PERCEPTION OF MEDICAL PROFESSIONALS ON RADIOLOGICAL SAFETY PRACTICES IN THE WORKPLACE

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PERCEPTION OF MEDICAL PROFESSIONALS ON RADIOLOGICAL SAFETY PRACTICES IN THE WORKPLACE (Abstract): Radiation protection aims to reduce unnecessary exposure to radiation to minimize the harmful effects of ionizing radiation, this goal is achieved by using different means and methods of radiation protection. The **aim** of this study was to analyze the knowledge, perceptions, and attitudes of medical personnel in the N-E Region of Romania regarding radiation protection and the effects of ionizing radiation. **Materials and methods:** The study was carried out based on the use of a structured questionnaire for data collection, a questionnaire that was distributed to the medical staff (doctors, nurses, radiologists) from hospitals and medical centers in the N-E Region of Romania. **Results:** The results show that most respondents know about the stochastic and deterministic biological effects of ionizing radiation, but a significant group has incomplete, average, or uncertain knowledge about this topic. **Conclusions**: These aspects suggest a need for additional education in the field of radiation protection in the workplace. **Keywords:** RADIATION PROTECTION, IONIZING RADIATION, BIOLOGICAL EFFECTS.

INTRODUCTION

In the medical field, ionizing radiation has become an inevitable tool used for diagnosing and treating a variety of medical conditions. Ionizing radiation is radiation (electromagnetic or corpuscular) that has enough energy to ionize the atoms (molecules) of the substance with which it interacts.

As their use has evolved, so have the cumulative doses of lifetime radiation that both patients and healthcare providers (healthcare professionals) receive. This requires a thorough understanding of the risks of radiation exposure and radiation dose reduction techniques in order to prevent biological effects. It was observed that although there were extraordinary benefits, there were associated dangers, equally great, not only for patients who underwent X-ray investigations, but also for the personnel who operated the facilities using X-rays. In addition to wearing radiation protection equipment (lead aprons, thyroid protection collars, lead salt glasses, gloves with lead insert), there were recommendations on limiting the exposure time (exposures as short as possible), along with X-ray beam filtering and the use of collimation (1-8).

Radiation exposure produces important biological effects, and prolonged exposure can lead to cell death. Biological effects are divided into stochastic effects and deterministic effects. The stochastic effects are due to cellular changes (DNA) and proliferation towards malignant diseases. The severity of the effects is independent of the dose but may increase with increasing dose. There is no threshold dose, the effects can occur even at very low doses, but the probability of the effect increases proportionally with the dose. The deterministic effects are due to cell death and have a threshold dose – a few Grays. They are specific depending on the affected tissue, and the severity of the effect is dose-dependent, the threshold being different from individual to individual (3, 14**).**

In the case of the use of CBCT (Cone Beam Computed Tomography), it has been observed that there are genotoxicity and cytotoxicity effects at the level of exfoliated oral epithelial cells. Cytotoxicity can lead to nuclear changes and usually causes lethal injury or necrosis (15).

Radiation protection is the totality of methods and means of reducing the harmful effects of ionizing radiation. Radiation protection aims to minimize the harmful effects of ionizing radiation by reducing unnecessary exposure to radiation. Ionizing radiation is used in the medical field to diagnose and treat a variety of medical conditions. The more they are used, the higher the cumulative lifetime radiation doses received by both professionally exposed personnel and patients (1).

After the discovery by W. C. Roentgen of X-rays in November 1895 and the increasingly accelerated use in the twenty-first century, the role of radiation protection was highlighted as an important tool for the management of health protection measures against the risks (for people and the environment) arising as a result of the use of ionizing radiation (5, 8).

A particular concern has been observed with long-term irradiation, at low, cumulative doses, which can lead to an increase in malignant diseases and genetic mutations, effects that can propagate to future generations. Thus, it is important to analyze the risk-benefit factor when using irradiation techniques (14). In order to reduce the radiation dose, the aim was to implement strategies to improve dose optimization, to draw up standard protocols, as well as to implement the concept of good practices (7, 12).

The radiation protection system aims to prevent the occurrence of deterministic effects and to reduce the occurrence of stochastic effects. Medical personnel working both in interventional radiology and in specialties that use interventional radiology techniques (cardiology, neurosurgery, orthopedics, urology, pulmonology, vascular surgery) are exposed to ionizing radiation coming from artificial sources (radiological installations), their protection is ensured by the use of lead screens (lead aprons, lead screens) (2, 16).

