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RESEARCH

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Awareness of radiation hazards and knowledge of radioprotective measures among radiologists and non-radiology staff: a cross-sectional survey

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Abstract

Background Ionizing radiation has become increasingly utilized in medical practice. Consequently, healthcare workers must be aware of radiation hazards and apply the necessary countermeasures to reduce occupational exposure. This study assessed the awareness of radiation hazards and knowledge of radiation protection measures among radiologists and non-radiologists. These findings may improve the application of various safety measures during medical interventions involving radiation.

Methods We conducted a cross-sectional questionnaire-based study among 200 medical personnel, including consultant surgeons, physicians, radiologists, nurses, and radiographers, across five hospitals in Jordan between November 2022 and February 2023. The questionnaire collected data on demographic characteristics, awareness of radiation hazards, and knowledge of radioprotective techniques.

Results Overall, the knowledge of radiation protection and awareness of radiation hazards among the participants were poor (51.55% and 37.17%, respectively). No significant difference was detected between the medical disciplines in terms of the level of knowledge of radiation protection; however, radiographers were significantly more aware of radiation hazards.

Conclusions According to our findings, medical personnel generally have poor awareness of radiation hazards and radiation protection protocols. However, this understanding can be enhanced through periodic in-service training and regular monitoring of occupational radiation exposure by health professionals.

Keywords Ionizing radiation, Radiation hazard, Radioprotective measure, Healthcare professional

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Background

Ionizing radiation is the physical process through which subatomic particles or electromagnetic waves with sufficient energy are transmitted from a source and absorbed through a substance or space. Medical imaging refers to the technology used to create images of various regions of the human body for diagnostic and treatment purposes. However, despite its many beneficial applications, radiation exposure poses considerable health hazards, including skin erythema, burns, cataracts, infertility, and bone marrow suppression [1].

Radiation protection provides an adequate level of defense for humans without limiting the positive effects of radiation exposure. Various personal protective equipment (PPE), such as aprons, thyroid shields, glasses, and gloves, have been developed to shield workers from radiation exposure during interventional radiology procedures. During fluoroscopy, all operating room personnel must wear PPE unless they are standing behind a protective screen. Lead PPE garments provide radiation protection equivalent to 0.25- to 1-mm-thick lead. Most regulations require a lead-equivalent thickness of at least 0.5 mm since this can attenuate more than 90% of scatter radiation [2].

Radiation absorption pads have also been shown to reduce scatter radiation to interventional radiologists, particularly in the upper body region [3]. Worker protection from ionizing radiation exposure in all medical disciplines aims to prevent deterministic effects and minimize the risk of stochastic effects, such as cancer induction. This includes monitoring dose limits and maintaining appropriate safety distances from the source of radiation for workers and members of the public. In most cases, the distance between workers and patients during radiological intervention is the most important predictor of occupational exposure because the degree of scatter is largely determined by the dose received by the patient. Accordingly, doses are optimized to accomplish the intended medical aim at the lowest necessary radiation dose to limit occupational exposure [4]. However, studies have revealed that although healthcare workers have a sufficient understanding of the dangers of radiation exposure, their awareness of radiation safety and knowledge of radiation protection practices are poor. Therefore, continued education in radiation protection for healthcare personnel is needed.

Using an online survey questionnaire, this study sought to ascertain both radiologists' and non-radiologists' understanding of radiation safety among those who work with medical radiation and run the risk of radiation exposure. Furthermore, we aimed to lessen the detrimental consequences of radiation on health that arise from the improper, risky, and unregulated use of radiation sources in medical practice.

Methods

This was a cross-sectional questionnaire-based study that was conducted between November 2022 and February 2023.

Ethical considerations

This study was approved by the ethics committee of our institution on 31 October 2022 (nonfunded research number: 9/1/2022/2023). All methods were performed in accordance with the relevant guidelines and regulations. Written informed consent was provided by the participants at the beginning of the survey.

