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ARTICLE

Assessment of radiation safety culture among radiological technologists in medical imaging departments in Saudi Arabia

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Abstract – This study aimed to evaluate the perception of radiation safety culture among medical radiological technologists (MRTs) in the Kingdom of Saudi Arabia. The study was performed from June 2022 to February 2023 and involved MRTs from various hospitals and medical centres in Saudi Arabia. A cross-sectional study was conducted using a self-administered and previously validated radiation safety culture survey instrument in medical imaging departments. The survey comprises 11 determinants of radiation safety culture, including personal accountability, teamwork in imaging, teamwork across imaging stakeholders, questioning attitude, feedback loops, organisational learning, leadership actions, non-punitive response, error reporting, radiation policy and overall perception of radiation safety. A total of 496 MRTs participated in this study. Results showed that most of the MRTs were male (75.0%), between 25 and 44 yr old (71.0%), with a bachelor's degree (53.2%) and had less than 5 yr of experience (41.1%). The highest mean scores were for personal accountability (4.43 ± 0.62) and teamwork in imaging (4.22 ± 0.91), while the lowest mean score was for non-punitive response (2.94 ± 1.01). The majority of the MRTs reported good perception for the personal accountability (71.8%), teamwork in imaging (56.5%) and organisational learning (46%) scales; moderate perception for the teamwork across imaging stakeholders (53.2%), questioning attitude (71%), feedback loops (47.6%), leadership actions (74.2%), error reporting (53.2%), radiation policy (54.8%) and overall perception of radiation safety (62.1%) scales; and poor perception for the non-punitive response scale (45.2%). Individual and organisational interference are warranted to adhere to a strong radiation safety culture with continuing education. Moreover, repeated measures are necessary to assess for categorical improvement associated with the relevant determinants that are also important to support a positive radiation safety culture.

Keywords: radiation protection / radiology department / radiation safety culture / radiological technologist

1 Introduction

Radiation safety culture (RSC) is a broader and more comprehensive concept that encompasses not only the scientific and technical aspects of radiation protection, but also the social and organizational factors that influence the attitudes, values, behaviors and experiences of radiation protection professionals and stakeholders. The consequences of RSC may be influenced by a variety of intrapersonal, interpersonal, organisational, community and policy aspects. The International Radiation Protection Association (IRPA) initially introduced the concept of radiation safety culture (RSC) in 2008. The IRPA defines RSC as the combination of scientific and social factors, including knowledge, values, behaviours and experience of radiation protection, in all its applications for patients, workers, the general public and the environment. The Health Physics Society's definition of RSC; "RSC is the core values and behaviours resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment." The definitions underline the significance of limiting harmful activities, reducing ionising radiation risks, maximising radiation protection and incorporating all stakeholders while expressing the multifaceted nature of RSC. Taken together, these factors represent a significant responsibility that can be addressed if there is a strong organisational RSC (Thome, 1987; Wrixon *et al.*, 2003).

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The healthcare industry works to improve people's health and quality of life in general. Ionizing radiation is widely used in diagnostic and therapeutic procedures, such as radiography, fluoroscopy, computed tomography, nuclear medicine and radiotherapy. While radiation technology does have numerous advantages for patients, using it incorrectly or incompetently can endanger the health of radiation workers and patients (Briggs-Kamara *et al.*, 2013). Ionising radiation use is therefore a double-edged sword (Briggs-Kamara *et al.*, 2013). Every year, around 7 million healthcare workers globally are vulnerable to radiation exposure due to their line of work. Moreover, over 1 billion radiological imaging examinations are performed annually around the world. Medical radiological technologist (MRT) professions are not always without risk. They frequently involve cost-risk-benefit analysis in the decision-making process. Radiation safety is a vital issue in medical imaging, as it involves the protection of patients, workers, the general public and the environment from the harmful effects of ionizing radiation. According to this concept, if radiation safety precautions are not put in place and followed, then ionising radiation utilised in diagnostic and therapeutic procedures will carry the danger of cancer induction to exposed patients and participating healthcare workers (Ploussi *et al.*, 2016).