In the case of interventional radiology, the leaded apron with or without a collar is the standard clothing used against ionizing radiation. It is designed sleeveless, so the armhole can be an unprotected area, and the radiation scattered from the patient can contribute to an increase in doses to different organs of the operator and thus increase the effective dose (6). Since the equipment mentioned above is quite heavy and has a drawback, the absence of sleeves, we tried to introduce a much lighter protective equipment, in order to observe its effectiveness against ionizing radiation. Thus, it was found that the proposed new equipment reduces the dose by approximately 98.1% and 90.1%, respectively. With the addition of radiation protection shields, a dose reduction of 99.0% and 98.2% was observed (17).

Another method of dose reduction is the "As Low as Reasonably Achievable" (ALARA) principle. This principle was first introduced in the nuclear energy sector and was later adopted in the field of radiology and medical imaging, with the aim of warning professionally exposed personnel that medical imaging should be used with justification (13).

Studies conducted so far indicate a low level of knowledge of radiation exposure in medical imaging among both healthcare professionals and patients (4). Studies from Greece and Turkey have highlighted significant deficiencies in radiation protection, influenced by educational level and professional experience, recommending continuous training and review of medical training to correct misperceptions and improve the quality of services (9, 10, 11).

In Romania, radiological safety in medicine is regulated and studied within the norms imposed by CNCAN (National Commission for the Control of Nuclear Activities). Research and regulations focus on diagnostic, interventional, and nuclear medicine radiology, with an emphasis on staff training, risk assessment, and implementation of radiation protection programs. For example, mandatory radiation protection courses for healthcare professionals and occupational exposure monitoring programs to ionizing radiation are required, tailored to the specific risks of each medical practice (18-20). What is important to emphasize is the lack of studies carried out at the national level, studies that assess the level of knowledge and attitudes regarding radiation protection. Thus, the purpose of this study was to analyze the knowledge, perceptions, and attitudes of medical personnel in the North-East Region of Romania regarding radiation protection and the effects of ionizing radiation.

MATERIALS AND METHODS

The observational study carried out in the North-Eastern region of Romania, between May 20 and June 15, 2024, aimed to analyze the knowledge, perceptions, and attitudes of medical personnel (doctors, nurses, radiologists) regarding radiation protection and the effects of ionizing radiation. The data were collected through a structured questionnaire, developed based on the literature and the research objectives, after obtaining the opinion of the Ethics Committee of "Grigore T. Popa" University of Medicine and Pharmacy Iasi.

The sample, consisting of 100 participants selected by a convenience technique, ensured adequate representativeness for statistical analyses.

The questionnaire, applied online between May 20th and June 15th, 2024, through the Google Forms platform, included questions about the biological effects of radiation, known methods of radiation protection, optimal exposure intervals, and workplace safety measures. Before data collection, a pilot phase was carried out to validate the instrument. Only fully completed questionnaires were considered, and the process included coding and statistical analysis of data, providing a detailed insight into the level of training and awareness of medical staff.

Statistical analysis was descriptive, presented in the form of frequencies, percentages, and mean values for the variables of interest, and the correlation analysis where Pearson or Spearman correlation coefficients were used to examine the relationships between the variables. The threshold of statistical significance was set at p=0.05.

RESULTS

The analysis was conducted on a representative sample of 95 respondents. Of the total participants, 75.8% have bachelor's or post-secondary studies (in the case of nurses), 10.5% have master's degrees, and 13.7% have completed postgraduate studies. 45.3% of respondents have 10 years or less of seniority in the specialty, which suggests that almost half of the respondents are at the beginning or middle of their career (fig. 1).

