Radiological risk perception in medicine: current issues and challenges found in a national survey

Pablo ANDRES[1,2,*], Cristian SOSA VERA[1,2], Fiorela MERMA VELASCO[1], Alexis MELANO CHÁVEZ[1], and Astrid BENGTSSON[1]

[1]*Centro Atómico Bariloche, Comisión Nacional de Energía Atómica, Av. E. Bustillo Km. 9.5, R8402AGP San Carlos de Bariloche, Argentina*
[2]*Instituto Balseiro, Universidad Nacional de Cuyo, Av. E. Bustillo Km. 9.5, R8402AGP San Carlos de Bariloche, Argentina*
*Corresponding author's e-mail: andresp@cab.cnea.gov.ar

Abstract. Radiological risk perception is the result of a complex combination of knowledge, cultural background, emotions of relative risks, and messages and information received from trustworthy people and reliable organisations. In order to look into this subject, a national survey was organised. A fifteen-question dedicated questionnaire was designed including socio-demographic variables (such as gender, age and profession) and questions about work environment, risk perception and risk communication were asked. A five-point Likert-type scale (from strongly agree to strongly disagree) was used for most of the questions. Also, surveyed people were asked to compare radiological risks in medicine with other daily and familiar risks such as those related to smoking, extreme sports and leisure activities. A web-based version was distributed among people by e-mail and through social networks. The survey was voluntary and anonymous. The participants pool consisted of 164 individuals (92 women and 72 men, age: 20 to 72 years old) from all over the country and 10 Argentine radiation protection experts. The descriptive statistics were used to present distribution of the socio-demographics and the respondents' risk perceptions. Results showed good agreement between risk perception of laypeople and experts in most situations; however, a negative correlation could be seen between these two groups when they were asked about the risk associated to a computed tomography (CT) exam and the training in radiological protection received by healthcare professionals while at college. Finally, a lot of work must be done in order to build an agreement between radiological risk perceptions and risk assessment due to radiation medical exposures. It should involve working on the design of public policies focused on radiological protection training for health staff, strengthening communication skills and channels and the recognition of the radiological protection of patients as a public health issue.

KEYWORDS: radiological protection, risk perception, risk communication, Argentina.

1 INTRODUCTION

Public concerns about radiation exposure and its health effects in human beings have intensified because of an increased number of radiation uses, such as medical diagnosis and disease treatment, industrial applications, and scientific and educational uses [1]. This concern coming from the public is closely related to how people perceive radiation risk. In other words, it takes account of people's subjective judgments about the occurrence of personal harm due to radiation exposure (e.g.: injury, illness, disease, death). Moreover, risk perception plays a key role in health and risk communication since it determines which hazards people care about and how they deal with it. Also, it helps identifying and understanding differences and similarities between laypeople and experts, which is translated, for example, in the way people define their regulation [2].

Ionising radiation is a broad, complicated and often misunderstood topic by the general public. Exposure to ionising radiation is usually associated with danger and harm, especially as the radiation dose increases [3]. However, individuals are all the time exposed to ionising radiation from different sources: naturally occurring, medical imaging and other human-made. Some studies point out a difference in both risk perception and knowledge of actual sources of ionising radiation between laypeople and radiation experts. Reasons for this difference can be found in how mass media portrays radiation-related health risks, which may exaggerate some of them and minimise others; the technical language used by experts is often misunderstood by the general public, given educational discrepancies in the population at large. According to some research studies, perception of radiological and nuclear risks is often emotional and unlikely to be altered; this often feeling-centred perception

usually explains why nuclear power is perceived as extremely risky in opposition as how radiological risks in medicine are discerned [4, 5].

When radiological risks in medicine are more deeply enquired into, some studies suggest that laypeople are not concerned about the radiation-related health effects from medical exams because of a widespread notion that healthcare professionals have received proper training and are competent in minimising risks. However, healthcare professionals may not be as informed as the public believes [6]. Physicians tend to underestimate the dose of ionising radiation from medical sources, and some are even unaware of which medical tests are sources of ionising radiation [7, 8]. There exists a great need to give proper goal-oriented information. That is, information focused on the characteristics of the population groups receiving it. Despite a vast radiation and nuclear related-history in Argentina, the studies assessing radiological risk perception cannot be easily found nationwide. For this reason, a national survey was performed to identify how people perceive this risk and how it is compared to other familiar risks people are often exposed to. Also, the survey searched for similarities and differences between the perception of risk laypeople and radiation protection experts have. In order to determine an effective methodology for instituting communication and educational programmes, it is vital to first gain an appreciation for current knowledge and perceptions which exist about ionising radiation among laypeople and national experts.

