Afghan Medical Journal

Afghan Medical Journal. 2026; 3(1):22–27. E-ISSN: 3007-0805

Knowledge of Ionizing Radiation Risks and Radiation Protection Among Radiology Staff in Public Specialized Hospitals in Kabul City: A Cross-Sectional Study

Dad Mohammad Behrooz Naasiri[1], Ahmad Wali Amini[2], Abdul Qudoos Ahmadi[3]

[1]Senior Teaching Assistant, Department of Medical Physics, Faculty of Allied Health, Kabul University of Medical Sciences, Kabul, Afghanistan.
[2]Teaching Assistant, Department of Medical Physics, Faculty of Allied Health, Kabul University of Medical Sciences, Kabul, Afghanistan.
[3]Associate Professor, Department of Community Health, Faculty of Nursing, Kabul University of Medical Sciences, Kabul, Afghanistan.

∗**Corresponding Author:**dadmohammadbehrooz@gmail.com

ABSTRACT

Background: The average radiation dose from natural sources is approximately 2.4 mSv per year, a considerable share of which is attributable to medical applications of radiation. About 30–50% of medical decision-making is based on radiological examinations. The extensive use of radiation in medical practice necessitates a well-trained, radiation-protection-aware workforce, given the well-established harmful effects of ionizing radiation. This study aims to determine the level of knowledge among radiology staff in public specialized hospitals in Kabul City regarding ionizing radiation and its associated risks.

Materials and Methods: This descriptive cross-sectional study was conducted in 2023 among 127 radiology staff working in 11 public specialized hospitals in Kabul City, Afghanistan. Data were collected using a structured 25-item multiple-choice questionnaire covering the nature of ionizing radiation, its types, associated risks, and principles of radiation protection. The face and content validity of the questionnaire were assessed and confirmed by experts in nuclear physics from Kabul University and faculty members of the Department of Medical Physics, Kabul University of Medical Sciences "Abu Ali Ibn Sina." Knowledge was categorized as good/excellent (20–25), moderate (13–19), and low (0–12). Data were analyzed using SPSS version 22.

Results: This study was conducted among 127 radiology staff members who completed the questionnaire out of 150 distributed questionnaires, usable questionnaire rate of 84.7%. Of the participants, 113 (89%) were male and 14 (11%) were female. The results showed that 13.4% of participants had a low level of knowledge, 81.9% had a moderate level of knowledge, and 4.7% had a good/excellent level of knowledge.

Conclusion: The findings of this study indicate a moderate level of knowledge among radiology staff. Considering the importance of protection against ionizing radiation, improving staff knowledge and skills is essential. Regular training in radiobiology, radiation physics, and radiation protection can help enhance performance and reduce risks.

Keywords: Ionizing radiation, radiation protection, knowledge, radiology staff, public specialized hospitals in Kabul City

Introduction

Many potentially life-threatening diseases and traumatic injuries would be difficult or impossible to diagnose without medical imaging modalities that use ionizing radiation, particularly X-ray–based imaging. Among all forms of ionizing radiation used in medicine, X-rays constitute the cornerstone of diagnostic radiography because of their indispensable role in disease detection and clinical decision-making. It has been estimated that approximately 30–50% of medical decisions are based on radiological examinations [1]. However, despite their considerable diagnostic benefits, repeated or prolonged occupational exposure to ionizing radiation may pose significant health risks to healthcare workers who routinely work in radiation environments.

The use of diagnostic imaging procedures has increased substantially worldwide, and reports indicate that more than ten million imaging examinations are performed every day [2]. Consequently, occupational exposure to ionizing radiation has become an important concern for healthcare professionals. Ionizing radiation is recognized as one of the major occupational hazards in healthcare and may cause serious, and sometimes irreversible, adverse effects in individuals exposed directly or indirectly, including healthcare workers and patients [3,4].