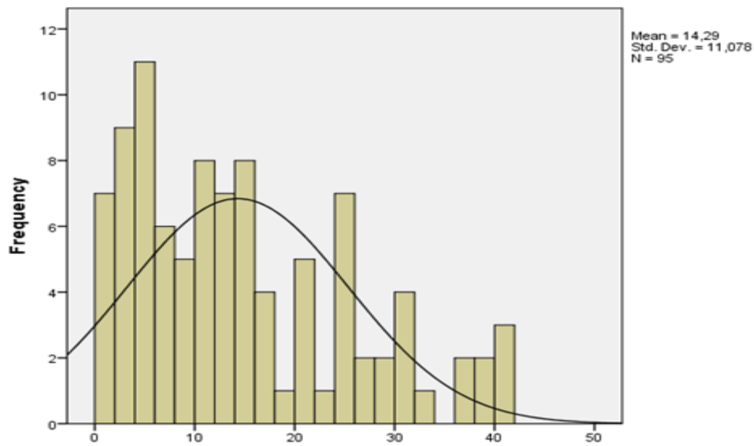

Fig. 1. Distribution of years of seniority of medical professionals

The perception of the safety status was achieved through the analysis of indicators, such as knowledge of the stochastic biological effects of ionizing radiation, fear of radiation effects, known radiation protection methods, optimal exposure range, and safety measures at work. After analyzing the results, it was found that most of the respondents (74.7%) have knowledge about the stochastic and deterministic biological effects of ionizing radiation, which shows a high level of information among the staff. A significant group (22.1%) has incomplete or average knowledge, suggesting a possible need for further education in this area. Very few respondents (2.1%) have no knowledge or are uncertain about this topic, which is positive, but still indicates the need for continuous awareness (tab. I).

TABLE I.

Do you know the stochastic/deterministic biological effects of ionizing radiation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	71	74.7	74.7	74.7
	Not	1	1.1	1.1	75.8
	Partially	21	22.1	22.1	97.9
	Ns/Nr	2	2.1	2.1	100.0
	Total	95	100.0	100.0	

From the analyses performed, a moderate positive correlation can be observed Pearson = 0.234, (Sig. 2-tailed) = 0.022 between the knowledge of these effects and the level of study. This suggests that as the level of education increases, knowledge of the biological effects of radiation tends to increase as well. Moreover, there is a significant but weak negative correlation between fear of ionizing radiation and level of education, suggesting that people with higher education tend to have less fear of radiation (-0.263, p = 0.010) (tab. II).

TABLE II.
The correlation between the level of education and knowledge/fear in relation to ionizing radiation

		Studies
Studies	Pearson Correlation	1
	Mr. (2-tailed)	
	N	95
Do you know the stochastic /? deterministic biological effects of ionizing radiation?	Pearson Correlation	,234*
	Mr. (2-tailed)	,022
	N	95
Are you afraid of ionizing radiation?	Pearson Correlation	-,263*
	Mr. (2-tailed)	,010
	N	95

The most harmful of all the diseases listed are leukemia and hematological diseases. The damage to the digestive system has an average of 2.83, which indicates a lower perception of harmfulness compared to other effects, and with a moderate perception (mean = 3.64) we have effects on the immune system. All perceptions of harmful effects (cancer, genetic mutations, leukemia, and thyroid disease) are strongly correlated with each other, with correlation coefficients ranging from 0.656 to 0.817. This indicates that those who consider one effect to be harmful tend to attach similar importance to the other effects (tab. III).

We found a negative correlation between the knowledge of these biological effects and the fear of radiation (-0.213). which suggests that there is a relatively weak association between the two investigated variables. which is nevertheless statistically significant (0.038). Thus. as the level of knowledge about the biological effects of ionizing radiation increases. the fear of ionizing radiation tends to decrease. and vice versa (tab. IV).

From the analysis of the data. we find that 62.1% of people say that they do not have a certain fear of ionizing radiation. but there is a considerable percentage that says that there are certain aspects that can lead to fears in the activity they do.

Concerns about ionizing radiation and the assessment of its biological impact highlight significant correlations between fear of radiation and the perception of serious conditions associated with exposure to it. For cancer. the correlation coefficient is 0.390. indicating a moderate and statistically significant positive correlation (p = 0.000) between fear of radiation and the belief that it is a serious effect of radiation exposure. This suggests that people with a greater fear of radiation tend to consider cancer as one of the most severe consequences of such exposure. For genetic mutations. the correlation coefficient is 0.220. statistically significant at the level of 0.05 (p = 0.032). which reflects a weak positive correlation between fear of radiation and its perception as harmful effects. Respondents with an increased fear of radiation are more likely to perceive genetic mutations as dangerous. although this association is less strong compared to that for cancer (tab. V).

TABLE III.