The foundation of all workplace behaviour is a strong safety culture. An organisation with a positive safety culture will have employees who consistently prioritise safety and prevent harm to their co-workers because these are simply part of the organisation's values and norms. However, cultivating this type of culture can be difficult (Cole *et al.*, 2014). People's responses to risks and opportunities are often influenced by societal expectations and their subjective interpretation of information rather than rational analysis. Given the current societal perception of radiation protection, it is crucial to cultivate a culture of radiation protection to avoid regressing to a time when fear and superstition dictated societal norms and scientific discovery was met with punishment (Golnik *et al.*, 2011).

The significance of radiation safety in the healthcare setting cannot be overstated, particularly as radiation usage has permeated the workplaces of RTs, exposing them to radiation on a regular basis. A solid RSC pursues to advance practice by controlling hazardous practices, limiting radiation risk and enhancing radiation protection (Ploussi *et al.*, 2016). Several studies have been published in Saudi Arabia that focused only on the radiation protection knowledge, awareness and practices of different groups of professionals or patients (Shubayr *et al.*, 2022; Alyami *et al.*, 2022). However, studies on RSC are scarce in Saudi Arabia, especially from a broader and more comprehensive concept that encompasses not only the scientific and technical aspects of radiation protection, but also the social and organizational factors that influence the attitudes, values, behaviors and experiences of radiation protection professionals and stakeholders. The aim of the study was to evaluate the perception of 11 determinants of RSC among MRTs in Saudi Arabia. The results of this study will provide valuable insights into the strengths and weaknesses of RSC in medical imaging departments, and suggest recommendations for improvement.

2 Materials and methodology

2.1 Study design and setting

This cross-sectional observational study was carried out in Saudi Arabia from June 2022 to February 2023. In this study, the participants were MRTs associated with the radiology department in different hospitals and medical centres in Saudi Arabia. The sample size was calculated using G*Power software with an effect size of 0.15, a p-value of 0.05, power of 95%, the required sample size was 130. A simple random sampling method was used for the study. The survey was distributed online *via* Google Forms and a total of 496 questionnaires were collected for the analysis. The ethics committee of Jazan University approved the study. The participant's consent was taken at the beginning of the survey.

2.2 Data collection tool

In this study, data were collected using a self-administered structured questionnaire. The questionnaire had two sections: the first section gathered socio-demographic data, including age, sex, educational level and work experience in years, and the subsequent section consisted of the RSC Survey Instrument for MRTs (Moore, 2021), which was previously validated (content validity index = 0.995) and found to be reliable (α =0.94). The survey comprised 11 determinants of RSC, including personal accountability, teamwork in imaging, teamwork across imaging stakeholders, questioning attitude, feedback loops, organisational learning, leadership actions, non-punitive response, error reporting, radiation policy and overall perception of radiation safety. It consists of 35 statements to assess the RSC in medical imaging departments. Each statement was evaluated on a five-point Likert scale (*strongly disagree*, *disagree*, *neutral*, *agree*, *strongly agree*) or a five-point frequency scale (*never*, *rarely*, *sometimes*, *most of the time*, *always*). When using the survey instrument, items related to a given factors should be averaged such that each scale can have a maximum score of 5.

2.3 Data analysis

Statistical Package for the Social Sciences version 27 was used for data entry and analysis. The participants' characteristics were analysed using descriptive statistics based on frequencies, percentages, averages and standard deviations. The Kolmogorov–Smirnov test was used to test for normality. The nonparametric tests Mann–Whitney and Kruskal–Wallis tests were applied to determine associations between variables due to the violation of normality. Mean scores for each statement and for each of the 11 scales were calculated. Mean scores below 3 indicate poor perception, from 3 to 4 indicate moderate perception and above 4 indicate good perception. Values of $p<0.05$ were considered significant.

