

RADIATION SAFETY COMPLIANCE IN THE RADIOLOGY DEPARTMENTS ACROSS SAUDI ARABIA: A CROSS-SECTIONAL ASSESSMENT



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ABSTRACT

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Aim: This study assesses the degree of compliance with radiation safety and protection protocols among the healthcare workers in the radiology departments in Saudi Arabia.

Methods: A cross-sectional survey conducted among healthcare workers in diagnostic imaging departments in government hospitals and health centers in Saudi Arabia. The structured questionnaire sections covering awareness of radiation safety, personal protective practices, and patient protection measures. A pilot study was conducted on 15 healthcare workers to ensure questionnaire reliability and clarity. The study included 450 healthcare workers employed in various medical diagnostic imaging departments for at least 1 year be eligible to participate. Descriptive statistics and multivariate linear regression (MLR) analyses were performed to identify predictors of compliance.

Results: the majority of participants (67.6%) have a high awareness level and (44.4%) of participants fall into the high self-protection measures category, while 47.8% of participants have a high level of patient protection. 25% of participants reported non-using radioprotector garments because they are "too heavy" or "worsen back pain". The multivariate linear regression (MLR) analysis revealed that participants with 6-10 years of radiology experience ($B = 0.662$, $t = 2.814$, $p = 0.005$)

and more than 10 years of experience ($B = 0.469$, $t = 1.981$, $p = 0.048$) show significantly higher awareness levels compared to those with 1-5 years of experience. Regarding the self-protection measures MLR revealed that both the awareness total score ($B = 0.384$, $t = 3.201$, $p = 0.001$) and the patient protection total score ($B = 0.364$, $t = 12.141$, $p < 0.001$) are significant positive predictors of adoption of self-protection measures.

Conclusion: Healthcare workers in Saudi Arabian radiology departments demonstrate good radiation safety knowledge, but gaps remain in consistently applying protective measures. Strengthening education and training is essential to improve compliance, reduce radiation exposure, and ensure a safer clinical environment.

الخلاصة

الخلفية: تهدف هذه الدراسة إلى تقييم مدى الالتزام ببروتوكولات السلامة والحماية الإشعاعية بين العاملين في أقسام الأشعة في المملكة العربية السعودية.

المنهجية: تم تنفيذ دراسة مقطعية شملت العاملين في أقسام التصوير التشخيصي بالمستشفيات الحكومية، والمراكز الصحية في المملكة، باستخدام استبيان منظم يغطي جوانب الوعي بالسلامة الإشعاعية، والممارسات الشخصية للحماية، إضافة إلى تدابير حماية المرضى. ولضمان وضوح وموثوقية الأداة أجريت دراسة تجريبية على عينة مكونة من 15 عاملاً في القطاع الصحي. شملت العينة النهائية 450 مشاركاً من العاملين في أقسام التصوير الطبي ممن لديهم خبرة لا تقل عن سنة واحدة. وتم تحليل البيانات باستخدام الإحصاء الوصفي والانحدار الخطي المتعدد لتحديد العوامل المؤثرة على مستوى الالتزام ببروتوكولات الحماية.

النتائج: أظهرت النتائج أن 67.6% من المشاركين لديهم مستوى عالٍ من الوعي بسلامة الإشعاع، بينما بلغت نسبة من يطبقون ممارسات حماية ذاتية عالية 44.4%، وبلغت نسبة من يظهرون مستوى عالٍ في حماية المرضى 47.8%. ومن اللافت أن 25% من المشاركين أفادوا بعدم استخدام الملابس الواقية من الإشعاع، مبررين ذلك بأنها "ثقيلة جداً" أو "تزيد من آلام الظهر". وقد كشف تحليل الانحدار الخطي أنهم أظهروا ($B = 0.662$, $t = 2.814$, $p = 0.005$) والمتعدد أن المشاركين الذين لديهم من 6 إلى 10 سنوات خبرة ($B = 0.469$, $t = 1.981$, $p = 0.048$) ومستويات وعي أعلى مقارنة بمن لديهم خبرة من 1 إلى 5 سنوات. كما أظهر التحليل أن كلاً من مجموع درجات حماية المرضى ($B = 0.384$, $t = 3.201$, $p = 0.001$) ودرجات الوعي ($B = 0.364$, $t = 12.141$, $p < 0.001$) يمثلان مؤشرات إيجابية مهمة في تبني ممارسات الحماية الذاتية.

