The Open Nursing Journal
DOI: 10.2174/0118744346359232250113075426, 2025, 19, e18744346359232
ISSN: 1874-4346

RESEARCH ARTICLE OPEN ACCESS

Adherence to Radiation Protection Principles in the Clinical Environment among Anesthesia and Operating Room Nursing Students: Implications for Educational Interventions

Sina Ghasemi[1], Hossein Khosravi[2,*], Behzad Imani[3] and Naeeme Shabani[4]

[1]*Student Research Committee, Hamadan University of Medical Sciences, Hamadan, Iran*
[2]*Department of Radiology, School of Allied Medical Sciences, Hamadan University of Medical Sciences, Hamadan, Iran*
[3]*Department of Operating Room, School of Paramedicine, Hamadan University of Medical Sciences, Hamadan, Iran*
[4]*Department of Medical Surgical Nursing, Student Research Committee, Hamadan University of Medical Sciences, Hamadan, Iran*

Abstract:

Background: The increasing use of ionizing radiation in clinical environments, particularly during surgeries such as orthopedics and neurosurgery, has heightened concerns about the potential health risks associated with this type of radiation. This issue is particularly relevant for nursing students undergoing training in operating room settings, where they are frequently exposed to various sources of radiation. To effectively implement radiation protection principles, it is crucial to evaluate the knowledge and attitudes of the students toward ionizing radiation. Understanding their level of awareness and beliefs about radiation safety will inform the development of targeted training programs aimed at minimizing exposure and enhancing safety in clinical environments.

Objective: This study aimed to investigate the level of knowledge, attitudes, and performance of 8th-semester undergraduate anesthesia and operating room nursing students toward radiation protection principles.

Methods: This cross-sectional study was conducted at the Hamadan University of Medical Sciences in 2024. In this study, students were selected *via* the census sampling method. The data related to the study were collected from valid questionnaires concerning the participants' level of knowledge, attitudes, and performance toward ionizing radiation. The data analysis was also conducted at the descriptive and inferential statistics level *via* SPSS version 16 software.

Results: The knowledge, attitudes, and performance of the students in both fields were inadequate compared to the ideal standards. Additionally, the mean attitude score toward protective principles was significantly greater among operating room nursing students than anesthesia nursing students (p-value = 0.023). Furthermore, a positive and significant correlation was found between students' Grade Point Average (GPA) and their scores on knowledge and attitudes toward protective principles (r = 0.449, p-value = 0.000 and r = 0.648, p-value = 0.000, respectively).

Conclusion: This study revealed that the level of knowledge among students regarding ionizing radiation is lower than the desired standards for ensuring safety in clinical environments. As a result, it is essential to implement targeted training courses to enhance students' understanding of the risks associated with ionizing radiation.

Keywords: Operating room nursing, Anesthesia, Education, Radiation protection, Awareness, Perception.

*Address correspondence to this author at the Department of Radiology, School of Allied Medical Sciences, Hamadan University of Medical Sciences, Hamadan, Iran; E-mail: hkhosravi55@gmail.com

Cite as: Ghasemi S, Khosravi H, Imani B, Shabani N. Adherence to Radiation Protection Principles in the Clinical Environment among Anesthesia and Operating Room Nursing Students: Implications for Educational Interventions. Open Nurs J, 2025; 19: e18744346359232.
http://dx.doi.org/10.2174/0118744346359232250113075426

Received: October 02, 2024
Revised: November 18, 2024
Accepted: November 25, 2024
Published: January 16, 2025

1. INTRODUCTION

Currently, radiology is the cornerstone of clinical diagnosis and effective patient management in medical sciences [1]. The ability of ionizing radiation to penetrate soft tissue and capture images that the human eye cannot see is essential in various branches of medical sciences [2]. The rapid advancement of modern imaging technologies is perceived as a double-edged sword due to the various radiation risks it poses [3]. On the other hand, universities must protect the safety and security of the students by educating them [4].

The operating room is a specialized clinical environment for anesthesia and operating room nursing students, characterized by high-risk factors [5, 6]. Medical staff in the operating room face numerous risks, including musculoskeletal injuries, chemical and biological toxins, carcinogenic substances, and both ionizing and non-ionizing radiation [7, 8]. The exposure of individuals to ionizing radiation is unavoidable due to the use of radiological imaging technology, particularly fluoroscopy with a C-Arm device, during orthopedic and spinal surgeries and implant placements in the operating room [9]. High doses of ionizing radiation, such as X-rays, can have both deterministic and stochastic effects. These types of radiation may lead to severe and irreversible damage, including blood cancer and genetic injuries [10]. Ionizing radiation can cause direct and indirect damage to DNA and living cells by generating free radicals, which are uncharged and unstable molecules. Unstable radicals can produce new toxic substances, such as hydrogen peroxide, in living tissues to stabilize themselves and cause other cellular alterations [11]. Therefore, effectively utilizing new medical imaging technologies and adhering to protection principles is essential [12].