3 Results

A total of 496 MRTs practicing in different radiology departments participated in this study. A summary of the socio-demographic characteristics of the MRTs is listed in Table 1.

Table 1. Summary of socio-demographic characteristics and the mean (SD) of the determinants of radiation safety culture.

	Count (%)	Personal accountability	Teamwork in imaging	Teamwork across imaging stakeholders	Questioning attitude	Feedback loops	Organizational learning	Leadership actions	Nonpunitive response	Error reporting	Radiation policy	Overall perception of radiation safety
Gender												
Female	124 (25.0)	4.5 (0.6)	4.3 (0.9)	3.8 (1.0)	3.6 (0.7)	3.9 (1.0)	4.0 (1.0)	3.3 (0.5)	3.0 (1.0)	3.5 (1.1)	3.8 (0.9)	3.7 (0.8)
Male	372 (75.0)	4.3 (0.8)	4.1 (0.8)	3.7 (0.7)	3.6 (0.7)	3.5 (1.1)	3.8 (0.9)	3.1 (0.6)	2.8 (1.1)	3.3 (1.0)	3.6 (1.0)	3.5 (0.7)
p value		0.279	0.055	0.607	0.823	0.115	0.127	**0.036**	0.356	0.451	0.500	0.143
Age (years)												
18-24	92 (18.5)	4.3 (0.9)	3.9 (1.2)	3.5 (1.0)	3.2 (0.7)	3.8 (1.1)	3.7 (1.1)	3.1 (0.6)	2.8 (1.1)	3.6 (1.1)	3.5 (1.1)	3.6 (0.7)
25-34	176 (35.5)	4.4 (0.5)	4.2 (0.8)	3.7 (0.9)	3.7 (0.7)	3.7 (1.1)	3.9 (1.0)	3.1 (0.5)	2.7 (1.0)	3.4 (1.0)	3.7 (1.0)	3.5 (0.8)
35-44	176 (35.5)	4.5 (0.5)	4.4 (0.6)	3.9 (0.9)	3.8 (0.7)	3.9 (1.0)	4.1 (0.8)	3.4 (0.5)	3.1 (0.9)	3.2 (1.1)	4.0 (0.8)	3.8 (0.9)
>45	52 (10.5)	4.2 (0.6)	4.1 (1.3)	3.8 (0.7)	3.4 (0.5)	3.9 (0.8)	4.0 (1.2)	3.2 (0.5)	3.2 (1.2)	3.7 (1.2)	3.8 (0.8)	3.6 (0.9)
p value		0.345	0.165	0.311	**0.009**	0.777	0.451	0.139	0.119	0.562	0.220	0.484
Education												
Diploma	160 (32.3)	4.5 (0.6)	4.4 (0.7)	3.8 (1.0)	3.7 (0.6)	3.9 (1.0)	4.1 (0.9)	3.3 (0.5)	3.0 (0.9)	3.4 (1.1)	3.9 (0.8)	3.8 (0.8)
Bachelor	264 (53.2)	4.4 (0.7)	4.1 (1.0)	3.7 (0.9)	3.5 (0.8)	3.7 (1.1)	3.9 (1.1)	3.2 (0.6)	2.9 (1.0)	3.5 (1.1)	3.6 (1.1)	3.5 (0.8)
Postgraduate	72 (14.5)	4.5 (0.6)	4.1 (0.9)	3.6 (0.8)	3.7 (0.6)	3.8 (0.7)	4.1 (0.8)	3.3 (0.5)	2.9 (1.2)	3.3 (1.1)	4.0 (0.6)	3.5 (0.8)
p value		0.575	0.316	0.615	0.181	0.621	0.667	0.582	0.881	0.785	0.147	0.124
Years of experience												
0-5	205 (41.1)	4.4 (0.7)	4.1 (1.0)	3.6 (0.9)	3.5 (0.8)	3.8 (1.1)	3.9 (1.1)	3.1 (0.6)	2.7 (1.1)	3.6 (1.0)	3.6 (1.1)	3.5 (0.7)
6–10	92 (18.5)	4.6 (0.6)	4.4 (0.8)	4.0 (0.8)	3.7 (0.6)	4.0 (1.0)	4.1 (0.9)	3.3 (0.4)	3.2 (0.9)	3.0 (1.2)	4.1 (0.8)	3.9 (0.8)
11–15	68 (13.7)	4.5 (0.6)	4.2 (0.8)	3.8 (1.0)	3.8 (0.8)	3.7 (1.2)	3.9 (1.0)	3.3 (0.5)	3.0 (0.8)	3.7 (1.1)	3.8 (0.9)	3.7 (0.9)
>15	132 (26.6)	4.4 (0.5)	4.3 (0.9)	3.8 (0.9)	3.5 (0.6)	3.7 (1.0)	4.1 (0.9)	3.3 (0.5)	3.1 (1.0)	3.3 (1.0)	3.8 (0.7)	3.6 (0.8)
p value		0.579	0.566	0.531	0.290	0.838	0.799	0.217	0.275	0.142	0.217	0.246