الاستنتاج: خلصت الدراسة إلى أن العاملين في أقسام الأشعة في المملكة العربية السعودية يمتلكون معرفة جيدة بسلامة الإشعاع، إلا أن هناك فجوات في التطبيق العملي لهذه المعرفة. ومن ثم، فإن تعزيز برامج التعليم والتدريب المستمر يُعد ضرورياً لتحسين مستوى الالتزام، وتقليل التعرض المهني للإشعاع، وضمان بيئة سريرية أكثر أماناً للجميع.

Keywords: Safety awareness, Radiology, Protection, adoption of self-protection measures

1. INTRODUCTION

Radiation exposure in medical environments presents considerable health hazards to both patients and healthcare professionals globally, with the growing dependence on diagnostic and interventional radiology leading to elevated exposure levels[1, 2].

Improvements in imaging technologies, including computed tomography (CT) and X-rays, have enhanced illness treatment; however, they have also increased occupational exposure concerns due to their extensive application, with billions of procedures conducted annually worldwide [3, 4].

Radiation safety is based on three fundamental principles: rationale, optimization, and dosage limiting [5]. Justification entails evaluating the advantages relative to the hazards associated with radiation-based techniques. Optimization, exemplified by the As Low As Reasonably Achievable (ALARA) concept, aims to minimize exposure while maintaining diagnostic efficacy [6]. Since any degree of exposure entails a stochastic risk, such as the development of cancer, the linear no-threshold (LNT) model advocates for proactive minimization strategies[7, 8].

Effective radiation protection necessitates rigorous training for the safety of both the individual and the patient. However, numerous clinicians particularly those not specializing in radiology obtain minimal training in dose-reduction techniques[9]. Compliance with radiation safety standards is frequently inadequate among practitioners utilizing fluoroscopy in non-radiology disciplines, including vascular surgery, gastroenterology, orthopedics, and cardiology[10, 11].

Across the Gulf region several studies highlighted disparate degrees of adherence to radiation safety protocols among radiology professionals. Almohammed et al., 2024 in the UAE, have shown that gender-specific issues (e.g., among pregnant radiographers) and ergonomic difficulties affect compliance with protective protocols.[12] Ibrahim P. Hussin et al., 2024, in the kingdom Saudi Arabia highlighted that 12% never used protective shielding for patients' reproductive organs and the need for better adherence to radiation protection guidelines. [13]

Furthermore, research conducted during the COVID-19 pandemic in Saudi Arabia has uncovered significant insights into the intersection of infection control and emergency response frameworks with radiation safety compliance, frequently extending current protocols and exposing structural vulnerabilities.[14] In Qatar, a study emphasized inadequate understanding of radiation hazards among physicians,

indicating that the concepts of radiation safety are not consistently understood or implemented beyond radiology departments.[15]

Numerous studies have evaluated physicians' comprehension of radiation safety, with certain findings indicating unexpectedly low levels of awareness, even among radiologists [16-19] . Radiographers play an essential component in the implementation of radiation protection guidelines because they conduct radiological tests [20, 21]. Radiographers, who execute imaging operations, are pivotal in the enforcement of radiation protective protocols [22]. They serve as a principal source of radiation-related information for patients, underscoring the necessity for elevated levels of professional competence and knowledge. [8]

Despite national regulations and international guidelines on radiation protection, there is growing concern about inconsistent compliance with radiation safety protocols among radiographers in Saudi Arabia's radiology departments. Compliance with ALARA, reduction of superfluous exposure, and proficient patient communication depend on the healthcare workers' awareness, training, and ethical behavior . Assessing these aspects is crucial for formulating effective interventions that enhance ethical and therapeutic standards. The aim of this study is to assess of compliance with radiation safety and protection among healthcare workers in the radiology departments in government hospitals and centers across Saudi Arabia.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A cross-sectional study was conducted among the healthcare workers in the radiology departments across Saudi Arabia. The survey was administered online between April and June 2024.

2.2 The study population and eligibility Criteria

Healthcare workers (radiologists, residents, nurses, Registrar/Medical officer, Medical Physicist/Physics Science Officer, Nuclear medicine technologist) employed in various medical diagnostic imaging departments for at least 1 year were eligible to participate. All these healthcare workers potentially impact the assessment of adherence to radiation protection standards. Participants will be selected from government hospitals and health centers across Saudi Arabia.