Inclusion criteria

All healthcare professionals, including radiologists and radiographers, as well as non-radiology consultants, surgeons, staff nurses, and general practitioners, from five different hospitals in Jordan were included in the survey distribution process.

Questionnaire design

We distributed 200 electronic copies of the same questionnaire to measure the level of understanding of healthcare personnel regarding radiation safety. The questionnaire was developed after a thorough literature review, and questions were chosen following consultation with various medical colleagues.

The questionnaire comprised three main components. The first component was composed of nine questions about demographic data, such as sex, age, experience, and daily workload. The second component comprised ten multiple-choice questions related to awareness and knowledge of radiology hazards, including questions such as which cells are the most sensitive to ionizing radiation, which organ has the highest radiosensitivity, and whether childhood abdominal computed tomography increases the lifetime risk of cancer. The third component comprised 11 multiple-choice questions related to protection and the safety regulations of applying radiation protection, such as wearing PPE (apron, lead glasses, or a thyroid shield) while working with radiation. Each correct answer was awarded one point. The overall average of (1) knowledge of radiation protection and (2) awareness of radiation hazards was then converted into a score of 0–100%. The study aimed to investigate the benefits of teaching the participants about radiation protection and awareness of radiation hazards via a focused course. Participants who took a training course in radiation protection and those who didn't take the course

were compared. The results demonstrate the benefit of teaching all participants who work with radiation about safety regulations and protection.

Statistical analysis

Statistical analysis was performed using SPSS software (version 25; IBM Corp., Armonk, NY, USA). Quantitative continuous variables are expressed as the means ± standard deviations. Categorical data were compared using the chi-squared test. Continuous data were compared using Student's t test with a 95% confidence interval. Correlations were evaluated using Pearson's correlation coefficient and a two-tailed test of significance. P values less than 0.05 were considered to indicate significance.

The participants' questionnaire assessed their knowledge of radiation protection and awareness of radiation hazards. The questionnaire scores range was from 0 to 100%. The participants were divided into groups, and their questionnaire scores were compared.

Table 1 Demographic characteristics of the participants

Characteristics	Minimum	Maximum	Mean	SD
Age (years)	22	70	34.42	7.681
Years in service (years)	1	48	8.81	7.715
Patients seen per day	0	250	29.93	37.233
Radiology images requested per day	0	350	17.87	38.852
Knowledge of radiation protection	9	82	51.55	14.499
Awareness of radiation hazards	0	100	37.17	27.457

SD standard deviation

Results

In total, 200 responses were received, with a response rate of 66%. The mean age of the participants was 34 years, and approximately 57.5% were men. The participants' knowledge of radiation protection and awareness of radiation hazards were poor (51.55% and 37.17%, respectively). Most participants were medical doctors (70.5%) with a radiological background (31.5%). A breakdown of the demographic data of the participants and their professions and departments is presented in Tables 1 and 2, respectively. No significant differences were observed between male and female participants regarding their knowledge of radiation protection or awareness of radiation hazards (Table 3). No significant difference was observed between the professions in terms of knowledge regarding radiation protection; however, radiographers had a significantly greater awareness of radiation hazards (58.97%; Table 4). A significant difference was observed between the different departments in terms of knowledge of radiation protection and radiology hazard scores, with the highest scores recorded by the radiology department personnel (55.70% and 52.56%, respectively) (Table 5). The number of years in service, patients seen per day, and images requested per day were weakly correlated with knowledge of radiation protection and radiation hazard

Table 3 Effect of sex on knowledge and awareness scores

Sex	Knowledge of radiation protection Mean (SD)	Awareness of radiation hazards Mean (SD)
Males	52.87% (12.24%)	37.33% (27.02%)
Females	49.79% (16.94%)	36.95% (28.18%)
P value	0.137	0.923

P values < 0.05 were considered significant

SD standard deviation

Table 2 Classification of the participants based on their profession and department

Profession	Number	%
Nurses	39	19.5
Physicians	141	70.5
Radiographers	13	6.5
Others	7	3.5
Department	**Number**	**%**
Anesthesiology	13	6.5
Emergency	9	4.5
Oncology	4	2.0
Radiology	63	31.5
Surgery	38	19.0
Others	73	36.5