Table 2. Descending order of radiation safety culture dimensions among radiological technologists.

Determinant	Mean (SD)
Personal accountability	4.43 (0.62)
Teamwork in imaging	4.22 (0.91)
Organizational learning	3.97 (0.97)
Feedback loops	3.80 (1.03)
Radiation policy	3.77 (0.93)
Teamwork across imaging stakeholders	3.75 (0.90)
Overall perception of radiation safety	3.63 (0.81)
Questioning attitude	3.58 (0.70)
Error reporting	3.41 (1.09)
Leadership actions	3.22 (0.87)
Nonpunitive response	2.94 (1.01)

The majority of the MRTs were male (75.0%) and within the ages of 25–44 yr. A total of 53.2% hold bachelor's degrees, 32.3% have diplomas and 14.5% have postgraduate degrees. Moreover, 26.6% of the MRTs had more than 15 yr of working experience in radiology departments while 41.1% had less than 5 yr of experience. The 11 determinants of RSC instrument were analysed based on the socio-demographic characteristics of the MRTs. A significant difference was observed in the leadership actions scale between both genders (p=0.036), with females reporting higher values than males. Questioning attitude was also significantly different between age groups (p=0.009); the 35–44 yr age group scored higher than the other age groups (Tab. 1).

Table 2 demonstrates the mean scores of the 11 scales of the RSC Survey Instrument. The dimensions are ranked from the highest to the lowest mean score, indicating the relative strength of each dimension in the RSC of the respondents. The highest mean score was obtained for personal accountability (4.43 ± 0.62), followed by teamwork in imaging (4.22 ± 0.91) and organizational learning (3.97 ± 0.97). The lowest mean score was obtained for nonpunitive response (2.94 ± 1.01), followed by leadership actions (3.22 ± 0.87) and error reporting (3.41 ± 1.09).

Table 3 shows the categorical levels based on the mean scores for the 11 scales of the RSC Survey Instrument, in which a mean score below 3 indicates poor perception, from 3 to 4 indicates moderate perception and above 4 indicates good perception. The majority of the MRTs were in the high level for the personal accountability (71.8%), teamwork in imaging (56.5%) and organisational learning (46%) scales, and in the moderate level for the teamwork across imaging stakeholders (53.2%), questioning attitude (71%), feedback loops (47.6%), leadership actions (74.2%), error reporting (53.2%), radiation policy (54.8%) and overall perception of radiation safety (62.1%) scales. Among the 11 scales, the highest percentage of MRTs in the poor level was for non-punitive response (45.2%).

4 Discussion

RSC ensures that people and organisations using radiation sources know the risks and take precautions to protect themselves, their co-workers and the public from ionising radiation. RSC can also prevent mishaps and maintain public trust and confidence in radiation safety (Ali, 2008). In this study, we evaluated the perception level of RSC among MRTs in Saudi Arabia working in different private and public hospitals using a previously validated tool.