The biological effects of ionizing radiation include genetic alterations, cell death, damage to the hematopoietic system, and injury to the gastrointestinal tract. Long-term exposure may increase the risk of cataracts, various malignancies, reduced life expectancy, and other radiation-related disorders [5,6]. As the use of diagnostic imaging continues to expand, radiation exposure to both patients and healthcare workers has also increased. Therefore, minimizing unnecessary radiation exposure while maintaining adequate diagnostic image quality has become a fundamental principle of modern radiological practice [7]. Adherence to radiation protection principles, appropriate use of personal protective equipment, and implementation of established radiation safety regulations and guidelines are essential measures for reducing radiation-related risks in imaging departments [4,8]. Furthermore, the health effects of ionizing radiation are often difficult to recognize because radiation-induced cancers do not have distinct clinical characteristics and may not become apparent until many years after exposure [9].

Adequate knowledge and knowledge of ionizing radiation hazards and radiation protection principles are therefore essential for all healthcare workers, particularly those employed in radiology departments and other areas with frequent radiation exposure. Insufficient awareness may result in either unnecessary fear of radiation or inadequate compliance with radiation protection measures, both of which may increase the likelihood of avoidable radiation exposure and its potentially irreversible consequences for healthcare workers and future generations [10]. Improving knowledge through continuous education and training can contribute substantially to reducing occupational radiation exposure and strengthening radiation safety practices [11,12]. Nevertheless, previous studies have reported that the level of knowledge regarding radiation sources, associated risks, radiation dose, and radiation protection principles remains inadequate among many healthcare professionals [13].

In Afghanistan, particularly in Kabul City, there is a substantial lack of published scientific evidence regarding the knowledge of radiology staff about ionizing radiation hazards and radiation

protection principles. Most published studies have been conducted in other countries, and their findings may not be directly applicable to Afghanistan because of differences in healthcare infrastructure, educational opportunities, radiation safety programs, and implementation of radiation protection regulations. Consequently, the level of knowledge among radiology personnel, their educational needs, and the areas requiring improvement in radiation protection practices have not been adequately documented in the Afghan healthcare system.

Addressing this awareness gap is essential for developing evidence-based educational strategies, strengthening the culture of radiation protection, improving occupational safety, and supporting future policies aimed at protecting both healthcare workers and patients. Therefore, the present study was conducted to assess the level of knowledge of radiology staff regarding the hazards of ionizing radiation in specialized public hospitals of Kabul City in 2023 and to provide baseline local evidence for future educational and radiation protection interventions.

Materials and Methods

This descriptive cross-sectional survey was conducted in 2023 among radiology department staff working in eleven specialized public hospitals in Kabul City, Afghanistan, including Wazir Mohammad Akbar Khan Hospital, Istiqlal Hospital, Maiwand Hospital, Cardiovascular Hospital, Ali Abad Hospital, Atatürk Hospital, Stomatology Hospital, Ibn Sina Emergency Hospital, National Radiology Center, Mohammad Ali Jinnah Hospital, and Shahid Sardar Mohammad Daud Khan Hospital. Initially, 13 public specialized hospitals in Kabul City were considered for inclusion; however, two hospitals were excluded because their hospital administrators did not provide the necessary cooperation to conduct the study. Therefore, the final study included 11 participating public specialized hospitals. A census approach was used, whereby all eligible radiology staff members in the participating hospitals were invited to participate. The 150 eligible radiology staff members represented the entire eligible study population across the eleven participating hospitals. Therefore, no sample was drawn from the eligible study population. The study aimed to describe the level of knowledge of ionizing radiation risks and radiation protection among radiology staff and did not seek to establish causal or predictive relationships.

Data were collected using a structured self-administered questionnaire adopted from previously published articles available in Dari, addressing knowledge of ionizing radiation hazards and radiation protection. The questionnaire was administered in Dari for data collection and was subsequently translated into English by the researchers with the assistance of faculty members from the Departments of Atomic and Nuclear Physics at Kabul University and Radiology at Kabul University of Medical Sciences Abu Ali Ibn Sina. Reliability testing of the adapted questionnaire (e.g., Cronbach's alpha or KR-20) was not performed in this study.

The adapted questionnaire was reviewed for face and content validity by experts from the Department of Atomic and Nuclear Physics at Kabul University and faculty members of the Department of Medical Physics at Kabul University of Medical Sciences Abu Ali Ibn Sina. Face and content validity were assessed qualitatively through expert review. The experts evaluated the questionnaire items in terms of clarity, relevance, appropriateness, and comprehensiveness in relation to the study objectives, and necessary modifications were made based on their comments and recommendations. A pilot study was conducted among nine radiology staff members to assess the clarity, comprehensibility, and practical applicability of the questionnaire. The pilot study was conducted solely for these purposes and was not used to assess internal consistency or other measures of reliability. Participants in the pilot study were not included in the final study sample. The full questionnaire and the corresponding answer key are provided in the appendices to enhance transparency and reproducibility.