Perception of the biological effects of radiation

What biological effects do you consider to be more harmful? Scale 1-5	A	B	C	D	E	F	G	H	I	J
MEAN	**4.25**	**4.15**	**4.31**	**4.01**	**3.01**	**3.05**	**3.81**	**3.64**	**2.83**	**3.64**
A	1									
B	.758**	1								
C	.817**	.760**	1							
D	.671**	.656**	.713**	1						
E	.328**	.307**	.296**	.301**	1					
F	.357**	.286**	.363**	.269**	.790**	1				
G	.448**	.390**	.533**	.454**	.414**	.354**	1			
H	.464**	.436**	.410**	.421**	.435**	.390**	.646**	1		
I	.420**	.368**	.389**	.331**	.623**	.567**	.517**	.627**	1	
J	.590**	.502**	.645**	.491**	.310**	.344**	.507**	.534**	.578**	1
Mr. (2-tailed)	**.000**	**.000**	**.000**	**.000**	**.002**	**.001**	**.000**	**.000**	**.000**	**.000**
N	**95**	**95**	**95**	**95**	**95**	**95**	**95**	**95**	**95**	**95**

A - [Cancer]. B- [Genetic mutations]. C- [Leukemia and hematological disorders]. D- [Thyroid disorders].
E- [Radiological burns]. F- [Acute radiation syndrome]. G- [Reproductive system damage]. H- [Eye system damage]
I- [Damage to the digestive system]. J- [Suppression of the immune system]

TABLE IV.

Analysis of correlations between knowledge of biological effects and fear of ionizing radiation

		Do you know the stochastic/ deterministic biological effects of ionizing radiation?	Are you afraid of ionizing radiation?
Do you know the stochastic / deterministic biological effects of ionizing radiation?	Pearson Correlation	1	-.213*
	Mr. (2-tailed)		.038
	N	95	95
Are you afraid of ionizing radiation?	Pearson Correlation	-.213*	1
	Mr. (2-tailed)	.038	
	N	95	95
*. Correlation is significant at the 0.05 level (2-tailed).			

TABLE V.
Correlations between fear of radiation and the perception of serious conditions associated with exposure to it

Correlations		Are you afraid of ionizing radiation?	What biological effects do you consider to be more harmful?			
			Cancer	Genetic mutations	Leukaemia and hematological disorders	Thyroid disorders
Are you afraid of ionizing radiation?	Pearson Correlation	1	.390**	.220*	.323**	.266**
	Mr. (2-tailed)		.000	.032	.001	.009
	N	95	95	95	95	95

**. Correlation is significant at the 0.01 level (2-tailed) / *. Correlation is significant at the 0.05 level (2-tailed).

In the case of leukemia and hematological disorders. the correlation coefficient is 0.323. significant at the level of 0.01 ($p = 0.001$). indicating a moderate positive correlation. People who show a greater fear of radiation are more inclined to consider leukemia and hematological disorders as harmful effects of radiation. For thyroid disorders. the correlation coefficient is 0.266. significantly at the level of 0.01 ($p = 0.009$). which indicates a moderate positive correlation. but relatively weaker than that observed for leukemia or cancer. There is a standard deviation of responses above 1 within the variables "Reproductive system impairment" and "Immune system suppression." which suggests a wide dispersion of opinions. indicating that participants have different perceptions of the severity of these effects (tab. 3).

In the study on the recognition of radiation protection methodologies. several techniques were evaluated to determine the level of familiarity and perception of their effectiveness among participants. Lead barrier screens. with a score of 90.6%. stand out as a widely accepted and considered effective method. Personal dosimetry. which obtained an average score of 60.4%. is not the most recognized method of radiation protection but indicates a high appreciation of its importance in safety measures (fig. 2).

Fig. 2. Known radiation protection methods

Concerning the category of various protective methods (classified under "Other.."). the most frequently mentioned methods of radiation protection are the collimation of the radiation beam and the use of personal protective equipment. such as the protective apron with Pb insert and the collar with Pb insert. to protect the thyroid.

each of which is mentioned several times. Also mentioned were the collimation. the use of filters. the walls plated with lead or barite. the leaded glass. and the performance of radiological investigations as rarely as possible.