Most MRTs scored within a moderate to high perception regarding the RSC. More than two-thirds of the participants showed a positive perception of the current RSC with moderate and high levels. This result shows that most MRTs are willing to create a work environment where safety is prioritised and all stakeholders understand their role in ensuring radiation safety. Our study is in line with a previous study that reported on the RSC, highlighting the positive impact of regulations on enhancing patient safety and promoting a safety culture (Berris *et al.*, 2017). A previous study measured the level of commitment to safety culture among radiation workers in different practices using a questionnaire survey. They found that the level of commitment to safety culture varied widely among the practices, from 23.3% to 90.0%, and was influenced by several factors related to the radiation exposure, the radiation protection equipment and training, the management support and supervision, and the personal attitude and motivation of the radiation workers. They advised that the practices with low levels of commitment to safety culture should take steps to improve their safety performance and behavior (Faanu *et al.*, 2010). Moreover, another study evaluated the impact of an RSC intervention program on the occupational exposure of radiation workers in different sectors. They found that the intervention program resulted in a lower and more uniform radiation dose for medical radiology, nuclear medicine, and industrial radiography workers, as well as a 48% drop in the collective dose above the investigation level for medical radiology workers. The study confirmed that the RSC program improved the radiation protection of the radiation workers in different sectors (Sotirios *et al.*, 2020).

The study analysed the 11 determinants of RSC instrument based on the socio-demographic characteristics of the MRTs. A significant difference was observed in the leadership actions scale between both genders (p=0.036), with females reporting higher values than males. Questioning attitude was also significantly different between age groups (p=0.009); the 35–44 yr age group scored higher than the other age groups. The difference in leadership actions between females and males may reflect the different styles and expectations of leadership in the healthcare setting, as well as the possible gender bias or discrimination that may affect the opportunities and recognition of female leaders. The difference in questioning attitude between age groups may indicate the different levels of experience, confidence, and curiosity of MRTs in different stages of their career, as well as the possible generational gap or conflict that may affect the communication and collaboration among MRTs of different ages. These findings suggest that gender and age may influence some aspects of RSC among MRTs, and that interventions to improve RSC should take into account these factors.

The dimensions in Table 2 were ranked from the highest to the lowest mean score, indicating the relative strength of each dimension in the RSC of the respondents. The highest mean score was obtained for personal accountability, followed by teamwork in imaging and organizational learning. The lowest

Table 3. Number and percentage of radiological technologists' responses in the level of perception towards radiation safety culture by determinant (N = 496).

Determinant	Poor	Moderate	Good
Personal accountability	4 (0.8%)	136 (27.4%)	356 (71.8%)
Teamwork in imaging	40 (8.1%)	176 (35.5%)	280 (56.5%)
Teamwork across imaging stakeholders	68 (13.7%)	264 (53.2%)	164 (33.1%)
Questioning attitude	52 (10.5%)	352 (71%)	92 (18.5%)
Feedback loops	68 (13.7%)	236 (47.6%)	192 (38.7%)
Organizational learning	44 (8.9%)	224 (45.2%)	228 (46%)
Leadership actions	112 (22.6%)	368 (74.2%)	16 (3.2%)
Nonpunitive response	224 (45.2%)	212 (42.7%)	60 (12.1%)
Error reporting	120 (24.2%)	264 (53.2%)	112 (22.6%)
Radiation policy	68 (13.7%)	272 (54.8%)	156 (31.5%)
Overall perception of radiation safety	68 (13.7%)	308 (62.1%)	120 (24.2%)

mean score was obtained for nonpunitive response, followed by leadership actions and error reporting. The result suggests that the MRTs have a high sense of responsibility and collaboration in their work, but they may face challenges in reporting errors, receiving feedback, and being supported by their leaders. The results also indicates that there is room for improvement in all dimensions, as none of them reached the maximum score of 5.