2 METHODOLOGY

A fifteen-question dedicated questionnaire was designed including socio-demographic variables (such as gender, age and profession) and questions about work environment, risk perception and risk communication were asked. A five-point Likert-type scale (from strongly agree to strongly disagree) was used for most of the questions. Also, surveyed people were asked to compare radiological risks in medicine with other daily and familiar risks such as those related to smoking, extreme sports and leisure activities.

The Likert-type scale was given the following values: 1. Strongly disagree; 2. Disagree; 3. Neither agree nor disagree; 4. Agree; 5. Strongly agree. In order to analyse the relative risk perception, participants could choose one of the following risk level options for each activity: very low; moderately low; low; neither low nor high; high; moderately high; very high. The correlation between variables was estimated by calculating the Pearson correlation coefficient. The descriptive statistics (such as mean and percentage) were used to present the distribution of the socio-demographics and the respondents' risk perceptions.

A web-based version of the questionnaire was distributed by email and through social networks. The survey was voluntary and anonymous. The participants pool consisted of random people from all over the country. The same survey was sent via email to 26 radiation protection national experts. The experts were selected among a group of thirteen men and thirteen women. They all have more than fifteen years of professional experience in radiation protection in different fields (nuclear, medicine, industry, regulatory authority) and are international recognised radiation protection professionals.

3 RESULTS

One hundred and sixty-four people replied the questionnaire, of whom, 92 were women and 72 were men (mean age: 36.2 years old, range: 20-72 years old). A high percentage (80.5%) of surveyed people had a university degree. Responses came from 18 out of 24 provinces, including the national capital city. On the other hand, only ten out of the 26 radiation protection national experts replied the survey, which represents only 38.5% of the experts reached.

Firstly, people were presented five risk categories related to health risks: radiation-related health risks (such as undergoing a computed tomography (CT) exam), leisure-related health risks (such as sunbathing at noon or doing extreme sports), smoking-related health risks, job-related health risks (such as job stress) and other (non-nuclear)-related health risks (such as driving a car or riding a

bicycle in a busy street during rush hour). Regarding risk, respondents had to classify these categories in five options: very low, low, neither low nor high, high and very high. The results are shown in Table 1.

Table 1: Risk perception. Comparison between laypeople and radiation protection experts. The Pearson correlation coefficient, *r*, is shown. References: LP: laypeople; RPE: radiation protection experts; VL: very low; ML: moderately low; L: low; NLH: neither low nor high; H: high; MH: moderately high; VH: very high.

	Radiation-related risks r = -0.16		Leisure-related risks r = 0.77		Smoking-related risks r = 0.64		Job-related risks r = -0.34		Other (non-nuclear)-related risks. r = -0.13	
	LP [%]	RPE [%]	LP [%]	RPE [%]	LP [%]	RPE [%]	LP [%]	RPE [%]	LP [%]	RPE [%]
VL	18.9	30.0	11.3	0.0	9.1	0.0	13.4	0.0	24.2	3.3
ML	34.1	0.0	18.3	10.0	14.0	0.0	13.4	0.0	16.7	6.7
L	17.1	20.0	7.9	10.0	8.5	0.0	9.1	0.0	11.8	10.0
NLH	11.0	20.0	8.2	5.0	4.9	10.0	5.5	40.0	15.4	23.3
H	10.4	10.0	23.2	45.0	23.8	30.0	23.2	10.0	17.9	33.4
MH	4.3	0.0	15.2	20.0	16.5	40.0	22.6	10.0	10.6	3.3
VH	4.3	20.0	15.9	10.0	23.2	20.0	12.8	40.0	3.5	20.0

The second half of the questionnaire was evaluated by applying a five-point Likert-type scale (from strongly agree to strongly disagree) and included the following topics: (a) information and knowledge about radiation-related health effects and radiation protection; (b) perception of increase of cases of cancer; (c) communication in social networks; (d) knowledge about overexposure situations and likelihood of radiological accidents. The results are summarized in tables 2 to 5.

Table 2: Information and knowledge about radiation-related health effects and radiological protection. References: LP: laypeople; RPE: radiation protection experts.