When asked about the optimal interval between exposures for optimization (referring to professionally exposed personnel - doctors. nurses. medical bioengineers. physicists). 24.2% of the participants opted for an interval of one hour. 11.6% for a day. 10.5% for a week and 8.4% for a month. while 45.3% gave other varied answers (tab. VI).

TABLE VI.

Best exposure interval for optimization

		Frequency	Percent
Valid	1 hour	23	24.2
	1 day	11	11.6
	1 week	10	10.5
	1 month	8	8.4
	Another answer	43	45.3
	Total	95	100.0

In terms of protection measures. respondents were questioned about the following variables: confidence in safety measures. regular updating of these measures. consultation with experts on radiation safety. and collaboration with radiation protection experts (tab. 7).

Regarding trust in security measures. the media of 7.94 indicates a relatively positive assessment of trust in existing security measures. although it is not perfect. The median of 9.00 suggests that most respondents rate this confidence close to the top of the scale. The standard deviation of 2.633 indicates moderate variability in responses. Positive kurtosis (0.553) suggests a slightly flat distribution. indicating that there are more very high ratings than in the case of a normal distribution (tab. 7).

TABLE VII.

Degree of confidence in radiation safety

How do you rate on a scale from 1 (not at all) to 10 (very much) the following statements?		[I am confident in the safety measures in place in the workplace]	[Security measures are periodically updated according to new technologies and research in the field]	[The occurrence of incidents related to workplace safety is low]	[We are regularly consulted on radiation safety]	[We call on radiation protection experts in case of incidents that occur in the workplace]
N	Valid	95	95	95	95	95
	Missing	0	0	0	0	0
Mean		7.94	7.81	6.75	7.29	8.23
Median		9.00	9.00	9.00	9.00	10.00
Std. Deviation		2.633	2.818	3.501	3.118	2.804
Kurtosis		.553	-.047	-1.445	-.888	.370
Std. Error of Kurtosis		.490	.490	.490	.490	.490

The results highlight that those who say they are confident in the safety measures are fully aware of the biological effects considered more harmful. There is a very strong and statistically significant relationship between the updating of security measures regularly and the level of confidence of employees in the security measures implemented in the workplace. The Pearson coefficient of 0.889 indicates a very strong and positive correlation. This means that as the clarity and availability of emergency procedures are present. employee confidence in radiation safety measures also increases. The meaning of 0.000 confirms that this relationship is extremely robust.

Moreover. in this examination. the associations between knowledge of radiation protection methods and confidence in safety measures were analyzed. The Pearson coefficient of 0.261 indicates a weak positive association between understanding the use of lead screens and confidence in safety protocols. suggesting that a deeper awareness of the protective role of these barriers contributes to increased confidence in workplace safety. although the influence is not particularly pronounced.

In terms of the perception regarding the periodic updating of security measures. the general perception is positive. but the variation in responses indicates that some employees believe that this aspect can be improved (mean: 7.81 - standard deviation: 2.818). Regarding the degree of occurrence of incidents related to safety at work. the average of responses is 6.75. showing a greater concern among employees regarding security incidents. However. the perception is quite varied. with a high dispersion of the answers provided (tab. VIII).

Regarding the periodic consultation of staff in relation to radiation safety. the variation in responses is relatively large. suggesting that some employees feel that they are not consulted often enough on issues related to radiation safety.

TABLE VIII.

Correlations between trust in security measures and different indicators

		Do you know the stochastic / deterministic biological effects of ionizing radiation?	What biological effects do you consider to be more harmful? [Cancer]	Known Radiation Protection Methods (Barrier Lead Screens)	How efficient is the equipment today?	How do you assess how the introduction and adoption of new technologies is managed?	[Security measures are periodically updated according to new technologies and research in the field.
I am confident in the security measures in place at work.	Pearson Correlation	-.299**	.212*	.214*	.390**	.261*	.889**
	Mr. (2-tailed)	.003	.039	.037	.000	.010	.000
	N	95	95	95	95	95	95

DISCUSSION

The present study was carried out starting from the following variables. namely. the knowledge of the stochastic biological effects of ionizing radiation. the fear of the effects of radiation. the known radiation protection methods. the optimal exposure interval. and the safety measures at the workplace.