The mean score of personal accountabilities (4.43 ± 0.62) was the highest among the 11 scales, with 71.8% of the MRTs scoring within the good perception level. Personal accountability means that everyone is entirely responsible for safety; they believe it is their responsibility to be aware of the standards and expectations and to adhere to them diligently. There is personal ownership for safety, and they are committed to promoting safety (Coldwell *et al.*, 2015). In addition, the mean scores of the teamwork in imaging (4.22 ± 0.91) and organisational learning (3.97 ± 0.97) scales were among those where the majority of MRTs scored good perception, accounting for 56.5% and 46% of MRTs, respectively. Teamwork is an essential component of RSC. In imaging, a team of MRTs, radiologists and other healthcare professionals work together to ensure that imaging procedures are performed safely and efficiently (George *et al.*, 2014). In the current study, participants reported a high level of commitment to promoting RSC as a whole team. A higher score in organisational learning indicates that MRTs seek out opportunities to improve radiation safety in the medical imaging departments.

The majority of the determinants of RSC (*i.e.*, 7 scales) were within a moderate level, including teamwork across imaging stakeholders, questioning attitude, feedback loops, leadership actions, error reporting, radiation policy and overall perception of radiation safety. However, poor perception about RSC was indicated for the non-punitive response scale, with a mean score of 2.94 ± 1.01 and 45.2% of the MRTs scoring below 3 out of 5. In addition, 24.2% of the MRTs reported poor perception about error reporting. This may be due to a lack of safety awareness among staff employees and their fear of being disciplined for mistakes. A consequence of this result is that it might be difficult to promote experience feedback, which is one of the main mechanisms for improving radiation protection practices, and thus RPC. A staff member may hide problems that could subsequently affect the effectiveness of patient safety as a result of such a culture. Managers, supervisors and co-workers might foster a culture where mistakes are treated without repercussion. The risk of patients complaining and patients requesting for reimbursement may have also been contributing factors to the decreased frequency of incident reporting (Azyabi *et al.*, 2021). Mistakes do happen in the radiology department, but they can be controlled by adhering to the rules (Pinto *et al.*, 2012). Real incidents can be decreased *via* the use of RSC measures, including providing non-punitive reactions to mistakes. Such measures also promote incident reporting and education, which can improve quality and safety (Toledo *et al.*, 2023).

The study recommends interventions for MRTs and their organizations to improve nonpunitive response, leadership actions, and error reporting, which were the dimensions with the lowest scores in the RSC. Implementation strategies involve encouraging MRTs to report errors without fear of retribution, integrating leadership skills training, and familiarizing them with error reporting systems through hands-on sessions. For organizations, establishing clear, non-punitive error reporting policies, introducing recognition programs for safety contributions, implementing accessible reporting systems, and holding regular meetings to discuss and learn from reported issues are essential. Practical examples include regular error reporting and leadership training workshops for MRTs, the establishment of feedback and recognition systems to motivate safety-oriented behaviors, development of accessible online reporting systems accompanied by safety meetings for continuous learning, leadership development programs for senior staff, and team-building activities to foster collaboration and communication. These focused strategies aim to significantly improve RSC in medical imaging departments, leading to safer patient care and a more positive work environment.

5 Conclusion

This study assessed the RSC among Saudi MRTs in medical imaging departments and presented its findings to support future improvement. The current level of perception of RSC is within moderate to high levels. However, poor perception of the non-punitive response scale was revealed in

this study. Individual and organisational interference are therefore warranted to adhere to a strong RSC with continuing education. Furthermore, repeated measures are essential to assess for categorical improvement associated with the relevant determinants that are also important to support a positive RSC.

Conflict of interest

The authors declare no conflict of interest.

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Ethical Approval

received ethical approval from the Ethics committee of Jazan University under the protocol number RC-45/03/786.

Informed consent

Written informed consent was obtained from all participants.