.	Level of agreement	LP [%]	RPE [%]
When a radiation medical procedure must be performed, information given to the patient is enough and reliable. Correlation coefficient: 0.65	Strongly agree	7.3	0.0
	Agree	32.9	20.0
	Neither agree nor disagree	20.8	0.0
	Disagree	31.7	70.0
	Strongly disagree	7.3	10.0
Health personnel receive enough training on radiological protection while at university. Correlation coefficient: -0.91	Strongly agree	4.3	0.0
	Agree	29.9	0.0
	Neither agree nor disagree	36.6	10.0
	Disagree	26.2	60.0
	Strongly disagree	3.0	30.0
Radiation-related risks can be under control regarding current scientific knowledge. Correlation coefficient: 0.96	Strongly agree	23.2	30.0
	Agree	51.2	50.0
	Neither agree nor disagree	17.7	10.0
	Disagree	7.3	10.0
	Strongly disagree	0.6	0.0

Participants were also asked to write down the words they often use to search for information about ionising radiation in medicine. The results are summarised in figure 1. The word clouds were built in the original language to avoid mistakes in translation and to highlight the differences between the vocabulary applied by experts and laypeople.

Table 3: Perception of increase of cases of cancer. References: LP: laypeople; RPE: radiation protection experts.

	Level of agreement	LP [%]	RPE [%]
Being exposed to ionising radiation at work increases the likelihood of future undesirable health effects. Correlation coefficient: 0.85	Strongly agree	42.1	50.0
	Agree	36.6	20.0
	Neither agree nor disagree	12.2	20.0
	Disagree	7.3	10.0
	Strongly disagree	1.8	0.0
Living near a nuclear power plant increases the incidence of cancer in the population. Correlation coefficient: 0.46	Strongly agree	15.2	10.0
	Agree	17.7	10.0
	Neither agree nor disagree	23.8	10.0
	Disagree	27.4	40.0
	Strongly disagree	15.9	30.0
Using ionising radiation in medical procedures results in more benefit than harm to the patient. Correlation coefficient: 0.93	Strongly agree	26.2	40.0
	Agree	47.6	50.0
	Neither agree nor disagree	20.7	10.0
	Disagree	3.7	0.0
	Strongly disagree	1.8	0.0
Radiation received when undergoing an x-ray exam as a patient increases the likelihood of cancer in the future. Correlation coefficient: 0.99	Agree	50.0	90.0
	Neither agree nor disagree	25.0	0.0
	Disagree	25.0	10.0

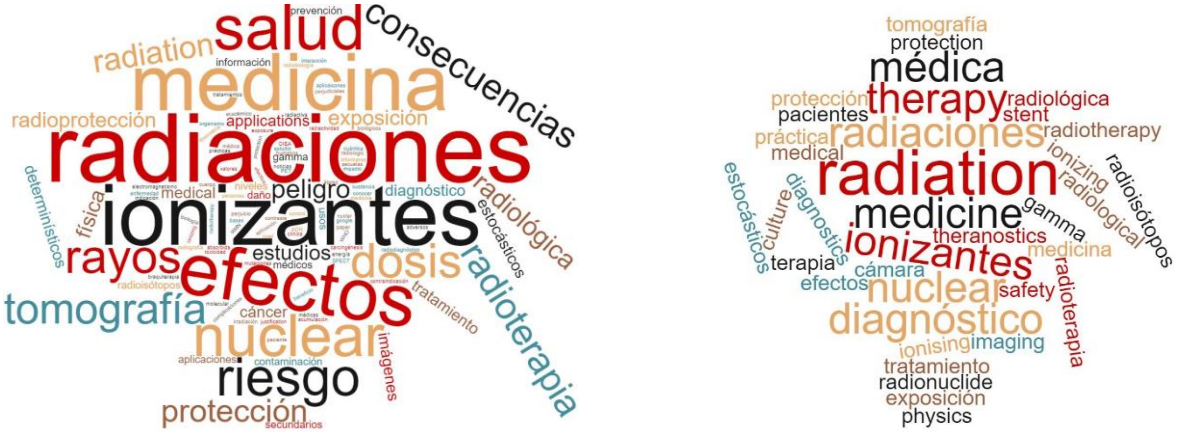
Table 4: Radiation risk communication in social networks. References: LP: laypeople; RPE: radiation protection experts.

	Level of agreement	LP [%]	RPE [%]
Short messages in social networks have enough and reliable information. Correlation coefficient: 0.99	Strongly agree	0.6	0.0
	Agree	6.7	10.0
	Neither agree nor disagree	42.1	40.0
	Disagree	37.2	40.0
	Strongly disagree	13.4	10.0

Table 5: Knowledge and perception of occurrence of overexposure situations. References: LP: laypeople; RPE: radiation protection experts.