The questionnaire consisted of two sections. The first section collected demographic information, including age, sex, marital status, educational level, job category, work experience, health status, and fear of radiation. The second section comprised 25 multiple-choice questions assessing knowledge of the nature of ionizing radiation, biological hazards, radiation protection principles, dose measurement units, permissible dose limits, imaging modalities, and protective equipment. Before questionnaire distribution, the participants were provided with the necessary instructions and were asked to complete the questionnaire individually based on their own knowledge without consulting external resources. Of the 150 eligible radiology staff members identified across the participating hospitals, 150 questionnaires were distributed, representing all eligible staff. All 150 questionnaires were returned, resulting in an initial response rate of 100%. Twenty-three questionnaires were excluded because of incomplete responses, while no participants refused to participate. Consequently, 127 completed and eligible questionnaires were included in the final analysis, yielding a usable response rate of 84.7% (127/150).

After coding, the data were entered into SPSS software version 22 for analysis. One point was assigned for each correct response and zero points for each incorrect response. The total knowledge score ranged from 0 to 25. For the purpose of this study, the knowledge score was categorized into three levels based on the proportion of correct responses: low/weak knowledge (0–12 scores, 0–48%), moderate knowledge (13–19 scores, 52–76%), and good/excellent knowledge (20–25 scores, 80–100%). These cutoff points were predefined by the researchers before data analysis to provide a consistent and practical interpretation of knowledge levels across the 25-item questionnaire. The classification was used solely for descriptive purposes and was not intended to represent a standardized or externally validated knowledge scale. Data were analyzed using descriptive statistics, including frequencies and percentages.

Knowledge levels were summarized according to participants' sex, educational level, and occupational category for descriptive purposes only. No inferential statistical tests were performed because the study was designed to describe knowledge levels rather than assess statistical associations or predictors.

Eligible population

The source population consisted of all healthcare staff working in the radiology departments of the 11 selected public specialized hospitals in Kabul City. The eligible population included all radiologists, radiologic technologists, and radiology nurses who were actively working in these departments during the study period and were invited to participate using a census sampling approach.

Inclusion criteria

All eligible radiology staff members, including radiologists/doctors, radiologic technicians, and nurses working in the radiology departments of the selected hospitals during the study period.

Staff members who were actively employed in the radiology departments at the time of data collection.

Staff members who provided informed consent to participate in the study.

Exclusion criteria

Staff members who were absent from the radiology departments during the data collection period.

Individuals who declined to participate or did not provide informed consent.

Participants who submitted incomplete questionnaires were excluded from the final analysis.

Results

All 150 eligible radiology staff members returned the questionnaire, resulting in an overall response rate of 100%. However, 23 questionnaires were excluded because they were incomplete. Therefore, 127 questionnaires were included in the final analysis, corresponding to a usable response rate of 84.7%. 113 (89%) were male, and 14 (11%) were female. The majority of participants were married (89.8%) and worked as radiology technicians (78.7%). Regarding educational attainment, 67.7% held a diploma, 24.4% held a bachelor's degree, and 7.9% held a master's degree, while none possessed a doctoral (PhD) degree.

With respect to attitudes toward radiation, 85.8% of the participants reported having fear of radiation. Regarding health status, 55.1% reported being in normal health at the time of the study, whereas 44.9% reported various health problems. In terms of age distribution, the largest proportions of participants were in the 31–40 years (31.5%) and 41–50 years (30.7%) age groups. Concerning work experience, most participants had 1–10 years (35.4%) or 11–20 years (34.6%) of professional experience. A total of 3175 responses were analyzed, of which 62.02% were correct and 37.98% were incorrect. The mean knowledge score was 15.51 out of a maximum possible score of 25.