2.3 Sample size calculations

The minimum required sample size was calculated to be 287 participants using Epi Info software, to achieve a 95% confidence level, a 5% margin of error, for a compliance proportion of 75.2% among healthcare workers.[23] A total of 450 participants were recruited to account for potential non-responses.

2.4 Data Collection Tool and the pilot study

A self-administered online questionnaire was developed based on the literature review and adapted to fit the Saudi Arabian context [23-25]. A pilot study was conducted with a sample of 30 randomly selected healthcare workers in the radiology departments to ensure questionnaire reliability and clarity. Results from the pilot study were not included in the final analysis.

2.5 Variables and Measurements

The questionnaire included demographic characteristics and questions assessing awareness of the safety measurements, practice, and radiation self-protection measures among participants. Patient protection Likert scale responses (4=always, 3=often, 2=sometimes, 1=never) were used to evaluate the frequency of adherence to radiation self-protection measures. Adherence scores will be categorized into Poor (<60%), Moderate (60–75%), and good adherence ($\geq 75\%$).

2.6 Statistical Analysis

In this research, SPSS version 27 was used for statistical analysis to explore relationships between participant characteristics and their levels of awareness, adoption of self-protection measures, and patient protection. Descriptive statistics summarized participant demographics, while Chi-square tests examined associations between age, experience, gender, and these levels. Pearson correlation was used to assess relationships between awareness, self-protection measures, and patient protection scores. Multivariate linear regression identified significant predictors of these scores, with adoption of self-protection measures and patient protection being strong predictors of awareness, while awareness and self-protection measures strongly predicted patient protection. The analysis aimed to understand the factors influencing radiology safety practices.

2.7 Ethical Considerations

The ethical approval was obtained from the Ethical Committee of King Khalid University, Abha, in Saudi Arabia. Informed consents were obtained from all participants prior to data collection. At the commencement of the survey, participants received comprehensive information regarding the study's aims, voluntary participation, confidentiality, and their entitlement to leave at any moment without repercussions. Participants expressed their approval by selecting an "I agree" button prior to advancing to the questionnaire.

3. RESULTS

Table 1 delineates the sociodemographic attributes of the participants, indicating that the predominant age group comprised young professionals aged 21–30 years (76.4%), with a gender distribution slightly favoring males (57.6%). The majority of participants were senior radiographers/radiographers (45.9%) or radiologists (32.9%), indicating a workforce predominantly involved in imaging procedures. The majority of participants were in the early stages of their careers, with 76% possessing 1–5 years of experience in radiography, indicating a primarily younger cohort. The predominant practice fields included general/mobile/dental radiology (38%) and computed tomography (17.7%), whereas lesser percentages focused on interventional fluoroscopy, mammography, nuclear medicine, or quality assurance positions. The characteristics indicate a heterogeneous, multidisciplinary cohort mostly composed of younger, less experienced personnel predominantly engaged in general radiology, potentially affecting their awareness and adherence to radiation safety protocols. Comprehending these distributions is crucial for analyzing the influence of demographic and professional variables on radiation safety practices.

Table 1 Sociodemographic Characteristics of Participants:

Sociodemographic		Frequency	%
Age	21-30	344	76.4
	31-40	88	19.6
	41-50	12	2.7
	>51	6	1.3
Gender	Male	259	57.6
	Female	191	42.4
Occupation	Radiologist	154	32.9
	Interventional radiologist	6	1.3

	Resident / fellow in training	21	4.5
	Registrar/Medical officer	9	1.9
	Medical Physicist/Physics Science Officer	21	4.5
	Senior radiographer/Radiographer	215	45.9
	Nuclear medicine technologist	11	2.4
	Medical assistant/Staff nurse	13	2.8
Experience in Radiology	1-5 Years	342	76
	6-10 Years	53	11.3
	More than 10 Years	55	11.8
Primary practice	General/Mobile/Dental	178	38
	Computed tomography	83	17.7
	Interventional/Fluoroscopy	22	4.7
	Mammography	12	2.6
	Nuclear medicine	17	3.6
	Non-radiation (MRI, Ultrasound)	102	21.8
	QC/QA/Radiation protection	18	3.8
	Radiation therapy	18	3.8

Figure (1) presents the percentage of correct and incorrect responses to various questions related to radiation awareness. The majority of participants correctly answered questions about following dosimeter controls, using a dosimeter, radiation in the operating room, availability of protective equipment, integrity checks of equipment, and radiation hazard warning signs, as indicated by the high proportion of green bars. However, areas such as how often equipment is checked and whether participants received fluoroscopic training show a significant number of incorrect responses, indicated by the red bars. This suggests gaps in awareness, particularly regarding equipment maintenance frequency and training on fluoroscopic procedures.

