KNOWLEDGE, ATTITUDES, AND PRACTICES TOWARD RADIATION SAFETY AMONG MEDICAL RADIOLOGY ENGINEERS

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Abstract: This study examines the knowledge, attitudes, practices, and occupational exposure to radiation and other risk factors among medical radiology engineers in radiotherapy settings. Given the importance of radiation protection in healthcare, the research assesses the extent of awareness and implementation of safety measures among professionals working in radiology departments. A validated questionnaire, the Questionnaire for the Assessment of Occupational Exposure and Safety in Radiology Departments, was used to collect data from 106 participants across three groups: medical radiology engineers from Bosnia and Herzegovina, Serbia, North Macedonia, and Montenegro, and a control group from EU countries. The study evaluated knowledge, attitudes, and practices using Likert-scale assessments and categorized responses based on established cutoff values. Results revealed that while theoretical knowledge of radiation safety was generally high across all groups, practical implementation remained inadequate, particularly in non-EU countries. Significant differences were observed in educational levels and exposure to occupational hazards, with radiology professionals from Bosnia and Herzegovina reporting the highest exposure to ionizing radiation and adverse climate conditions ($p = 0.004$ and $p = 0.044$, respectively). A strong correlation was found between poor practice quality and higher exposure to physical hazards ($r = 0.282$, $p = 0.018$), highlighting gaps in safety compliance. Attitudes towards radiation safety and protective measures varied, influencing workplace behaviors and adherence to protocols. These findings underscore the necessity for improved standardized training and occupational safety regulations across regions. Strengthening educational programs, enforcing compliance with protective measures, and implementing continuous professional development initiatives are crucial for mitigating occupational risks among medical radiology engineers.
Keywords: Radiation safety, occupational exposure, radiology, knowledge-attitude-practice,

1. INTRODUCTION

Occupational health and safety require all employers to provide a safe working environment for their employees. Healthcare workers (HCWs) in radiology departments should have adequate knowledge of the risks and safety precautions related to radiation exposure to protect their own health and provide patients with accurate information about radiation exposure (D'Souza et al, 2013). Occupational exposure to numerous hazards that potentially leave serious consequences for the health of employees, has an impact on whole society. Radiation protection (protection of patients and protection of professionally exposed individuals) is often not included in education, training, qualification, and competency programs in these specialties. Relevant professional bodies and regulatory authorities should collaborate to establish acceptable criteria for radiation protection education and training, as well as methods for recognizing competency in radiation protection (Yashima S et al, 2022). Workers are exposed to a wide range of hazardous and harmful working conditions during the work process, which, under certain circumstances, can cause health damage. These conditions include hazards, harmful factors, and physical efforts. Hazards include mechanical dangers, falls and collapses, electrical shock, fire and explosions, and hot and cold substances. Harmful factors include chemical substances, biological and physical hazards, while efforts involve static-dynamic and psychophysiological strains (CDC, 2015). The term hazard refers to a broad spectrum of physical, chemical, biological, mechanical, and environmental dangers associated with regular practices. The American National Institute for Occupational Safety and Health (NIOSH) distinguishes 29 physical, 25 chemical, 24 biological, 10 ergonomic, and 6 types of psychosocial hazards (WHO, 2021). The World Health Organization defines occupational health as a public health area aimed at "promoting and maintaining the highest level of physical, mental, and social well-being of workers in all occupations" (Koehoorn M et al, 2021). Different professions involve different hazards and risks, ranging from physical effort and falls to blood, chemical hazards, and biological agents (WHO,2017). In any medical application involving ionizing radiation, obtaining the most accurate and reliable result with the lowest possible dose is only achievable if the following key principles are adhered to. This is directly related to the level of knowledge healthcare professionals have regarding the negative effects of radiation on human health. Studies assessing the level of knowledge and awareness of radiation safety practices among healthcare professionals indicate gaps in knowledge about the biological effects of radiation, even in groups that work continuously with radiation (UNSCEAR, 2008). The aim of the study was to investigate the knowledge, attitudes, practice and exposure to radiation and the exposure to risk factors of medical radiology engineers in the radiotherapy setting.