In terms of knowledge of the stochastic

biological effects of ionizing radiation. the analysis showed that some of the respondents have adequate knowledge about the effects of radiation. but we have an important number of those who show that they have incomplete knowledge. indicating the need for additional education. The moderate positive correlation between knowledge of the effects and level of education suggests that more advanced education is associated with a better understanding of the effects of radiation. These conclusions are also supported by the cross-sectional study carried out in Greece involving 132 members of the medical staff. including nurses. radiographers. and doctors. with a response rate of 97% (10). A study in Nigeria found that 92% of medical personnel demonstrated a solid knowledge of radiation safety. but only 81% complied with protective measures (20). In Sri Lanka. nurses showed satisfactory awareness of radiation protection. but gaps in understanding the effects of radiation persisted. indicating a need for further training (21).

In terms of fears about the effects of radiation. the perception of risks varies significantly. with healthcare professionals and patients often having limited knowledge and fears related to exposure. The fear of radiation decreases with the increase in the level of education. having a significant negative correlation coefficient. The negative correlation between knowledge about the effects of radiation and fear of it suggests that a better understanding of the effects of radiation helps reduce fears. although fear is greater in the case of cancer. leukemia. and genetic mutations. Numerous studies reiterate the need for a high level of knowledge about radiation protection (22). There is a fairly unified perception regarding the harmfulness of biological effects. Analyzing the average of the responses on the knowledge of these effects. the following can be found: for carcinogenic effects. there is an average of 4.25 responses. which indicates that most consider cancer as one of the most harmful effects of ionizing radiation. In terms of genetic mutations. the average of 4.15 suggests that they are considered to be very harmful.

In terms of radiation protection methods. various radiation protection methods have been implemented to reduce the risks associated with radiation exposure. These include the use of protective equipment (lead aprons. collars for thyroid protection). limiting exposure time. filtering the X-ray beam. and collimation. By applying these measures. significant reductions in the effective dose have been achieved (8. 16. 17). Our research supports these conclusions. from applied questionnaires showing that lead barrier screens are the most known and appreciated (90.6%). and personal dosimetry has a moderate recognition (60.4%) (fig. 2). However. awareness of radiation protection methods has a weak correlation with trust in security measures. indicating that a better understanding of protection does not significantly influence confidence in security measures. Correlated with our results. a survey in Karachi revealed that although radiology workers had a basic understanding of radiation protection. their confidence in patient protection measures was insufficient (23).

Other research. however. has shown a significant correlation between understanding radiation and protective practices. but this has not extended to trust in safety measures ("An empirical analysis of the relationship between understanding. attitudes. and practices toward radiation – Focusing on the population eligible for South Korean National Health Insurance Service Examination") (24).

Regarding the optimal exposure range. the ALARA principle ("As Low as Reasonably Achievable") remains an essential benchmark. which aims to minimize radiation exposure by justifying each exposure. This approach focuses on minimizing the radiation dose received. both for patients and occupationally exposed staff (13). From our results. the optimal interval between exposures varies significantly. with most respondents indicating short intervals (for 1 hour). and a considerable proportion giving varied answers. Overall. the implementation of these optimization strategies is essential to protect healthcare professionals while ensuring high-quality imaging (25).

The study also looked at trust in workplace safety measures. This is relatively high. but variable. The very strong correlation between the regular updating of security measures and the level of trust suggests the importance of keeping the measures up to date in order to ensure a high level of confidence in these measures. Especially in interventional radiology and other specialties that use radiological techniques. safety measures are essential. These include wearing protective equipment and using lead screens. Studies have shown that new protective equipment can significantly reduce the dose of radiation. but there are still unprotected areas. such as the arms. that require additional solutions to minimize exposure (6. 17).

The main limitation in the present study was represented by access to medical professionals and the presence of non-probability sampling.

CONCLUSIONS

The analysis shows that the level of education of medical professionals significantly influences the knowledge about the effects of ionizing radiation. Most respondents have a good understanding of these effects. although there is a need for continuous training. An inverse correlation was observed between the level of education and fear of radiation. with those with advanced education being less fearful. The fear of radiation is directly proportional to the perceived severity of these conditions. The variability of perceptions of the optimal exposure range suggests the need for clearer guidelines.

Confidence in radiation safety measures is high. but constant updates and consultations with experts are essential to maintain it. A well-protected and educated work environment reduces perceived radiation-related risks.

CONFLICT OF INTEREST AND FUNDING

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