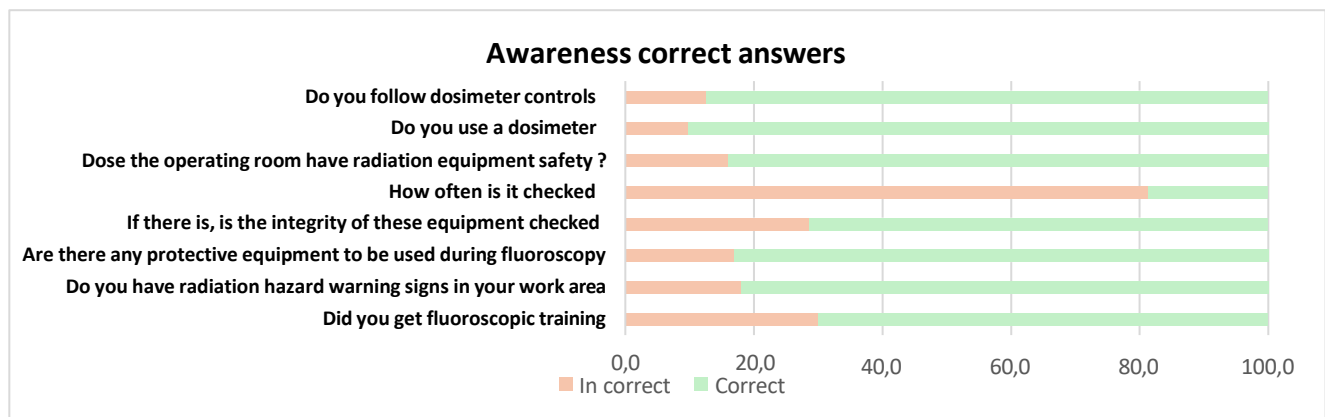


Figure 1 Distribution of the participants according to correct answers of awareness questions

Figure (2) represents the frequency of protective equipment practice during radiology procedures. For wearing a thyroid shield during procedures and lead gloves during fluoroscopy, the responses are mixed, with a notable portion of participants indicating they "sometimes" or "rarely" use them. Wearing a lead apron during portable radiography and fluoroscopy is more consistent, as most participants report using it "most of the time" or "always." However, the use of a thermoluminescent dosimeter shows a varied distribution, with some participants "never" or "rarely" using it, while others use it more frequently. Overall, the chart highlights varying adherence to safety practices, with certain protective measures being underutilized by some participants.