Table 4 Effect of profession on knowledge and awareness scores

Profession	Knowledge of radiation protection Mean (SD)	Awareness of radiation hazards Mean (SD)
Nurse	47.09% (17.18%)	31.05% (27.71%)
Physician	52.55% (13.44%)	36.49% (27.16%)
Radiographer	55.24% (13.10%)	58.97% (21.46%)
Others	49.35% (18.82%)	44.44% (25.66%)
P value	0.146	0.012

P values < 0.05 were considered significant

SD standard deviation

Table 5 Effect of the department on knowledge and awareness scores

Department	Knowledge of radiation protection Mean (SD)	Awareness of radiation hazards Mean (SD)
Anesthesiology	48.25% (11.96%)	25.64% (22.85%)
Emergency	50.51% (10.27%)	37.04% (36.43%)
Oncology	45.45% (19.63%)	33.33% (9.07%)
Radiology	55.70% (13.31%)	52.56% (25.18%)
Surgery	53.35% (13.72%)	31.29% (24.35%)
Others	48.07% (15.70%)	29.22% (26.09%)
P value	0.042	< 0.001

P values < 0.05 were considered significant

SD standard deviation

Table 6 Correlations between service years, patients seen daily, and images requested daily and knowledge and awareness scores

	Knowledge of radiation protection	Awareness of radiation hazards
Service years		
Pearson correlation	− 0.041	0.093
P value	0.565	0.190
Patients seen per day		
Pearson correlation	− 0.057	0.085
P value	0.425	0.234
Images requested per day		
Pearson correlation	− 0.042	0.089
P value	0.559	0.210

Sig significance

P values < 0.05 were considered significant (two-tailed)

scores; however, these correlations were not significant (Table 6). Finally, attending an occupational radiation exposure education course had a significant positive impact on knowledge of radiation protection and radiation hazard scores (Table 7).

Table 7 Effect of occupational radiation exposure course attendance on knowledge and awareness scores

Occupational radiation exposure course attendance	Knowledge of radiation protection Mean (SD)	Awareness of radiation hazards Mean (SD)
Course attended	55.44% (14.34%)	51.37% (26.46%)
Course not attended	49.84% (14.28%)	30.94% (25.58%)
P value	0.012	< 0.001

P values < 0.05 were considered significant

SD standard deviation

Discussion

Our study demonstrated that the participants' level of knowledge of radiation protection and awareness of radiation hazards was poor. Moreover, there was no significant difference in the level of knowledge of radiation protection between the medical disciplines; however, radiographers were significantly more aware of radiation hazards.

Long-term ionizing radiation exposure increases the risk of carcinogenesis and can lead to other harmful effects [5]. Ionizing radiation is known to be associated with most forms of leukemia and cancer in many organs. Many studies have evaluated healthcare professionals' awareness of the dangers of ionizing radiation exposure and protection from hazards and have revealed that medical doctors at various levels (consultants vs. residents) have variable understanding of how radiation causes cancer [6]. In addition, a study on awareness of protection and knowledge about radiological examinations showed that healthcare professionals who work with ionizing radiation have insufficient general knowledge of radiation, radiation protection, health hazards, and doses received by patients during radiological intervention.

In this study, we evaluated the comprehension, perception, and mitigation of dangers associated with radiological intervention and focused on healthcare professionals who do not work in radiation-related disciplines but utilize ionizing radiation as part of their work [7]. Overall, inadequate knowledge regarding the health risks associated with ionizing radiation was observed, which was consistent with the findings of other studies [8]. A previous study examined the knowledge of radiation doses for common radiographic procedures among radiologists and non-radiologists. One-third of non-radiologists could not distinguish between radiological examinations with and without ionizing radiation [9]. Another study collected both quantitative and qualitative data on physicians' knowledge and attitudes toward medical radiation

exposure and showed that most physicians underestimated radiation doses [10].