	Level of agreement	LP [%]	RPE [%]
Overexposure of patients when undergoing radiation-medical exams happened in Argentina Correlation coefficient: 0.03	Agree	31.1	90.0
	Neither agree nor disagree	62.8	10.0
	Disagree	6.1	0.0
The likelihood of radiological accidents at nuclear power plants is higher than that related to radiation medical exams Correlation coefficient: 0.93	Agree	13.4	0.0
	Neither agree nor disagree	35.4	20.0
	Disagree	51.2	80.0

Figure 1: Word clouds built with the words that laypeople (left image) and radiation protection experts (right image) often use to search for information about ionising radiation in medicine. The answers are written in the original language.



4 DISCUSSION

A web-based version of the questionnaire was distributed by email and through social networks. The radiation protection experts were sent an email with the survey's web link and a brief explanation about the framework and objectives of this research. The web link was available during one month and no reminder was sent during this period of time. The small percentage of participation (38.5%) of this group of people surveyed lays on the table whether radiation protection experts are really interested in the subject and what professional societies do in order to communicate the facts. Further research must be done in order to find out the reasons and responses for this behaviour, that is, such a little participation in the survey. Also, a joint effort should be done to work together (experts and healthcare professionals) and to agree common communication strategies.

Perception of health risks (Table 1): Risk is usually defined in the literature as a multiplicative combination of the probability of a hazardous event occurring and the severity of the resulting negative consequences [9]. From this point of view, risk itself is understood as an objective approach to risk assessment, which often considers two key components: how severe the negative consequences are and the likelihood of the occurrence of a malignant event. Nevertheless, risk perception is much more complex since it is influenced by characteristics other than probability and severity. Risk perception is shaped by the knowledge people have about the existence of a health risk and by the feeling of being themselves at risk [10]. Health risks were grouped in five categories: radiation-related, leisure-related, smoking-related, job-related and other (non-nuclear)-related. A positive correlation was found about leisure and smoking-related risks between laypeople and experts. On the other hand, a negative correlation coefficient can be seen when the radiation-related risk perception is estimated between laypeople and experts. Almost three quarters of the first group perceived radiation medical exams as a low-risk activity against a half of experts replying this way. The results found here do not fit with those published in previous surveys carried out by other authors [7], where it was found that experts have a systematic lower risk perception for risks concerning radiation and nuclear technology than the general public.

Information and knowledge about radiation-related health effects and radiological protection (Table 2): Determining what information is important to patients undergoing an X-ray medical exam and how satisfied they are with the information provided by healthcare staff is critical. Patients should know what the potential adverse or side effects might be in order to face them more appropriately, especially when they undergo radiation therapy for cancer treatment. According to the results obtained in this survey, almost half of the respondents (laypeople) think the information given to patients is enough and cover the patient's needs. Nevertheless, experts do not agree and they believe the information given to patients is insufficient or scarce. International literature suggests there is a lot to do in this

field: on one hand, patients are satisfied with the information received [11, 12]. On the other hand, some reports state that at least one third of patients wish they had known more about the risks of potential adverse effects from their treatment before they were exposed to it [13]. Since there are no local studies about this subject, the remaining question is whether these international findings can be extrapolated to the results observed in this survey, keeping in mind socio-demographics and cultural differences between populations. In order to solve this out new research works on this topic will be carried through soon.

Regarding training of healthcare personnel, only one third of laypeople think the radiological protection training received at university is enough. This could be understood as a need for improvement in the training opportunities related to radiation protection. It also might be seen as an opportunity to enquire into how healthcare professionals are trained on radiation protection while at college and identify, if had, teaching programme's weaknesses. Radiation protection experts, on the other hand, consider the training in radiation-related topics received by healthcare personnel is insufficient. This lack of correlation between the perspectives of both groups might be justified by a lack of information among laypeople, how they receive it [6] and because these individuals usually tend to trust physicians, even when they usually underestimate doses of ionising radiation from medical sources, and some are even unaware of which medical tests are sources of ionising radiation [7, 8].