Based on the predefined knowledge classification, 81.9% of participants demonstrated a moderate level of knowledge, 13.4% had low knowledge, and 4.7% exhibited good/excellent knowledge. These findings indicate that the overall level of knowledge among radiology staff was moderate

Table 1: Demographic Characteristics of Radiology Department Staff in Public Specialized Hospitals of Kabul City

Hospitals name	Eligible Staff	Included participants	Gender		Educational level		Marital status			Job category		
			Male	Female	Diploma	Bachelor's	Master's	Single	Married	Doctors	Technicians	Nurses
Wazir Mohammad	11	8	8	0	7	1	0	0	8	0	8	0
Esteqlal	8	6	6	0	2	4	0	0	6	1	5	0
Maiwand	8	6	5	1	3	3	0	1	5	0	6	0
Cardiology	7	5	5	0	0	4	1	1	4	1	4	0
Aliabad	20	15	15	0	8	3	4	2	13	7	8	0
Atatürk	8	6	6	0	6	0	0	0	6	0	6	0
Stomatology	6	5	5	0	5	0	0	1	4	0	5	0
Ibn Sina Emergency	9	9	8	1	6	1	2	1	8	1	6	2
National Institute of Radiology	48	45	37	8	35	8	2	2	43	9	36	0
Sardar Mohammad Daoud Khan	16	15	13	2	8	6	1	3	12	5	10	0
Mohammad Ali Jinnah	9	7	5	2	6	1	0	2	5	1	6	0
150	127	113	14	86	31	10	13	114	25	100	2	

Table 1 shows the demographic characteristics of the participants, including gender, job type, marital status, and educational level among the staff of the radiology departments in public hospitals in Kabul City.**Table 2: Distribution of Knowledge Level among Male and Female Radiology Staff in Public Specialized Hospitals of Kabul City**

Gender	Total *n* (%)	Knowledge Level		
		Low knowledge	Moderate knowledge	Good/excellent knowledge
Male	113 89.0%	16 14.2%	92 81.4%	5 4.4%
Female	14 11.0%	1 7.1%	12 85.7%	1 7.1%
Total	127 100%	17 13.4%	104 81.9%	6 4.7%

Percentages in the Male and Female rows are row percentages calculated using the number of participants within each sex group as the denominator (Male = 113; Female = 14). Percentages in the Total row are based on the overall sample size (n = 127).**Table 3: Distribution of Knowledge Levels among Radiology Staff According to Educational Level.**

Educational Level	Total *n* (%)	Knowledge Level		
		Low knowledge	Moderate knowledge	excellent knowledge
Diploma	86 67.7%	10 11.6%	73 84.9%	3 3.5%
Bachelor's Degree	31 24.4%	3 9.7%	26 83.9%	2 6.5%
Master's Degree	10 7.9%	4 40.0%	5 50.0%	1 10.0%
Doctoral Degree (PhD)	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Total	127 100.0%	17 13.4%	104 81.9%	6 4.7%

Percentages in each educational level row were calculated using

the number of participants within each educational category as the denominator (Diploma = 86, Bachelor's Degree = 31, Master's Degree = 10, PhD = 0). Percentages in the Total row were calculated based on the overall sample size (n = 127).

Table 4: Distribution of knowledge levels according to the occupational category of radiology department staff in hospitals

Occupational Category	Total *n* (%)	Knowledge Level		
		Low knowledge	Moderate knowledge	excellent knowledge
Physician	25 19.7%	3 12.0%	19 76.0%	3 12.0%
Radiology Technician	100 78.7%	12 12.0%	85 85.0%	3 3.0%
Nurse	2 1.6%	2 100.0%	0 0%	0 %
Total	127 100.0 %	17 13.4%	104 81.9%	6 4.7%

Percentages in each occupational category row were calculated using the number of participants within each occupational group as the denominator (Physician = 25, Radiology Technician = 100, Nurse = 2). Percentages in the Total row were calculated based on the overall sample size (n = 127).