Given that most of our participants were medical doctors, our study demonstrated a significant difference among departments regarding the level of knowledge of radiation protection and radiological hazards. Approximately half of the participants (51.55%) had a general knowledge of radiation protection, and although this percentage was higher among the radiology department personnel, it did not significantly differ from that of other professions. The level of awareness regarding radiation hazards was greater among radiographers (58.97%) than among that in other professions (37.71%). No significant differences were observed between men and women in terms of radiation protection knowledge or awareness of radiation hazards. Surgery and emergency department personnel ranked second in terms of knowledge of radiation protection and radiation hazard awareness, respectively (Table 5). In contrast, anesthesiology department personnel reported the least understanding of radiation protection and awareness of radiation hazards. This finding is consistent with a study showing that a substantial percentage of anesthesiologists demonstrated a lack of awareness regarding radiation risks [1]. This could be due to the low use of medical radiation in this discipline; however, anesthesiologists are at considerable risk of radiation exposure during surgical procedures that require medical radiation. Hence, awareness of radiation hazards is crucial.

We demonstrated that personnel who attended a course on occupational radiation exposure had greater levels of awareness regarding radiation hazards and knowledge regarding radiation protection. This finding supports the findings of another study, which showed that practitioners who had received radiation exposure training and were familiar with European radiation protection and safety standards were more likely to inform patients of the risks of medical radiation [10].

Moreover, this study showed that the number of years in service, number of patients seen per day, and number of images requested per day were weakly associated with the level of knowledge about radiation protection and radiation hazards. This finding is consistent with a study that evaluated physicians' knowledge of the harmful effects of ionizing radiation and demonstrated that medical doctors in various stages of their careers (consultants vs. residents) had varying levels of understanding about radiation risks, indicating that awareness of ionizing radiation is not acquired over time [7].

After performing a literature review, we found variable outcomes in previous studies. Awosan et al. found poor radiation protection practices despite good knowledge of radiation hazards among the participants, but radiation exposure and prevalence of abnormal clinical conditions were found to be low. Periodic in-service training and monitoring on radiation safety was suggested [11].

In 2020, Behzadmehr et al. conducted a systematic review of published articles on radiation protection among health care worker. Their results indicate that in most studies, more than half (50%) of the participants had average knowledge. Furthermore, 60% of the participants had a positive attitude toward radiation protection, but in most studies, they had only average practices regarding radiation protection. [12]

This study has several limitations. First, the sample size was relatively small to reflect knowledge among all practitioners involved. Secondly, about 70% of participants were doctors; as a result, our sample may not have accurately represented the practices of other healthcare providers. Third, this study did not include personnel from specialized private radiation centers where there may be increased occupational radiation hazards due to the increased exposure to radiation.

In summary, our study demonstrated varied levels of knowledge regarding radiation protection among participants; however, their awareness of radiation hazards was inadequate. Therefore, we propose that physicians, nurses, and all those who work with or are exposed to medical radiation should receive formal education and training and that such courses should be mandatory to renew their license to practice. Hospitals should also ensure the correct use of PPE and safety measures during medical radiation interventions. Furthermore, physicians should continually research radiation hazards and the latest radioprotective practices to increase their awareness.

Conclusions

According to our findings, medical personnel generally have poor awareness of radiation hazards and radiation protection protocols. However, this understanding can be enhanced through periodic in-service training and regular monitoring of occupational radiation exposure by health professionals.

Abbreviation

PPE Personal protective equipment

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Author contributions

J.F, R.T, S.A, and A.A contributed extensively in study design, data collection, and evaluation. J.F. and R.T. participated in study drafting and statistical analysis. J.F., R.T., and A.A participated extensively in data analysis and the conclusion. J.F. and S.A. were responsible for overall supervision, and R.T and S.A have reviewed and edited the final draft of the manuscript. A.I, R.A, M.A, H.A, R.A, and B.A contributed extensively in data collection, survey preparation, and distribution. All authors contributed extensively in the editing process of

the paper's final draft. As corresponding author, I declare that all listed authors have fulfilled all 4 requirements for authorship according to international rules.