Perception of increase of cases of cancer (Table 3): Increased cancer risk near nuclear power plants remains in fact an open question; answers will come from larger and deeper radiation epidemiology studies. In the meantime, some papers state this open question feature, where the need for more research is highlighted [14, 15], and some other reports show negative results when correlating increase of cancer risk and the radiation doses received by people living in the neighbourhood of a nuclear power plant [14, 16]. The perception of increase of cases of cancer is quite the same between laypeople and radiation protection experts. However, a clear difference could be seen about the perceptions these groups have about the consequences of living near a nuclear power plant. This could be a consequence of inappropriate communication strategies carried out by organisations and professional societies working with ionising radiation, as well as the media pressure performed by anti-nuclear groups.

When people were asked about the likelihood of developing cancer after being exposed to radiation as a consequence of a medical exam, meaning, as a patient, one half of laypeople replied that this exposure does not increase the likelihood of cancer in the future. One explanation for this response might be that laypeople perceive the risk of medical exposure more generously, since the psychological characteristics of these risks including voluntariness (individuals decide to undergo medical exams and treatments to improve their lives), and distribution of risks and benefits are different [4, 5].

Radiation risk communication in social networks (Table 4): Although short messages in social networks have become an important and frequent channel of communication utilised both by different public and governmental organisations and private companies, one half of individuals surveyed do not trust them and in their opinion the information provided is not enough. The same percentage of the experts surveyed agreed with the other group's point of view; however, 40% out of them showed what might be considered as a neutral opinion about this way of communication. One reason for these responses could be fake news, which plays an important negative role in science communication, as well as the hunger for first news and a tendency for misleading and attracting attention. Moreover, these short messages are usually spread by "influencers" regardless of accuracy and no official references at all [17]. This biased and often shocking information make people believe it despite a lack of a proven scientific source. Another reason for this atmosphere of mistrust could be that scientific knowledge regarding radiation risks still has not reached the general public in Argentina [18, 19]. In addition to it, a recent research performed in this country found that one half of the information spread by the media is incorrect or erroneous from the scientific or technical point of view. Moreover, it usually prompts the reader to a line of thought that could be assumed to be biased [20]. Although the

headlines can be changed and corrected later, the question is whether it can really take it back and the possible potential harm repaired.

When reading the clouds of Figure 1, words like *"dosis"* (dose), *"efectos"* (effects), *"riesgo"* (risk), *"consecuencias"* (consequences), *"salud"* (health), *"cáncer"* (cancer), *"peligro"* (danger) show up only in the laypeople's cloud. Although further research must be done in this field, this could mean that laypeople look for information thinking of themselves as patients. From that point of view, the search is guided by questions whose answers do not come from experts (and maybe patients do not bring themselves to ask those questions). In other words, laypeople seem to search for information while thinking about the results and radiation-related health effects on their own bodies, whilst experts, a priori, seem to be focused on technical aspects only. This is not only a radiation risk communication problem, but also a science and technology communication issue.

Knowledge and perception of occurrence of overexposure situations (Table 5): Accidents and risks from medical radiation exposure have been widely described and studied for the last few decades [21]. Several millions of medical diagnostic and therapeutic radiation exams are performed annually worldwide, so medical radiation incidents can be expected (actually, they happen), some of them recognised sometime after their occurrence. If properly and timely identified, most radiological incidents are easy to manage and do not usually cause casualties. In Argentina, almost 300 radiological incidents (patients overexposed to radiation due to medical exams) have been recorded until 2016 [22]. However, most of the individuals surveyed ignore the facts. This could be a consequence of inappropriate communication strategies carried out at a national level.

5 CONCLUSION

Perception of radiological and nuclear risks has often an emotional component among laypeople, which is conditioned sometimes by a communication bias coming from the media, unlikely to be altered. Also, experts are influenced by their environment and reality. This often feeling-centred perception usually explains why nuclear power is perceived as extremely risky in opposition as how radiological risks in medicine are discerned. And there are usually differences between the perception different groups of individuals have about it. The bigger the differences, the more difficult the possibility to build bridges of communication.

By carrying out this research, several topics could be pointed out: the authors could draw a picture of how laypeople and radiation protection experts perceive radiation risks, in particular those associated with medical procedures. Furthermore, a comparison between these two groups of people could be made, and the findings should be used to improve communication strategies and regulations currently valid in the country. Last, based on the findings of this research, the authors remark the need to go one step further considering the bias among the different groups studied and the impact of radiation comprehension and communication.

Although there is neither right nor wrong risk perception, a lot of work must be done in order to build an agreement between radiological risk perception and risk assessment due to radiation medical exposures. It should involve working on the design of public policies focused on radiological protection training for health staff, strengthening communication skills and channels, and most importantly, the recognition of the radiological protection of patients as a public health issue.

6 REFERENCES

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