Generally, radiation protection principles refer to a set of measures aimed at minimizing the exposure of patients, health workers, and the public to ionizing radiation, allowing the benefits of radiography while ensuring patient safety [3]. In all medical imaging techniques, three principles are applied: justification, optimization, and dose limitation. The optimization principle serves to increase individuals' knowledge about the effects of radiation exposure [13]. To reduce the risk of radiation exposure, medical science students should have comprehensive knowledge of protective protocols against radiation exposure provided throughout their educational period in college [3].

In the past, training on the principles of working with radiation was not considered essential in the curriculum of medical science students. However, given its significant importance, some countries, such as Japan, now require the relevant educational council to include training on the principles of working with radiation and familiarizing oneself with the potential risks for better professional performance of nurses and healthcare personnel [14]. Assessing the level of knowledge of healthcare personnel working with radiation and conducting Radiation Protection (RP) courses can help reduce the exposure of specialists and patients to ionizing radiation [13].

The findings of previous studies indicate that the knowledge, attitudes, and practices of nurses and medical radiation workers regarding ionizing radiation protection principles vary due to multiple factors [15, 16]. Furthermore, many studies have shown that students in various medical science fields have limited knowledge about ionizing radiation and its protective principles [17, 18]. A study by Srivastava *et al*. found that dental students possess low to average levels of knowledge, attitudes, and practices regarding ionizing radiation [19]. Additionally, the study conducted on the levels of knowledge among interventional cardiologists showed disappointing results [20]. Research indicates a critical need for improved training to increase healthcare workers' knowledge and awareness of radiation protection principles [21]. Determining people's knowledge, attitudes, and performance concerning radiation protection across different fields can help healthcare policymakers better manage and improve awareness, attitude modification, and performance. As shown in Fig. (**1**), various factors such as age, field of study, and gender affect the degree of adherence and attitudes toward radiation protection principles [13, 22]. Most studies on ionizing radiation awareness and familiarity with protective principles have focused on specialists, physicians, and personnel. However, no studies in Iran or other countries have investigated the level of awareness among anesthesia and operating room nursing students, despite their constant presence in the operating room and exposure to X-rays during orthopedic and spinal surgeries. Additionally, similar studies have primarily focused on assessing individuals' knowledge and attitudes. In contrast, this study also examined students' performance alongside their knowledge and attitudes. Therefore, to investigate the necessary training for providing correct knowledge to students and healthcare personnel regarding radiation and its principles, this study aimed to clarify the perception, attitudes, and performance levels of anesthesia and operating room nursing students toward protective principles against ionizing radiation.

2. METHODS

2.1. Study Design and Participants

The present cross-sectional study was conducted in 2024 at the Hamadan University of Medical Sciences. The statistical population included anesthesia and operating room nursing students at the Hamadan University of Medical Sciences. Among them, 140 students were selected using the census sampling method and based on the inclusion criteria. Due to the limited number of students in these two fields at the Hamadan University of Medical Sciences, sampling was conducted for two consecutive years from different students to obtain a sufficient sample size. Out of 151 questionnaires distributed among students, 11 were excluded due to non-return or incomplete information, leaving 140 completed questionnaires for analysis. Students in this study were selected based on two entrance criteria:

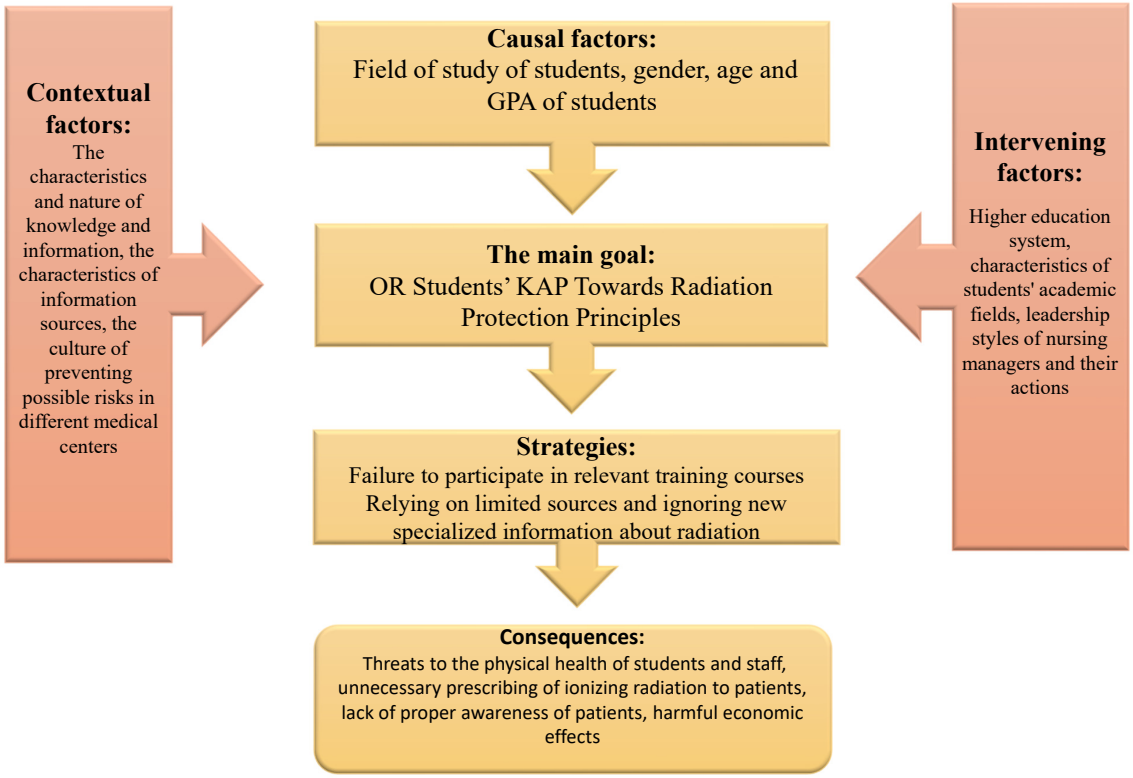

Fig. (1). The theoretical framework of the research.

2.1.1. Academic Standing

Being in the last semester of their respective programs (8th-semester undergraduate students in anesthesia and operating room nursing).

2.1.2. Willingness to Participate

Students' voluntary agreement to participate in the study, along with their consent to the study's objectives and procedures.

Participation in additional courses on learning the principles of working with radiation and C-Arm machines compared to others was considered an exit criterion for this study.

2.3. Measuring instruments

In this research, two self-administered questionnaires were used for data collection as follows:

(1) The demographic information questionnaire included questions about age, sex, field of study, student's Grade Point Average (GPA), and academic semester. In Iran, the grading system is regulated by the Ministry of Science, Research, and Technology and operates on a scale from 0 to 20. In this system, a passing grade for any academic course is defined as a score greater than 10. This score represents the minimum level of proficiency required for students to demonstrate a foundational understanding of the subject matter. Furthermore, scores above 18 are classified as 'A' or 'excellent' according to the Ministry's regulations, indicating a very high level of academic achievement. This grading structure emphasizes a clear distinction between various performance levels, allowing both students and educators to assess academic excellence more effectively.

(2) The second section included a questionnaire on knowledge, attitudes, and performance regarding radiation protection principles. It consists of 30 items divided into 3 dimensions, each composed of 10 items: (1) knowledge, such as "awareness of the role of changing radiation conditions in reducing patient dose"; (2) attitudes, such as "ensuring full protection of radiation workers when using film badges"; and (3) performance, such as "maintaining distance during exposure." The questionnaire utilized a scoring system, where responses were assigned a score of 1 for 'Yes' and 0 for 'No.' This scoring method allowed for the calculation of total scores to assess the participant's knowledge, attitudes, and performance regarding the subject. To obtain the final score for each participant, the scores given for each item were collected and then summed, resulting in a range from a minimum of 0 to a maximum of 10 for each individual. In this method, scores below 5 are considered weak, scores from 5 to 8 are considered average, and scores between 8 and 10 are considered excellent [23]. The questions in this questionnaire covered the risks of

ionizing radiation, the ALARA principle, permissible radiation dose limits, the role of film processing conditions, the role of different parts of the X-ray machine (collimator, filter, intensifying screen) in the patient, and radiographer dose, the use of Bucky film, the use of protective equipment, performing blood tests for health assessment of radiographers, and specific patient conditions. The reliability and validity of this questionnaire have been confirmed in previous studies [23, 24]. In the study by Gharibi *et al*., the validity and reliability of the questionnaire were determined *via* the content validity method with several professors, and its reliability was reported as 0.76 based on Cronbach's alpha test [23]. Also, In Amjadi *et al*.'s study, Cronbach's alpha coefficient for this questionnaire was reported as 0.79 [24].