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All data and materials are available upon request: jehadz@hu.edu.jo. The questionnaire is available at https://doi.org/10.6084/m9.figshare.23386790 and https://doi.org/10.6084/m9.figshare.23514750.

Declarations

Ethics approval and consent to participate
The study protocol was reviewed and approved by the Institutional Review Board of Hashemite University (nonfunded research no. 9/1/2022/2023). Participants' data were kept anonymous and confidential. All study procedures were conducted according to the World Medical Association Declaration of Helsinki. Written informed consent was provided by the participants at the beginning of the survey before they answered the questions.

Consent for publication
Written informed consent was provided by the participants at the beginning of the survey before they answered the questions.

Competing interests
The authors declare that there are no competing interests.

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References

1. Khamtuikrua C, Suksompong S (2020) Awareness about radiation hazards and knowledge about radiation protection among healthcare personnel: a quaternary care academic center-based study. SAGE Open Med 8:2050312120901733. https://doi.org/10.1177/2050312120901733
2. Schueler BA (2010) Operator shielding: how and why. Tech Vasc Interv Radiol 13:167–171. https://doi.org/10.1053/j.tvir.2010.03.005
3. Koenig AM, Maas J, Viniol S, Etzel R, Fiebich M, Thomas RP, Mahnken AH (2020) Scatter radiation reduction with a radiation-absorbing pad in interventional radiology examinations. Eur J Rad 132:109245. https://doi.org/10.1016/j.ejrad.2020.109245
4. Le Heron J, Padovani R, Smith I, Czarwinski R (2010) Radiation protection of medical staff. Eur J Rad 76:20–23. https://doi.org/10.1016/j.ejrad.2010.06.034
5. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103 (2007) Ann ICRP 37:1–332. https://doi.org/10.1016/j.icrp.2007.10.003
6. Exposures from natural radiation sources (2000) United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reports 1:83–156.
7. Yucel A, Alyesil C, Sim S (2011) Physicians' knowledge about ionizing radiation and radiological imaging techniques: a cross-sectional survey. Acta Radiol 52:537–539. https://doi.org/10.1258/ar.2011.100288
8. Yurt A, Cavuşoğlu B, Günay T (2014) Evaluation of awareness on radiation protection and knowledge about radiological examinations in healthcare professionals who use ionized radiation at work. Mol Imaging Radionuclide Ther 23:48–53. https://doi.org/10.4274/mirt.00719
9. Lee RK, Chu WC, Graham CA, Rainer TH, Ahuja AT (2012) Knowledge of radiation exposure in common radiological investigations: A comparison between radiologists and nonradiologists. Emerg Med J 29:306–308. https://doi.org/10.1136/emermed-2011-200481
10. Lumbreras B, Vilar J, González-Álvarez I, Guilabert M, Parker LA, Pastor-Valero M, Domingo ML, Fernández-Lorente MF, Hernández-Aguado I (2016) Evaluation of clinicians' knowledge and practices regarding medical radiological exposure: findings from a mixed-methods investigation (survey and qualitative study). BMJ Open 6:e012361. https://doi.org/10.1136/bmjopen-2016-012361
11. Awosan KJ, Ibrahim MTO, Saidu SA, Ma'aji SM, Danfulani M, Yunusa EU, Ikhuenbor DB, Ige TA (2016) Knowledge of Radiation Hazards, Radiation Protection Practices and Clinical Profile of Health Workers in a Teaching Hospital in Northern Nigeria. J Clin Diagn Res 10:LC07–LC12. https://doi.org/10.7860/JCDR/2016/20398.8394
12. Behzadmehr R, Doostkami M, Sarchahi Z, Dinparast Saleh L, Behzadmehr R (2020) Radiation protection among health care workers: knowledge, attitude, practice, and clinical recommendations: a systematic review. Rev Environ Health 36:223–234. https://doi.org/10.1515/reveh-2020-0063

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