2. MATERIALS AND METHODS

The absence of official data and an accepted research tool in the Balkan region led to the development of the Questionnaire for the Assessment of Occupational Exposure and Safety in Radiology Departments. The questionnaire was validated and published in 2022 (Ristanić-Beroš et al.). This tool was used to assess exposure to physical, biological, and chemical hazards. Overall, the validity of the questionnaire in examining practice, knowledge and attitude was determined with Cronbach's alpha = 0.787. The total number of questions adequate for the questionnaire about knowledge, attitude and practice were 89 questions. In this number, general questions and laboratory questions were not included. Knowledge was assessed based on 32 questions, practice based on 16 questions and attituted based on 41 questions. Answers were presented as Likerts scale. Based on cut off values knowledge, attituted and practice was classified. This study included radiological technology professionals of both sexes, working with sources of ionizing radiation at all three levels of healthcare, across both public and private healthcare institutions. The research specifically focused on individuals working in the field of radiotherapy. Participants were divided into three groups, with two intervention groups and one control group consisting of subjects from EU countries.

Statistical analysis: For statistical data analysis, the IBM SPSS Statistics 27.00 software (IBM Corporation, Armonk, New York) was used. Categorical variables were presented as frequencies (absolute numbers or percentages). The results of the descriptive statistical analysis of risks were presented with the following parameters: mean and standard deviation. The scales examined were presented relative to the average score. The correlation of factors with each other and in relation to sociodemographic characteristics, as well as their correlation with the knowledge, attitudes, and practices of the respondents, were analyzed using Spearman's correlation for data with a nonparametric distribution. Knowledge, Attitudes, and Practices Toward Radiation Safety Among Medical Radiology Engineers Knowledge, attitude, and practice were scored based on the proportion of correct answers for knowledge and practice, and the proportion of positive attitude responses. The classification of knowledge was based on the proportion of correct answers: <50% was considered unsatisfactory knowledge; 55-74.9% was considered satisfactory knowledge; 75.1-100% was considered excellent knowledge. The attitude score was based on the proportion of questions with a positive attitude, with: <50% representing a negative attitude, 50-75% representing a satisfactory attitude, and 75% or more representing a positive attitude. Practice was classified based on the proportion of correct results, where: unsatisfactory practice was 0-50%, 50.1-74.9% represented satisfactory practice with significant deficiencies to be improved, and 75% or more represented excellent practice. The Chi-square test ($\chi 2$) was used to examine the difference between expected and observed values in one or more categories in contingency tables. The results of the research were presented textually, in tables, and graphically. Statistical significance was set at a probability level of $p<0.05$.

3. RESULTS

The study included a total of 106 subjects. The control group consisted of 51 participants, all from EU countries. The intervention groups included 55 participants in total. Group I comprised 19 subjects from Bosnia and Herzegovina, while Group II included 36 subjects from Serbia, North Macedonia, and Montenegro. Basic information about subjects is provided on Table 1.