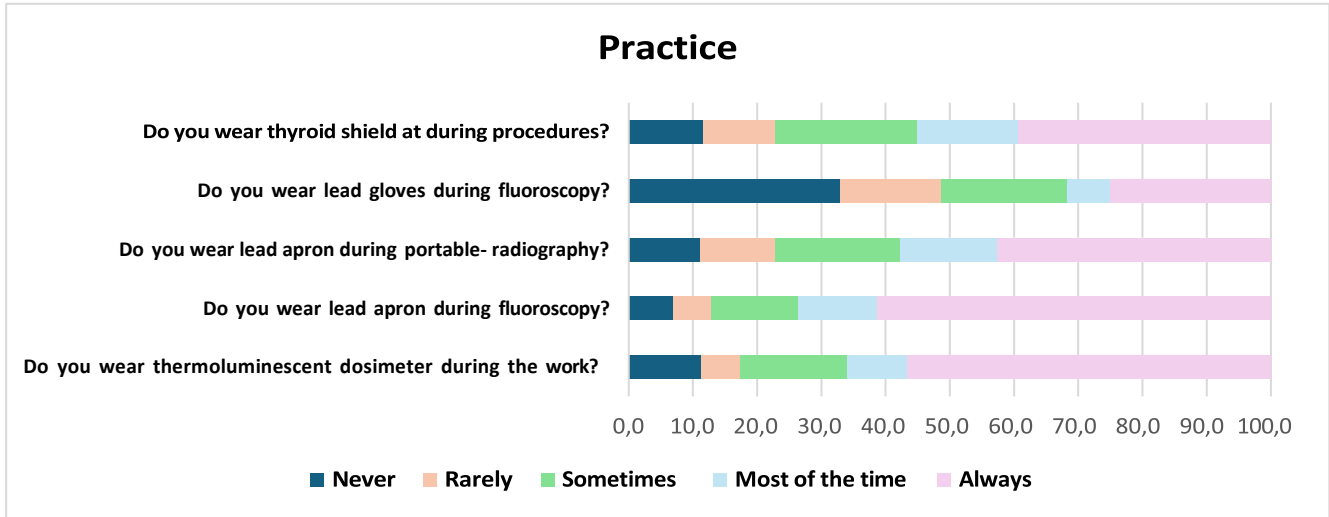


Figure 2 Distribution of the participants according to their self-protection measures performance

Figure (3) displays the frequency of various safety measures taken to protect patients during radiology procedures. Most participants consistently reported closing the room door and using proper sources to image receptor distances, as indicated by the high percentage of "always" responses. The use of lead shields, gonadal shields, and proper collimation shows more variability, with a significant portion of participants using these measures "most of the time" or "sometimes." The use of skin markers, cones, and light beam diaphragms also demonstrates inconsistency, with some participants "rarely" or "never" utilizing them. Overall, while certain patient protection practices are consistently followed, others reveal areas for improvement, indicating inconsistent adherence to full protective measures across all domains.

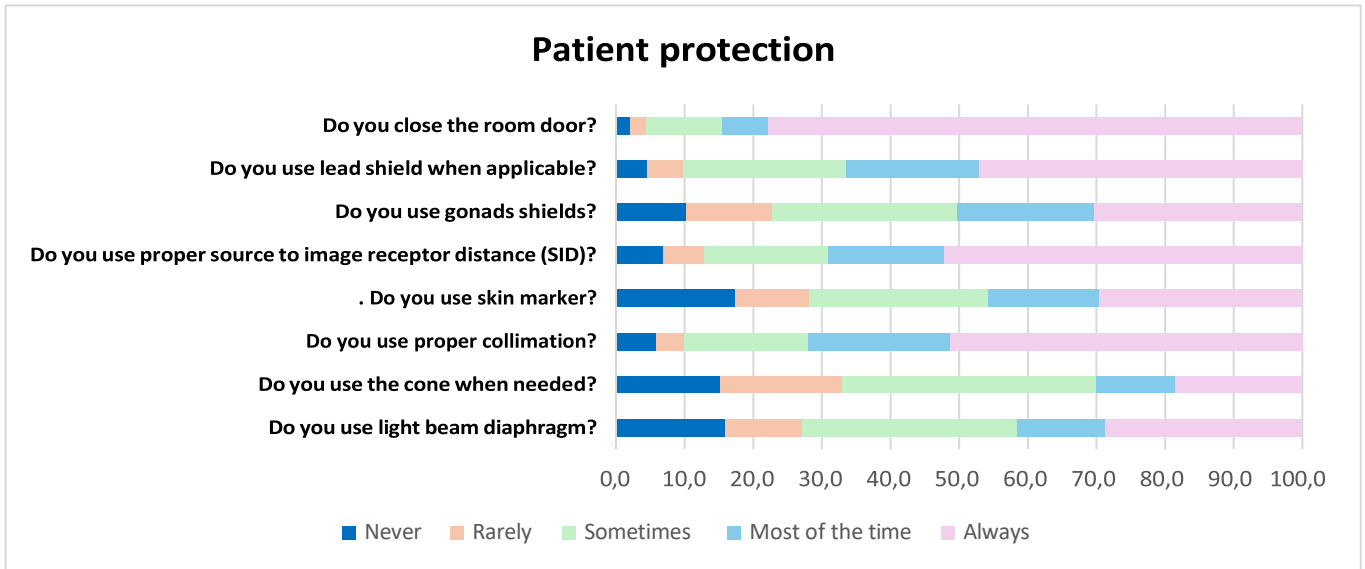


Figure 3 Distribution of the participants according to their patient protection performance