2.4. Data Collection

After obtaining permission from the Ethics Committee of the Hamadan University of Medical Sciences, students were informed about the study through public announcements and face-to-face interactions. Students who met the inclusion criteria were invited to participate. After providing their consent, the researchers explained the study's objectives and distributed the questionnaires. At a predetermined time, the questionnaires were distributed in printed form among the students. Each student completed the questionnaires themselves and returned them to the researchers, taking approximately 20 minutes. The confidentiality of the participants' information was assured.

2.5. Statistical Analysis

Finally, data analysis was conducted *via* SPSS, version 16.0 (SPSS Inc., Chicago, Ill., USA) software, with a significance level of 0.05. First, the assumption of normality of the data was checked *via* the Kolmogorov– Smirnov test. Descriptive statistics included the frequency, percentage, mean, and standard deviation. Fisher's exact test and independent t-tests were used to compare the frequency distributions of qualitative and quantitative demographic characteristics between the students. Additionally, the Pearson correlation coefficient was used to determine the relationships between the grades obtained from the questionnaire and their demographic characteristics.

3. RESULTS

This study examined 8th-semester undergraduate students in the operating room for nursing (n=70) and anesthesia nursing (n=70). Additionally, 66 participants (47.14%) were male, and 74 participants (52.86%) were female. The mean ± standard deviation of the age of the students was 22.7 ± 1.25 years. Additionally, the mean GPA of the students based on the score was 17.49 ± 0.65. According to Fisher's exact test, there was no statistically significant difference in terms of sex between the two groups of anesthesia and operating room nursing students (*p*-value=0.811). Also, missing values were not inferred.

Furthermore, the independent t-test results between the mean age and GPA of students in the anesthesia and operating room nursing groups did not significantly differ. The significance levels were 0.186 and 0.776, respectively (Table **1**).

Based on our findings, the means ± standard deviations of the total scores of students' knowledge levels regarding radiation protection methods among anesthesia and operating room nursing students were 5.40 ± 2.64 and 4.71 ± 2.46, respectively. Additionally, the means ± standard deviations of the total scores of students' attitudes toward radiation protection methods among anesthesia and operating room nursing students were 5.82 ± 2.68 and 4.42 ± 2.35, respectively. Moreover, the means ± standard deviations of the total score of their performance level in the two groups were 5.82 ± 1.09 and 5.71 ± 1.07, respectively (Table **2**).

The independent t-test results revealed a statistically significant relationship between the scores of students' attitudes toward radiation protection principles among anesthesia and operating room nursing students (*p*-value=0.023). There was no statistically significant relationship between the mean scores of knowledge level and performance of students between the anesthesia and operating room nursing groups. However, the average score among operating room nursing students was greater than that among anesthesia nursing students.

Furthermore, Table **2** demonstrates the mean scores and standard deviations of students' knowledge level, attitudes, and performance regarding radiation protection principles based on sex. According to the results of this table, the mean scores of knowledge level and attitudes toward radiation protection principles among female students were significantly higher than those among male students (*p*-value <0.001). However, no statistically significant difference was observed in the performance level scores of the students in terms of these principles between the male and female students (*p*-value=0.098).

Table 1. Student's demographic characteristics by study groups*.

-		Operating Room Nursing (n=70)	Anesthesia Nursing (n=70)	*p*-value
Age	Mean ± SD	22.9 ± 1.26	22.5 ± 1.23	0.186
	95% CI	(22.5,23.3)	(22.1,22.9)	
Grade Point Average (0-20)	Mean ± SD	17.51 ± 0.66	17.47 ± 0.64	0.776
	95% CI	(17.28,17.74)	(17.24,17.69)	
Sex	Male	45.7% (n=32)	48.5% (n=34)	0.811
	Female	54.3% (n=38)	51.5% (n=36)	

Note: *All students were in the 8th semester.

Table 2. The mean scores of students' level of knowledge, attitude, and performance regarding the principles of radiation protection by field of study and gender.

Variable	Mean (Standard deviation)					
	Field of Study		*p*-value	Sex		*p*-value
	Operating Room Nursing (n=70)	Anesthesia Nursing (n=70)		Male (n=66)	Female (n=74)	
Knowledge	5.40 (2.64)	4.71 (2.46)	0.266	3.87 (2.59)	6.10 (2.05)	0.000
Attitude	5.82 (2.68)	4.42 (2.35)	0.023	3.48 (2.12)	6.59 (2.07)	0.000
Performance	5.82 (1.09)	5.71 (1.07)	0.661	5.54 (1.06)	5.97 (1.06)	0.098

Table 3. Correlation coefficients of the scores of knowledge level, attitude, and performance towards the principles of radiation protection with grade point average and age of students.