Table 5: Distribution of Correct Responses across Individual Knowledge Items Related to Ionizing Radiation and Radiation Protection

Question	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	
Correct responses n (%)	109 (85.8%)	96 (75.6%)	21 (16.5%)	116 (91.3%)	22 (17.3%)	25 (19.7%)	114 (89.8%)	117 (92.1%)	
Question	Q_9	Q_{10}	Q_{11}	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{16}	
Correct responses n (%)	107 (84.3%)	90 (70.9%)	95 (74.8%)	112 (88.2%)	39 (30.7%)	95 (74.8%)	52 (40.9%)	61 (48%)	
Question	Q_{17}	Q_{18}	Q_{19}	Q_{20}	Q_{21}	Q_{22}	Q_{23}	Q_{24}	Q_{25}
Correct responses n (%)	99 (78.0%)	72 (56.7%)	58 (45.7%)	58 (45.7%)	108 (85.0%)	70 (55.1%)	83 (65.4%)	110 (86.6%)	40 (31.5%)
Total Correct responses	1969/3175 (62.02%)								

Values are presented as n (%), where n is the number of participants who answered each knowledge item correctly. Percentages were calculated based on the total sample (N = 127). The overall correct response rate across all 25 knowledge items was 62.02% (1969/3175).

Table 6: Distribution of Participants According to Knowledge Level Regarding Ionizing Radiation Risks and Radiation Protection

Knowledge Level	low Knowledge	Moderate Knowledge	Good/Excellent Knowledge	Total
Frequency (n)	17	104	6	127
Percentage (%)	13.4	81.9	4.7	100.0

Knowledge levels were classified as low (0–12 points), moderate (13–19 points), and good/excellent (20–25 points) based on the 25-item knowledge assessment score.

Discussion

The present descriptive cross-sectional study found that the overall level of knowledge regarding ionizing radiation risks and radiation protection among radiology staff in the eleven participating public specialized hospitals in Kabul City was moderate. Based on the results of the study, 13.4% of participants had low knowledge, 81.9% had moderate knowledge, and 4.7% had good/excellent knowledge. The overall correct response rate across the 25 knowledge items was 62.02%, and the mean knowledge score was 15.51 out of 25. These findings indicate that, although most participants demonstrated a moderate level of knowledge, important gaps remained in specific areas of radiation safety.

The moderate level of knowledge observed among radiology staff in Kabul may be related to differences in educational background, limited access to continuing professional education, and variations in the availability and quality of in-service training on radiation protection. The availability and consistency of institutional radiation-protection programs, updated safety guidelines, supervision, and access to educational resources may also influence staff knowledge. However, these factors were not directly assessed in the present study and should therefore be considered possible explanations rather than established determinants.

The results of this study are generally consistent with several international studies conducted in the field of healthcare workers' and radiographers' knowledge of radiation protection. In the studies conducted by Paolicchi et al. **[9]**, O'Sullivan et al. **[14]**, Maharjan et al. **[15]**, and Fataftah et al. **[16]**, it was reported that the level of knowledge regarding radiation protection principles and the radiation dose of radiological examinations was not optimal, and in many cases, knowledge deficits were observed among radiographers and some healthcare workers. Furthermore, in the study by Paolicchi et al. **[9]**, it was found that most radiographers underestimated the actual dose of radiological examinations, and only a small proportion participated in regular radiation protection courses. These findings are broadly consistent with the knowledge gaps observed in the present study, however, similarities across studies should be interpreted cautiously because the studies differed in participant characteristics, questionnaire content, scoring methods, and healthcare settings.

In the study by O'Sullivan et al. **[14]**, it was also reported that most radiology staff had not received adequate formal training in radiation protection, and their understanding of radiation dose in imaging procedures was limited. This finding is consistent

with the present study, in which a moderate overall knowledge level and specific knowledge gaps were observed. However, the present study did not assess previous training in sufficient detail or examine statistical associations between training and knowledge level.

In contrast, studies by Fataftah et al. **[16]** and Maharjan et al. **[15]** reported differences in knowledge levels among various healthcare groups, including radiologists, students, and other healthcare staff. Although the overall level of knowledge remained low in these studies, variations in knowledge were described across different participant groups. In the present study, knowledge levels were also described according to participants' demographic characteristics. However, because only descriptive statistics were used, no inferential statistical analysis was performed to determine whether demographic characteristics were statistically associated with knowledge level. Therefore, the observed differences between groups should be interpreted descriptively and should not be considered evidence of statistically significant associations or causal relationships. Similarly, Ramanathan and Ryan **[17]** reported that even among specialized radiology staff, knowledge of radiation dose and its associated risks remained limited, with radiation risks frequently being underestimated. This provides further context for the moderate level of knowledge observed among participants in the present study.