Table 1. Basic information about subjects

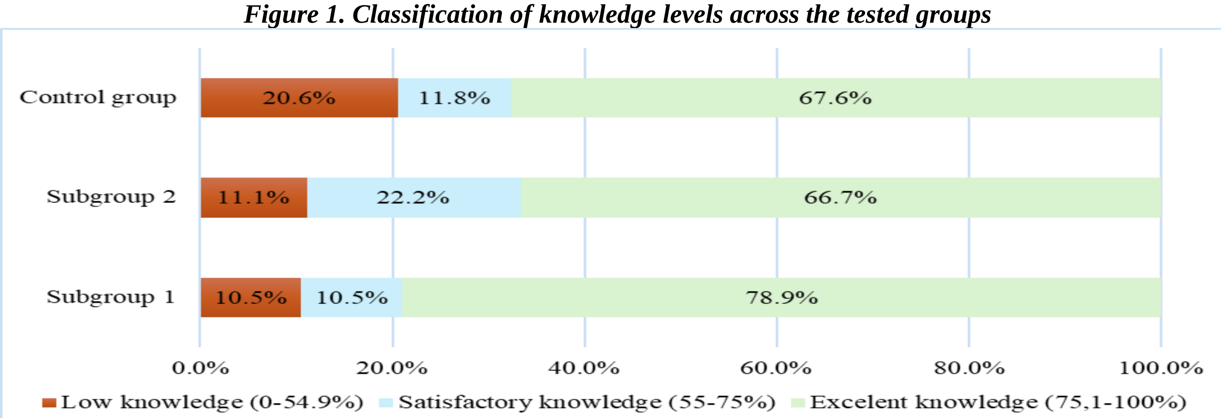
		Group 1 (BiH)	Group 2 (Srb, Mont, N.Mac)	Group 3 (EU)	x^2, p
		%	%	%	
Sex	*Female*	21.10%	47.20%	51.00%	5.207
	Male	78.90%	52.80%	49.00%	0.074
Education level	*High school*	0.00%	0.00%	7.80%	**11.891**
	Associate degree	10.50%	41.70%	41.20%	**0.018**
	Higher education degreee	89.50%	58.30%	51.00%	
Years of experience	*<1 year*	5.30%	2.80%	5.90%	3.732
	1-5 years	21.10%	22.20%	21.60%	0.880
	6-10 years	21.10%	22.20%	15.70%	
	11-20 years	26.30%	27.80%	41.20%	
	21+ years	26.30%	25.00%	15.70%	
Average age	*Mean ± SD*	37.21±8.24	37.83±10.05	36.61±8.18	0.817

Source: Authors' research

Of the 106 subjects included in this study, no significant differences in sex distribution were observed between the groups ($p = 0.074$). The mean age was also comparable across groups, with no significant differences ($p = 0.817$). Regarding educational attainment, 89.5% of subjects in Group 1 had a higher education degree (university degree), compared to 58.3% in Group 2 and 51.0% in Group 3. Significant differences were obsereved based on education level ($p=0.018$). Risk assessments at the workplace were conducted for 57.9% of subjects in group I, 69.4% in group II, and 74.5% in the control group. Significant differences were observed, with group I showing the lowest occurrence of risk assessments.

Knowledge, attitude and practice: The assessment of knowledge regarding safety procedures in radiotherapy was conducted using 5 questions. The results indicated no significant differences in knowledge, with the majority of participants demonstrating a good understanding. In the control group, excellent knowledge was observed in 67.6% of subjects, satisfactory knowledge in 11.8%, and poor knowledge in 20.6%. In Group 2, 66.7% of participants demonstrated excellent knowledge, while 22.2% had satisfactory knowledge. In Group 1, excellent knowledge was observed in 78.9% of respondents, and satisfactory knowledge in 10.5%. No statistically significant differences were found between the groups ($\chi^2 = 3.283$, $p = 0.512$) (Figure 2).

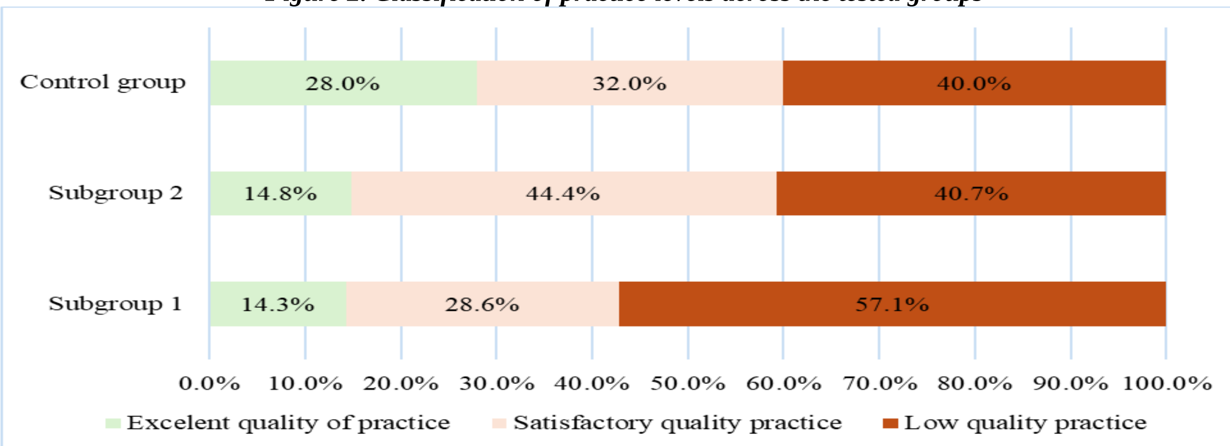
Figure 1. Classification of knowledge levels across the tested groups