Variable	Field of Study	n	Knowledge		Attitude		Performance	
			r	*p*-value	r	*p*-value	r	*p*-value
Grade point average	Operating room nursing	70	0.575	0.000	0.575	0.000	0.142	0.416
	Anesthesia nursing	70	0.309	0.070	0.650	0.000	0.314	0.066
	Total	140	0.449	0.000	0.648	0.000	0.227	0.098
Age	Operating room nursing	70	0.205	0.237	0.272	0.114	0.361	0.033
	Anesthesia nursing	70	-0.250	0.148	-0.208	0.230	-0.120	0.491
	Total	140	0.005	0.970	0.085	0.482	0.127	0.296

The results indicate a statistically significant relationship between the overall GPA of all the students and the mean scores of their knowledge level and attitudes toward radiation protection principles, such that there is a positive and significant correlation between the students' GPA and the mean scores of their knowledge level and attitudes toward radiation protection principles (*p*-value = 0.000). However, statistical analyses revealed no relationship between the GPA and the grade obtained from students' performance concerning radiation protection principles (*p*-value = 0.059). Furthermore, among operating room nursing students, there was a significant positive correlation between their GPA and their level of knowledge and attitudes toward radiation protection principles (r=0.575 and r=0.677, respectively) (*p*-value = 0.000). However, among anesthesia nursing students, only a significant and positive correlation was found between their attitude level and GPA (r=650) (*p*-value = 0.000) (Table **3**).

Concerning the variable of the students' age, no significant correlation was found between the ages of all the students and their levels of knowledge, attitudes, and performance. However, among operating room nursing students, only a significant and positive correlation was found between their performance level concerning radiation protection principles and their age (r=0.361) (*p*=0.033). No significant correlation was found among anesthesia nursing students regarding age, knowledge level, attitudes, or performance.

4. DISCUSSION

The use of modern medical imaging technology plays a vital role in the diagnosis and management of diseases. These methods provide necessary information in the shortest possible time, which is increasingly important in various surgical procedures, especially orthopedic and spinal surgeries. However, the risks associated with using ionizing radiation through various imaging methods and adhering to protective protocols by personnel and students, in addition to their level of knowledge, depend on multiple factors, such as education level, current training policies, and the tools available for their training and practice [13]. Due to the limited studies on the knowledge, attitudes, and performance of students in these fields toward ionizing radiation, we compared our results with research conducted on students in other medical science disciplines.

Based on our study findings, considering the score range between zero to ten, the level of knowledge, attitude, and performance of anesthesia and operating room nursing students was average. In line with this result, research conducted by Cheki *et al*. found that radiology students' knowledge of radiation protection principles was also average [25]. However, a study conducted in Norway on final-year medical students indicated a low level of knowledge among students regarding the risks associated with ionizing radiation [26]. These results can be justified, considering that radiology students have more information about the principles of protection against ionizing radiation than students in other disciplines. Additionally, research conducted by Faggioni *et al*. showed that students' knowledge regarding radiation protection principles in several fields of medical sciences was poor. Similarly, Salih *et al*. reported that final-year nursing students' awareness and knowledge were poor [27]. Furthermore, a study in Iran revealed that

the level of knowledge among operating room staff regarding radiation protection principles was low, and their performance was average [28].

The issues mentioned above indicate a fundamental concern at different levels of education in various medical science disciplines regarding the ineffectiveness of teaching radiation protection principles. This lack of knowledge can lead to misconceptions and behaviors that may affect the health services provided. Additionally, the lack of knowledge among students can potentially lead to the unnecessary prescription of ionizing radiation imaging tests in the future [26]. This can also result in inadequate patient education for various procedures, leading to diverse challenges. Furthermore, these issues can impact legal matters such as obtaining informed consent from patients for surgical procedures. Without accurate information from healthcare professionals, patients may be unable to make informed decisions regarding alternative treatments based on the advantages and disadvantages of each method, exposing them to various risks and challenges.

Our study revealed that operating room nursing students have significantly better attitudes than anesthesia nursing students. In this context, the study by Alavi *et al*. also considered the field of study as one of the predictors of individuals' knowledge levels regarding radiation protection principles [16]. This difference can be explained by the educational curriculum and the direction of training in working with C-Arm machines by operating room nursing students, who have taken courses such as medical physics and familiarized themselves with the basics of radiology, which are not included in the radiography curriculum, may have higher scores as a result. Based on our study findings and other research, it is recommended that educational units or specific courses, such as RP courses, be considered for students in various fields, especially those present in the operating room environment. Guidelines for using these types of radiation confidently for patient treatment should be established. Previous studies have shown that clinical training courses in the field of radiation protection principles significantly impact students' knowledge and performance regarding these principles [29].