Overall, the findings indicate that knowledge of ionizing radiation risks and radiation protection among the participating radiology staff was moderate, with important gaps in specific areas of radiation safety. These findings support the importance of continuous radiation-protection education, dose-monitoring education, and periodic competency assessment. However, because this was a descriptive cross-sectional study, it cannot determine whether training or other factors cause differences in knowledge or improve radiation-protection practices. Further analytical and intervention-based studies are

warranted to investigate these relationships and evaluate the effectiveness of educational interventions.

Limitations

Study Design: Due to the cross-sectional design, causal relationships between different factors and knowledge levels cannot be established.

Self-reported Information: The use of self-administered questionnaires may have introduced response bias.

Limited Generalizability: The findings are limited to the eleven participating public specialized hospitals in Kabul City and should not be generalized to radiology staff working in other public or private hospitals, non-participating hospitals, or other regions of Afghanistan.

Instrument Validation Although the questionnaire was adapted from previously published and validated instruments and was reviewed for face and content validity by experts, the internal consistency reliability of the adapted questionnaire (e.g., Cronbach's alpha or KR-20) was not assessed in the present study. This should be considered when interpreting the findings, as it may have affected the measurement properties of the instrument.

Limited Statistical Analysis: The study mainly focused on descriptive statistics and extensive analyses to identify factors associated with knowledge were not performed.

Questionnaire Reliability: Although the questionnaire underwent expert review for face and content validity and pilot testing for clarity and applicability, formal reliability testing was not performed. Therefore, the reliability of the adapted questionnaire could not be confirmed and should be considered a limitation of this study.

Conclusion

The present study found that radiology staff in public specialized hospitals in Kabul City had a moderate level of knowledge regarding ionizing radiation risks and radiation protection principles. Knowledge gaps were identified in some areas of radiation safety, highlighting the need for continuous radiation-protection training, dose-monitoring education, and periodic competency assessments to improve occupational radiation safety.

Recommendations

Based on the findings of this study, which indicated a moderate level of knowledge among radiology staff regarding ionizing radiation risks, the following recommendations are proposed:

Radiation protection principles and safety standards should be emphasized in radiology departments, with support from relevant experts in medical physics and radiation protection.

Regular radiation safety knowledge assessments should be conducted among radiology staff to identify knowledge gaps and improve radiation protection practices.

Continuous training programs and specialized workshops on radiation protection should be developed and implemented for radiology staff to enhance their knowledge and knowledge.

Radiation protection concepts should be strengthened in radiology education curricula and professional training programs, with greater emphasis on practical radiation safety principles.

Further studies with larger and more diverse samples are recommended to evaluate factors affecting radiation protection knowledge and the effectiveness of educational interventions.

Acknowledgments

The authors of this study express their sincere gratitude and appreciation to all radiologists and staff of the public specialized hospitals in Kabul City for their valuable cooperation in the collection and completion of data for this research. The authors also sincerely acknowledge the professors and colleagues who contributed to the conduct and progress of this study. Their support and cooperation played an important role in the success of this research. In addition, the researchers extend their gratitude to the esteemed Directorate of Scientific Research of Kabul University of Medical Sciences (KUMS) and to all individuals who, in any way, assisted in the execution of this study.

Conflict of Interest

The authors declare that there is no scientific, financial, or personal conflict of interest related to this research. This study was conducted independently.

Ethical approval and consent

Ethical approval for this study was obtained from the Scientific Research Committee of the Faculty of Physics, Kabul University, on1401/11/27 (2023/2/16), under Protocol No. 33. Written institutional permission to conduct the study and collect data was obtained from the responsible authorities of all eleven participating public specialized hospitals before data collection. Before completing the questionnaire, the purpose of the study was explained to all participants, and their participation was entirely voluntary. Informed consent was obtained from all participants before data collection. No names, personal identifiers, or other identifiable information were collected from the participants. Each questionnaire was assigned a code, and all collected data were kept confidential and used solely for research purposes.

References

1. Abdellah RF, Attia SA, Fouad AM, Abdel-Halim AW. Assessment of physicians' knowledge, attitude and practices of radiation safety at Suez Canal University Hospital, Egypt. Open J Radiol. 2015;5:250-258. doi:10.4236/ojrad.2015.54034.
2. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and risks of ionizing radiation: UNSCEAR 2020/2021 Report, Volume I. Scientific Annex A: Evaluation of medical exposure to ionizing radiation. New York: United Nations; 2022.