Source: Authors' research

In the control group, excellent practice was observed in 28% of respondents, satisfactory practice in 32%, and low-quality practice in 40%. In Subgroup 2, 14.8% of participants demonstrated excellent practice, while 44.4% had satisfactory practice. In Subgroup 1, excellent practice was observed in 14.3% of respondents, and satisfactory practice in 28.6%. No statistically significant differences were identified between the groups ($\chi^2 = 2.966$, $p = 0.564$).

Figure 2. Classification of practice levels across the tested groups



Source: Authors' research

Exposure to physical hazards during practice was assessed (see Table 2). The findings showed that participants across all three groups had similar levels of exposure to most hazards, except for climate and microclimate conditions, and ionizing radiation. Subjects in group I (BiH) had the highest exposure to climate and microclimate hazards (84.25%), while the control group had the lowest (54.9%), with a significant difference (p = 0.044). Additionally, subjects in group I (BiH) experienced the highest exposure to ionizing radiation, while the control group had the lowest (56.9%), also with a significant difference (p = 0.004).

Table 2. Exposure to physical hazards

Exposure to agents of a physical nature	Group I	Group II	Control group	x^2	p
Climate and microclimate	**84.2%**	72.2%	**54.9%**	**6.232**	**0.044**
Increased and decreased barometric pressure	73.7%	63.9%	54.9%	2.210	0.331
Illumination	78.9%	77.8%	56.9%	5.528	0.063
Sound	73.7%	72.2%	54.9%	3.668	0.16
Infrasound	68.4%	58.3%	54.9%	1.043	0.594
Ultrasound	68.4%	58.3%	52.9%	1.372	0.504
Vibrations	68.4%	69.4%	54.9%	2.273	0.321
Non-Ionizing radiation	68.4%	69.4%	54.9%	2.273	0.321
Ionizing radiation	**89.5%**	83.3%	**56.9%**	**10.892**	**0.004**
Airpolution	73.7%	69.4%	51.0%	4.525	0.104
Mechanical force	68.4%	66.7%	54.9%	1.724	0.422
Electrical power	68.4%	61.1%	54.9%	1.113	0.573

Group I (Bosnia and Herzegovina), Group II (Serbia, N. Macedonia, Montenegro), Control Group (EU)

Source: Authors' research

Attitutde about level of exposure to diferent hazards: The classification of attitudes regarding exposure to different hazards is presented in Table 3. Low exposure to physical risk factors was reported by 36.7% of the control subgroup, 22.2% of group II, and 26.3% of group I respondents (p = 0.690). Low exposure to chemical risk factors was reported by 75% of respondents in group I, 75.9% in group II, and 70% in the control group (p=0.816). Low exposure to biological risk factors was reported by 21.2% of the control group, 20% of group II, and 27.8% of group I respondents. No significant differences (p>0.05).

Table 3. Classification of attitudes regarding exposure to different hazars

Exposure to	Level of exposure	Group I	Group II	Control Group	p
Physical risk factors	Positive attitude and low exposure	26.3%	22.2%	36.7%	0.690
	Satisfying attitude and moderate exposure	63.2%	63.0%	46.7%	
	Negative attitude and high exposure	10.5%	14.8%	16.7%	
Biological risk factors	Positive attitude and low exposure	27.8%	20.0%	21.2%	0.658
	Satisfying attitude and moderate exposure	27.8%	14.3%	21.2%	
	Negative attitude and high exposure	44.4%	65.7%	57.6%	
Chemical risk factors	Positive attitude and low exposure	75.0%	75.9%	70.0%	0.816
	Satisfying attitude and moderate exposure	12.5%	13.8%	23.3%	
	Negative attitude and high exposure	12.5%	10.3%	6.7%	