In our study, a significant difference was found in the level of knowledge and attitudes between male and female students, with women reporting higher levels. However, no significant difference was found in performance regarding safety principles based on sex. In line with our results, Aspasia Goula *et al*. reported a significant relationship between sex and attitudes toward radiation protection principles. They observed that women had more misconceptions than male employees. Fear and stress about future pregnancy and the continuous risks of fluoroscopy and its effects on the fetus were considered reasons for the misconceptions and attitudes of female personnel [22]. In contrast, Kahkhaei and Sarani's research among operating room staff found that men had a higher level of awareness and lower performance than women [28]. Similarly, Asadian and Zarghani concluded that no significant relationship exists between sex and knowledge, attitudes, and performance regarding radiation protection principles [30]. Felayani *et al*.'s study on radiology students also reported no significant relationship between students' level of knowledge and awareness and their sex [31]. These findings were consistent with studies by Cheki *et al*. [25] and Shabani *et al*. [13]. The discrepancy could be attributed to differences in the study population, academic disciplines, and the countries where the research was conducted, which affect how people are educated.

The findings of our study demonstrated a significant positive relationship between GPA and the level of knowledge and attitudes toward radiation protection principles among operating room nursing students. This relationship was also present among anesthesia nursing students regarding their GPA and attitudes. However, the Pearson correlation test results did not reveal a significant relationship between the age of anesthesia or operating room nursing students and their attitudes toward or knowledge of radiation protection principles. In line with our results, Jabari's study observed no correlation between the knowledge and performance of operating room personnel and their age and educational level [32]. Furthermore, Amjadi *et al*. reported no correlation between individuals' demographic variables and their knowledge and awareness of radiation protection principles [24]. Similarly, Sundaran Kada's study found no relationship between the age of medical students and their knowledge and knowledge [26], suggesting that age cannot be considered a predictive factor for students' knowledge, attitudes, or performance levels.

Based on the findings of the present study, organizing training courses and incorporating coursework familiarizing students with the principles of working with ionizing radiation into the anesthesia and operating room nursing curriculum could be considered essential. Additionally, studies have shown that increasing students' knowledge can significantly reduce their stress and anxiety while working with ionizing radiation [14]. Therefore, specific training courses that include the necessary knowledge of the biological effects of radiation, the justification of exposure, the optimization of implementation methods, and the advantages and disadvantages of each technique are recommended. These courses can play a significant role in reducing students' stress and mitigating the risks associated with exposure to ionizing radiation.

5. LIMITATIONS AND RECOMMENDATIONS

Some of the limitations of this study include its cross-sectional nature and the use of self-report measures, which could lead to incorrect answers influencing the responses. Therefore, participants were assured of the confidentiality of the questionnaires. Additionally, the limited research population compared with the 8th semester anesthesia and operating room nursing students at Hamadan University of Medical Sciences is another limitation that could impact the generalizability of the

results. Given the level of knowledge and awareness of anesthesia and operating room nursing students, various training courses on the principles of radiation protection should be held at universities, and their effectiveness should be evaluated in future studies. Due to the low number of students in these fields in each faculty, further studies should be conducted in this area, and their results should be compared with those of the present study. Another limitation of our study was using students' GPA as the sole measure of their academic performance in past semesters, which could be influenced by various factors. Therefore, it is suggested that future studies, including those conducted in different countries, use the Weighted Average Mark (WAM) to better control for the impact of various factors on students' academic performance scores.

CONCLUSION

Based on the results of the current study, the level of knowledge, attitudes, and performance of operating room nursing and anesthesia students regarding protective principles is insufficient. To minimize unnecessary exposure and ensure that operating room personnel understand the correct principles of working with radiation, nursing managers, department officials, and educational policymakers need to prioritize training on radiation safety principles. A fundamental effort is required to provide more robust education and acquire greater Radiation Protection (RP) in universities. Proper Knowledge, Attitudes, and Practices (KAP) and continuous training can easily prevent many types of radiation-related harm for both interventionalists and patients. Participating in in-service training programs is crucial for cultivating positive RP attitudes. Creating a culture that emphasizes self-care is essential for improving performance.

AUTHORS' CONTRIBUTION

S.G. and H.K.: Study conception and design; N.S.: Data collection; B.I.: Analysis and interpretation of results. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

RP	=	Radiation Protection
KAP	=	Knowledge, Attitudes, and Performance
WAM	=	Weighted Average Mark

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Approval was obtained from the Ethics Committee of Hamadan University of Medical Sciences, Iran with the code (IR.UMSHA.REC.1402.677).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants and their legal guardians.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author [H.K], on special request.