Authors contributions

N. Shubayr: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project Administration. Md. Muawwadhah: Methodology, Data Curation. M. Shami: Software, Validation. H. Jassas: Formal Analysis. R. Tawhari: Investigation, Visualization. O. Oraybi: Data Curation, Writing - Review & Editing. A. Madkhali: Experimental Design, Data Analysis. A. Aldosari: Resources. Y. Alashban: Funding Acquisition, Supervision, Writing - Review & Editing.

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References

Ali NM. 2008. Challenges in promoting radiation safety culture. *J Nucl Sci Technol* 45: 623–626.

Alyami A, Majrashi N, Shubayr N, Alomairy N, Abuhadi N. 2022. Assessment of radiation protection awareness and safety practices among nurses in nuclear medicine departments in Saudi Arabia. *Radioprotection* 57: 49–54.

Azyabi A, Karwowski W, Davahli MR. 2021. Assessing patient safety culture in hospital settings. *Int J Environ Res Public Health* 18: 2466.

Berris T, Zontar D, Rehani MM. 2017. Survey on impact of regulations on radiation safety and development of radiation safety culture in 25 countries. *J Med Imaging (Bellingham)* 4: 031204.

Briggs-Kamara MA, Okoye PC, Omubo-Pepple VB. 2013. Radiation safety awareness among patients and radiographers in three hospitals in Port Harcourt. *Am J Sci Ind Res* 4: 83–88.

Coldwell TG, Cole P, Edwards C, Makepeace J, Murdock C, Odams HJR, Whitcher R, Willis S, Yates L. 2015. The advantages of creating a positive radiation safety culture in the higher education and research sectors. *J Radiol Prot* 35: 917–933.

Cole P, Hallard R, Broughton J, Coates R, Croft J, Davies K, Devine I, Lewis C, Marsden P, Marsh A, McGeary R, Riley P, Rogers A, Rycraft H, Shaw A. 2014. Developing the radiation protection safety culture in the UK. *J Radiol Prot* 34: 469–484.

Faanu A, Schandorf C, Darko EO, Boadu M, Emi-Reynolds G, Awudu AR, Gyekye PK, Kpeglo DO. 2010. Inter-comparison of safety culture within selected practices in Ghana utilising ionising radiation. *Radiat Prot Dosimetry* 142: 88–91.

George R, Lau L, Ng K-H. 2014. Team approach to optimize radiology techniques. In: *Radiological Safety and Quality*, pp. 161–176. Netherlands, Dordrecht: Springer.

Golnik N, Tulik P. 2011. IRPA initiative on radiation protection culture. *Polish J Med Phys Eng* 17: 1.

Moore QT. 2021. Validity and reliability of a radiation safety culture survey instrument for radiologic technologists. *Radiol Technol* 92: 547–560.

Pinto A, Caranci F, Romano L, Carrafiello G, Fonio P, Brunese L. 2012. Learning from errors in radiology: a comprehensive review. *Seminars in Ultrasound, CT and MRI* 33: 379–382.

Ploussi A, Efstathopoulos EP. 2016. Importance of establishing radiation protection culture in Radiology Department. *World J Radiol* 8: 142–147.

Shubayr NA, Alashban YI. 2022. Knowledge on radiation emergency preparedness among nuclear medicine technologists. *Radioprotection* 57: 27–31.

Sotirios E, Panagiotis A, Konstantinos K, Eleftheria C, Christos H. 2020. The impact of radiation protection training on the radiological safety and the related culture of exposed workers in Greece. *J Radiol Prot* 40: 997–1009.

Thome M. 1987. Principles of the international commission on radiological protection system of dose limitation. *Br J Radiol* 60: 32–38.

Toledo JCd, Almeida LS, Lizarelli FL. 2023. Process management and safety culture in radiotherapy services: impacts on quality patient care and safety. *Production* 33: e20220083.

Wrixon A, González AJ, Akashi M, Boice Jr JD. 2003.The evolution of the system of radiological protection: the justification for new ICRP recommendations. *J Radiol Prot* 23: 129–142.

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