3. Dellie ST, Admassie D, Ewnetu Y. An Assessment of Final-Year Medical Students and Interns Awareness
4. of Radiation Exposure to Common Diagnostic Imaging Procedures. Advances in Radiology. 2014;2014(1):426909. doi:10.1155/2014/426909.
5. Amirzadeh F, Tabatabaie SHR. Survey of radiation protection awareness among radiation workers in Shiraz hospitals. Iran J Nucl Med. 2005;13(2):38-43.
6. Alotaibi M, Saeed R. Radiology nurses' Awareness of radiation. Journal of Radiology Nursing. 2006 Mar 1;25(1):7-12. doi:10.1016/j.jradnu.2005.12.001.
7. International Commission on Radiological Protection. The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann ICRP. 2007;37(2-4):1-332. doi:10.1016/j.icrp.2007.10.003.
8. Shahbazi-Gahrouei D. Quality control of the radiological equipment in Chaharmahal and Bakhtiari hospitals. J Shahrekord Univ Med Sci. 2004;5(4):11-18.
9. International Atomic Energy Agency. Radiation protection and safety of radiation sources: international basic safety standards. IAEA Safety Standards Series No. GSR Part 3. Vienna: International Atomic Energy Agency; 2014. STI/PUB/1578
10. Paolicchi F, Miniati F, Bastiani L, Faggioni L, Ciaramella A, Creonti I, Sottocornola C, Dionisi C, Caramella D. Assessment of radiation protection awareness and knowledge about radiological examination doses among Italian radiographers. Insights Imaging. 2016;7(2):233-42. doi:10.1007/s13244-015-0445-6.
11. McGowan C, Heaton B, Stephenson RN. Occupational x-ray exposure of anaesthetists. Br J Anaesth. 1996;76(6):868-9. doi:10.1093/bja/76.6.868.
12. Khan FR, Ul-Abadin Z, Rauf S, Javed A. Awareness and attitudes amongst basic surgical trainees regarding radiation in orthopaedic trauma surgery. Biomed Imaging Interv J. 2010;6(3). doi:10.2349/biij.6.3.e25.
13. International Atomic Energy Agency. Radiation protection and safety in medical uses of ionizing radiation. IAEA Safety Standards Series No. SSG-46. Vienna: International Atomic Energy Agency; 2018. STI/PUB/1775. ISBN:978-92-0-101717-8.
14. Tamjidi A. Evaluation of observance of radiation protection in radiology centers in Bushehr. Iran South Med J. 2002;4:47-52.
15. O'Sullivan J, O'Connor OJ, O'Regan K, Clarke B, Burgoyne LN, Ryan MF, Maher MM. An assessment of medical students' awareness of radiation exposures associated with diagnostic imaging investigations. Insights Imaging. 2010;1(2):86-92. doi:10.1007/s13244-010-0009-8.
16. Maharjan S, Parajuli K, Sah S, Poudel U. Knowledge of radiation protection among radiology professionals and students: a medical college-based study. Eur J Radiol Open. 2020;7:100287. doi:10.1016/j.ejro.2020.100287.
17. Fataftah J, Tayyem R, Al-Dwairy S, Al Manasra AR, Ibrahim A, Al Ryalat R, et al. Awareness of radiation hazards and knowledge of radioprotective measures among radiologists and non-radiology staff: a cross-sectional survey. Egypt J Radiol Nucl Med. 2024;55:128. doi:10.1186/s43055-024-01300-4.
18. Ramanathan S, Ryan J. Radiation awareness among radiology residents, technologists, fellows and staff: where do we stand? Insights Imaging. 2015;6(1):133-9. doi:10.1007/s13244-014-0365-x.
19. Joya M. Assessment of knowledge among fifth- and third-year medical students regarding ionizing radiation and radiation protection. Kabul: Department of Radiology Kabul University of Medical Sciences; 2016.
20. Shafi H, Qaymyan N, Amani N, Bijani S, Kamali Ahanghar S. Evaluation of nurses' awareness of principles of radiation protection in Shahid Beheshti Hospital. Iran J Surg. 2016;24(2):71-82.