FUNDING

This study was funded by Research and Technology Vice-Chancellor of Hamadan University of Medical Sciences, Iran has been the financial sponsor of this project.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The authors would like to thank all the participants, managers, and officials who supported this research. Also, they would like to express their gratitude to the Research and Technology Vice-Chancellor of Hamadan University of Medical Sciences for the financial support of this study in the form of project number 140211109876.

REFERENCES

[1] Khan M O, Khan M S, Janjua O, Ali A, Hussain S. Knowledge of radiation legislation and radiation exposure in common radiological investigations among final year medical students, foundation doctors, specialist radiology registrars and radiographers at a UK university teaching hospital. BJR| Open 2018; 1(1): 20180014. http://dx.doi.org/10.1259/bjr.20180014

[2] Almohaimede A A, Bendahmash M W, Dhafr F M, Awwad A F, Al-Madi E M. Knowledge, attitude, and practice (KAP) of radiographic protection by dental undergraduate and endodontic postgraduate students, general practitioners, and endodontists. Int J Dentis 2020; 2020

[3] Rai S. Study of knowledge on radiation hazards and radiation protection among medical college students in coastal karnataka. Int J Cur Res Rev 2021; 13(10): 74-4.

[4] Beik Khourmizi M, Saidi F, Khorrami F, Hadavi M. Evaluation of Operating Rooms students' satisfaction about their Field of Study and Views on Job Future. Res Medi Educ 2020; 12(1): 62-9. http://dx.doi.org/10.29252/rme.12.1.62

[5] Azarabad S, Zaman SS, Nouri B, Valiee S. Frequency, causes and reporting barriers of nursing errors in the operating room students. Res Med Educ 2018; 10(2): 18-27. http://dx.doi.org/10.29252/rme.10.2.18

[6] Ghasemi S, Imani B, Jafarkhani A, Hosseinefard H. Roles of two learning methods in the perceived competence of surgery and quality of teaching: A quasi-experimental study among operating room nursing students. J Adv Med Educ Prof 20234; 12(3): 180-8. http://dx.doi.org/10.30476/JAMP.2024.101481.1932

[7] Ghasemi S, Imani B, Rahmani R, Zandi S. Prevalence of musculoskeletal disorders and its association with the work ability index among staff working in the operating room of governmental hospitals in hamedan, iran. Iranian J Ergon 2024; 11(4): 251-60.