Figure(4) illustrates the reasons for not using radioprotective garments and personal dosimeters among participants, based on the level of consistency. The most commonly reported reason is that the garments are "too heavy" or "worsen back pain," cited by nearly 25% of participants. Other significant reasons include laziness and the availability of other protection, both reported by about 10-15% of participants. Disruption of movement and defective garments (cracked, broken, or torn) were less frequently mentioned but still notable. These results suggest that physical discomfort and convenience are major factors influencing the inconsistent use of radioprotective equipment, with practical and ergonomic issues being particularly prominent.

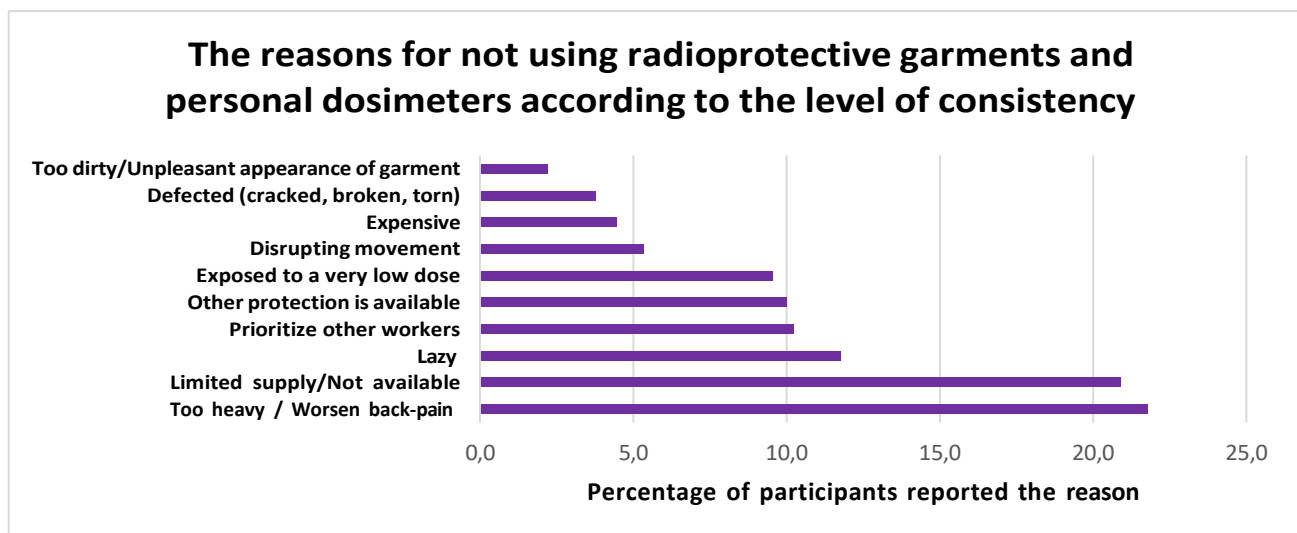


Figure 4 Distribution of the participants according to their reasons for not using radioprotective garments and personal dosimeters according to the level of consistency

The mean score for awareness is 73.3 ± 20.8 , and the median score is 75 (0 - 100%). For self-protection measures, the mean score is slightly lower at 65.5 ± 23.6 , and a median of 70 (0 - 100). Patient protection shows a mean score of 67.8 ± 20.6 , and a median of 68.8 (0 - 100). These findings indicate variability in participants' awareness, practice, and patient protection, with relatively high median scores but wide ranges.

In terms of awareness, the majority of participants (67.6%) have a good awareness level (>75%), while 20.2% have poor awareness (<60%), and 12.2% have moderate awareness (60-75%). Regarding practice levels, 44.4% of participants fall into the good adherence practice category (>75%), while 28.2% demonstrate poor adherence practice levels (<60%), and 27.3% are at a moderate adherence level (60-75%). As for patient protection, 47.8% of participants have a good adherence level of patient protection, with 20.9% in the poor adherence category and 31.3% in the moderate adherence category. This indicates that while a majority exhibit good awareness, there is a significant proportion of participants with poor levels of adoption of self-protection measures and patient protection, suggesting areas for improvement in practical adherence and safety measures.

