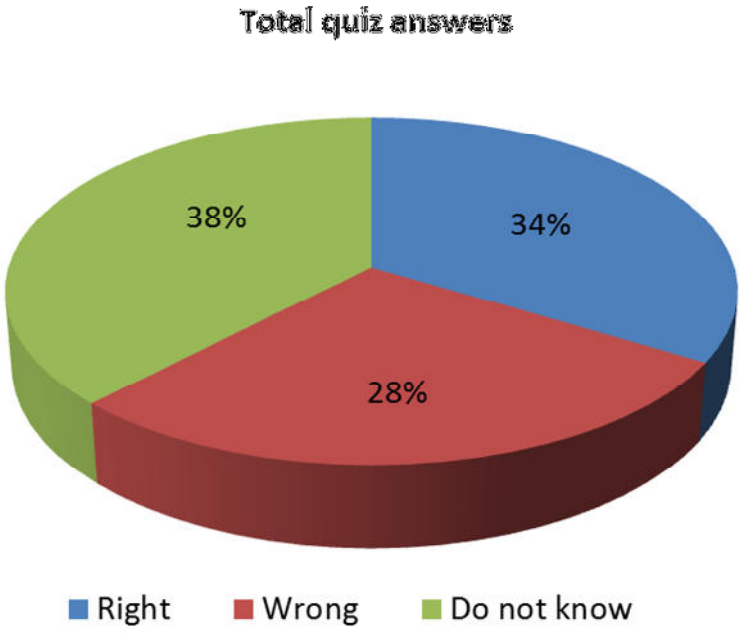

Fig 1. Percentage of total quiz answers of third year high school students: 34% right, 28% wrong and 38% do not know.

Two lectures about fifty minutes each one, are presented. The first one was about the Brazilian experience during the Goiânia radiological accident. Many slides of

professionals who worked in that accident were showed. The second class was about the applications of ionizing radiation. In these two lectures the questions and answers of the quizzes that students did before were discussed.

During the presentation of lectures, students clearly demonstrated their fascination with the themes, asking many questions and expressing surprise to know in which ways ionizing radiation is present in everyday life. Teachers were also very interested and participative.

4. Conclusions

The number of correct answers was small, confirming that most students are unaware of the applications of ionizing radiation, which could explain the phobia observed when addressing the topic.

Disclosure of ionizing radiation applications can be the way to demystify radioactivity through the knowledge of many uses of it in the society. Some concepts as justification, risk-benefit and cost-benefit relationship should be addressed in the lectures.

Partnerships are being signed with the schools so that this disclosure occurs annually in order to arouse young people's interest in the nuclear area.

Most data are being generated by the quiz application in other schools. That will allow a comparison among schools and grade schools. Quiz and a blank space to students make questions or give theirs opinion has help us to improve our lectures to this specific public.

5. References

1. LUCENA E. A., REIS, R. G., SORES, A. P., et al, **Radiação ionizante, energia nuclear e proteção radiológica para a escola,** *Braz J Rad Sciences***,** DOI: 10.15392/bjrs.v5i1.215, 2017.

2. IAEA, International Nuclear Information System – INIS Collection. **The Physicological Impact of the Radiological Accident in Goiânia**. Disponível em <http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/20/008/20008221.pdf >. Último acesso: 10 de janeiro de 2017.

3. ANSARI, A. **Radiation Threats and Your Safety: a Guide to Preparation and Response for Professionals and Community**, Taylor & Francis Ltd, ISBN 13: 9781420083613, 2009.

4. Midori Yoshida, Eiichi Honda, Oyunbat Dashpuntsag, **Availability of Japanese Government's supplemental texts on radiation reflecting the Fukushima Daiichi Nuclear Power Plant accident for elementary and secondary education from dental students' understanding**, Journal of Environmental Radioactivity, pages 155-156, 2016.

5. Goto, S., Nozawa, I., Lino, S., **Characteristics of Nuclear Power and Radiation Education for Schools in Fukushima Prefecture, Japan** – *in: International Conference New perspective in Science Education*, 5ª Edition – Florence, IT, 2017.

6. Shimizu Y, Iida H, Nenoi M and Akashi M, **Importance of Supporting School Education on Radiation After the Fukushima Daiichi Nuclear Power Plant Accident**, *J Health Educ Res Dev*, DOI: 10.4172/2380-5439.1000214, 2017.

7. HAN, E. O., KIM, J. R., and CHOI, Y. S., **Educational Effects of Radiation Work-study Activities for Elementary, Middle and High School Students.** Nuclear Engineering and Technology. Volume 46, Issue 3, pags. 447 – 460, 2014.

Ionizing radiation is generally divided into electromagnetic radiation and particulate radiation. Charged particles are affected, and this will include protons, beta particles and alpha particles. Neutrons, another particulate form of ionizing radiation, won't be affected. Electromagnetic ionizing radiation, cosmic rays and gamma rays, are not effected. Is alpha radiation a ionization radiation? Ionizing radiation is everywhere. It arrives from outer space as cosmic rays. It is in the air as emissions from radioactive radon and its progeny. Naturally occurring radioactive isotopes enter and remain in all living things. It is inescapable. Indeed, all species on this planet evolved in the presence of ionizing radiation. While humans exposed to small doses of radiation may not immediately show any apparent biological effects, there is no doubt that ionizing radiation, when given in sufficient amounts, can cause harm. These effects are well known both in kind and in degree. While ionizing ... Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research. As the use of ionizing radiation increases, so does the potential for health hazards if not properly used or contained. Acute health effects such as skin burns or acute radiation syndrome can occur when doses of radiation exceed certain levels. Low doses of ionizing radiation can increase the risk of longer term effects such as cancer. What is ionizing radiation? Ionizing radiation is a type of energy released by atoms that travels in the form of electromagnetic waves (gamma or