[8] Lebni JY, Azar FE, Sharma M, *et al*. Factors affecting occupational hazards among operating room personnel at hospitals affiliated in western iran: A cross-sectional study. J Publ Heal 2021; 29(5): 1225-32.
http://dx.doi.org/10.1007/s10389-019-01169-y
[9] Jenkins NW, Parrish JM, Sheha ED, Singh K. Intraoperative risks of radiation exposure for the surgeon and patient. Ann Transl Med 2021; 9(1): 84.
http://dx.doi.org/10.21037/atm-20-1052 PMID: 33553377
[10] Calabrese EJ, Selby PB. Background radiation and cancer risks: A major intellectual confrontation within the domain of radiation genetics with multiple converging biological disciplines. J Occup Environ Hyg 2023; 20(12): 621-32.
http://dx.doi.org/10.1080/15459624.2023.2252032 PMID: 37642576
[11] Iannucci J, Howerton LJ. Dental radiography-E-book: Principles and techniques. Elsevier Health Sciences 2016.
[12] 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.
http://dx.doi.org/10.1016/j.ejro.2020.100287 PMID: 33294498
[13] Shabani F, Hasanzadeh H, Emadi A, *et al*. Radiation protection knowledge, attitude, and practice (KAP) in interventional radiology. Oman Med J 2018; 33(2): 141-7.
http://dx.doi.org/10.5001/omj.2018.26 PMID: 29657683
[14] Yoshida M, Iwamoto S, Okahisa R, Kishida S, Sakama M, Honda E. Knowledge and risk perception of radiation for japanese nursing students after the fukushima nuclear power plant disaster. Nurse Educ Today 2020; 94: 104552.
http://dx.doi.org/10.1016/j.nedt.2020.104552 PMID: 32805471
[15] Alzubaidi MA, Al Mutairi HH, Alakel SM, Al Abdullah HAS, Albakri IA, Alqahtani SFA. Assessment of knowledge and attitude of nurses towards ionizing radiation during radiography in Jeddah City, 2017. Egypt J Hosp Med 2017; 69(7): 2906-9.
http://dx.doi.org/10.12816/0042590
[16] Dabbagh ST, Alavi SS, Abbasi M, Mehrdad R. Medical radiation workers' knowledge, attitude, and practice to protect themselves against ionizing radiation in Tehran Province, Iran. J Educ Health Promot 2017; 6(1): 58.
http://dx.doi.org/10.4103/jehp.jehp_126_15 PMID: 28616425
[17] Alkhaldi W F, Alsehli M D, Alammari R O, *et al*. Awareness of radiation protection and common radiation dose levels among healthcare workers. Glob J Qual Saf Healthc 2023; 6(1): 5-1.
http://dx.doi.org/10.36401/JQSH-22-14
[18] Khalifa MA, Alghanem S, Mohamad AAM. Awareness of radiation dose and incurred risk among clinicians at a tertiary care hospital in Bahrain. J Bahrain Med Soc 2023; 35(1): 42-50.
http://dx.doi.org/10.26715/jbms.35_1_5
[19] Srivastava R, Jyoti B, Jha P, Shukla A. Knowledge, attitude, perception toward radiation hazards and protection among dental undergraduate students: A study. J Int Oral Health 2017; 9(2): 81-7.
http://dx.doi.org/10.4103/jioh.jioh_26_16
[20] Uthirapathy I, Dorairaj P, Ravi S, Somasundaram S. Knowledge and practice of radiation safety in the Catherization laboratory among Interventional Cardiologists – An online survey. Indian Heart J 2022; 74(5): 420-3.
http://dx.doi.org/10.1016/j.ihj.2022.08.001 PMID: 35970381
[21] Behzadmehr R, Doostkami M, Sarchahi Z, Dinparast Saleh L, Behzadmehr R. Radiation protection among health care workers: Knowledge, attitude, practice, and clinical recommendations: A systematic review. Rev Environ Health 2021; 36(2): 223-34.
http://dx.doi.org/10.1515/reveh-2020-0063 PMID: 32894727
[22] Goula A, Chatzis A, Stamouli MA, Kelesi M, Kaba E, Brilakis E. Assessment of health professionals' attitudes on radiation protection measures. Int J Environ Res Public Health 2021; 18(24): 13380.
http://dx.doi.org/10.3390/ijerph182413380 PMID: 34948989
[23] karami , ghaderi , moradiyan , mostafaee , Gharibi F, Elahimanesh F. Evaluation of level of knowledge, attitude and performance of Radiologists in Sanandaj city regarding radiation protection in 2014. Scient J Nurs, Midwif Parame Facu 2017; 2(4): 24-32.
http://dx.doi.org/10.29252/sjnmp.2.4.24
[24] Amjadi A, Ghanei Gheshlagh R, Abdolmohammadi J, Dehvan F. Job satisfaction and its relationship to radiation protection knowledge, attitude and practice. Scient J Nurs, Midwif Parame Facu 2022; 8(2): 92-100.
[25] Cheki M, Farzanegan Z, Tahmasbi M, Karami A. Determination of the last semester radiology technology students' knowledge about radiation protection, radiation exposure and cancer risk of diagnostic examinations with lonizing radiation. Majallah-i Ilmi-i Pizishki-i Jundi/Shapur 2021; 20(3): 226-35.
http://dx.doi.org/10.32598/JSMJ.20.3.2537
[26] Kada S. Awareness and knowledge of radiation dose and associated risks among final year medical students in Norway. Insights Imaging 2017; 8(6): 599-605.
http://dx.doi.org/10.1007/s13244-017-0569-y PMID: 28952058
[27] Salih S, Nordin MN, Alkatheeri A, *et al*. Assessment of nursing students' awareness toward ionizing radiation: Cross-sectional study. Nurs Rep 2023; 13(2): 855-64.
http://dx.doi.org/10.3390/nursrep13020075 PMID: 37368342
[28] Kahkhaei F, Sarani H. Surgical technologists' knowledge and performance about radiation protection in Zahedan educational hospitals. A descriptive-analytical study. J Educ Health Promot 2020; 9(1): 283.
http://dx.doi.org/10.4103/jehp.jehp_162_20 PMID: 33282988
[29] Zainudin N H M. Radiation safety awareness among nursing students in universiti sultan zainal abidin (UniSZA): A survey study Asian J Medi Biomedi 2023; 183-93.
[30] Asadian S, Zarghani H. Evaluation of knowledge, attitude, and performance of radiographers towards radiation protection in Southern Khorasan Province, Iran. Iranian J Medi Phys 2018; 15(4): 222-5.
[31] Felayani F, Wibowo AS, Al Amin K. Knowledge and awareness regarding radiation safety among radiology study program students. J Edu Heal 2023; 14(04): 133-40.
[32] Jabbari M. Assessment of knowledge, awareness, and practice of procedures for protecting operating room personnel from ionizing radiation: A cross-sectional investigation using a questionnaire Avicenna J Care Heal Operat Room 2023; 1(3): 79-83.