Source: Authors' research

Correlation analysis revealed a significant positive correlation between practice quality and exposure to physical hazards (rho = 0.282, p = 0.018). However, knowledge showed no correlation with practice or exposure to any hazards (rho < 0.1, p > 0.5). Additionally, exposure to physical risk factors was significantly correlated with exposure to biological hazards (rho = 0.466, p < 0.001) and chemical hazards (rho = 0.459, p < 0.001).
Other findings: Control procedures are crucial among radiologists. It was observed that 94.7% of workers in group 1, 77.8% in group 2, and 94% in the control group performed morning equipment checks. The proportion of subjects in group 2 performing morning checks was significantly lower (p < 0.001). Additionally, check-ups during working hours were significantly more frequent in the control group, with 36.1% of subjects reporting they conduct check-ups during working hours, compared to 25% in subgroup 1 and 19.2% in subgroup 2 (p = 0.023). One of the most important factors in radiotherapy is the proper use of equipment. The attitude that wearing personal protective equipment reduces exposure was expressed by 73.7% of subjects in group I, 86.1% in group II, and 88.2% in the control group. In group I (BiH), 26.7% of subjects were uncertain about its effectiveness, but none were opposed. In group II, 2.8% of subjects had a negative attitude, and 11.1% were unsure. In the control group, 5.9% were unsure, and the same proportion held a negative attitude.

4. DISCUSSIONS

The findings of our study indicate that while participants demonstrate good knowledge, their practices lack quality, and attitudes are correlated with practices. Similarly, a study conducted in Iran (Shabani et al., 2018) showed that subjects mostly had satisfactory knowledge, and factors such as sex, education level, years of experience, and hospital type did not significantly impact attitudes toward radiation protection. However, years of experience had a major influence on the quality of practice (p<0.001). The same study noted that professionals working in radiotherapy possessed adequate knowledge but struggled with its practical implementation. In a study from Tehran, Alavi et al. (2017) found a significant correlation between sex and both attitudes and practices. Additionally, participants with a university degree demonstrated significantly better knowledge (p<0.001). One key challenge identified was the implementation of education on radiological protective measures. Abdellah et al. (2015) reported that 88.8% of medical doctors in her study had not undergone basic safety procedure training, and 80% had not read these procedures. Moreover, the use of personal protective equipment was limited, with only 57.5% of participants using such equipment. Ooi and colleagues examined the knowledge, attitudes, and practices (KAP) of healthcare workers during the COVID-19 pandemic. Their results highlighted favorable KAPs among radiology professionals in Singapore concerning workplace preparedness during the pandemic, although they emphasized the need for sustainable efforts. The authors proposed developing policies to foster a motivated and resilient workforce during pandemics, ensuring preparedness for future crises (Ooi et al., 2022). A systematic review by Behzadmehr et al. (2021) analyzed the KAPs of healthcare workers and provided clinical recommendations. The review included 41 studies with 11,050 participants. Among the studies, most (n=33, 80.4%) evaluated healthcare workers' knowledge of radiation protection. Knowledge assessment varied across studies, employing different tools and item counts. Knowledge levels were generally categorized as poor, average, or sufficient. Sufficient knowledge levels ranged from 2% to 95%, with most studies (18 out of 33) reporting that over 50% of participants had sufficient knowledge. In six studies, knowledge levels were classified as average (5.6–12.1%). (Behzadmehr et al., 2021).

5. CONCLUSIONS

Despite the expectation that the field of radiotherapy and individual practices should be standardized and guided by universally accessible procedures, significant regional differences are evident. While participants demonstrate good theoretical knowledge, the primary issue lies in its implementation in practice, where significant errors occur. This is further reflected in a higher proportion of participants with negative attitudes toward exposure to hazards, primarily physical and biological. Employee education and the establishment of standard operating procedures (SOPs) form the foundation for improving participants' practices.

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