Table (2) shows the association between participant characteristics (age, experience in radiology, and gender) and their awareness level. In terms of age, there is no statistically significant association with awareness levels ($p = 0.26$). Most participants across all awareness levels are between 21-30 years old, though participants in the good awareness group have a slightly lower percentage (73.7%) compared to the poor and moderate groups. Participants with more experience in radiology (6-10 years and more than 10 years) are more likely to have higher awareness levels, as indicated by a significant association ($p = 0.047$). Specifically, participants with 1-5 years of experience dominate the poor awareness group (86.8%), while those with more than 10 years of experience are more represented in the good awareness group (13.2%). Gender does not show a significant association with awareness levels ($p = 0.12$), although males are slightly more represented in the poor awareness group (67%) compared to the good awareness group (54.9%). This suggests that experience in radiology plays a key role in increasing awareness, while age and gender have less influence.

Table 2 Association between the participant characteristics and their awareness level:

	Awareness Levels			P value ^a
	Poor N=51	Moderate N=55	Good N=304	
Age in years	21-30	n 76	44	0.26
		% 83.50%	80.00%	
	31-40	n 13	8	67

Experience in Radiology	41-50	%	14.30%	14.50%	22.00%	0.047
		n	1	1	10	
	>51	%	1.10%	1.80%	3.30%	
		n	1	2	3	
	1-5	%	1.10%	3.60%	1.00%	
		n	79	42	221	
	Years	%	86.8%	76.4%	72.7%	
		n	6	4	43	
	6-10	%	6.6%	7.3%	14.1%	
		n	6	9	40	
> 10	%	6.6%	16.4%	13.2%		
	n	6	9	40		
Gender	Male	n	61	31	167	0.12
		%	67.0%	56.4%	54.9%	
	Female	n	30	24	137	
		%	33.0%	43.6%	45.1%	

a Chi-square test

Table (3) shows the association between participant characteristics (age, experience in radiology, and gender) and their self-protection measures levels. Age does not show a significant association with self-protection measures levels ($p = 0.71$). Participants aged 21-30 make up the majority across all self-protection measures levels, though their representation is slightly higher in the poor self-protection measures adopters group (81.1%) compared to the moderate (71.5%) and good (76.5%) groups. There is also no significant association between radiology experience and adoption of self-protection measures ($p = 0.53$). Participants with 1-5 years of experience form the largest proportion in all self-protection measures groups, particularly in the poor and good self-protection measures adopters groups. Those with more than 10 years of experience are more evenly distributed across the groups, though they form the smallest percentage. Similarly, gender is not significantly associated with self-protection measures adoption levels ($p = 0.43$). Males make up a slightly higher proportion in the poor self-protection measures adopters group (60.6%) compared to the moderate (52.8%) and good adherence (58.5%) groups, but the difference is not substantial. Overall, there is no significant correlation between age, experience, or gender with the self-protection measures adoption level, suggesting that these factors do not strongly influence participants' practice behaviors.

Table 3 Association between the participant characteristics and their Practice level:

		self-protection measures			P value ^a
		Poor N=127	Moderate N=123	Good N=200	
Age in years	21-30	n	103	88	0.71
		%	81.1%	71.5%	
	31-40	n	20	30	38

		%	15.7%	24.4%	19.0%	
	41-50	n	3	3	6	
		%	2.4%	2.4%	3.0%	
	>51	n	1	2	3	
		%	0.8%	1.6%	1.5%	
Experience in Radiology	1-5 Years	n	99	88	155	0.53
		%	78.0%	71.5%	77.5%	
	6-10 Years	n	12	16	25	
		%	9.4%	13.0%	12.5%	
	> 10 Years	n	16	19	20	
		%	12.6%	15.4%	10.0%	
Gender	Male	n	77	65	117	0.43
		%	60.6%	52.8%	58.5%	
	Female	n	50	58	83	
		%	39.4%	47.2%	41.5%	

Table (4) displays the association between participant characteristics (age, experience in radiology, and gender) and their patient protection levels. There is no significant association between age and patient protection levels ($p = 0.18$). Participants aged 21-30 dominate all levels, comprising around 75-77% of each group. Similarly, those aged 31-40 form a smaller proportion, while participants aged 41-50 and over 51 represent the smallest fractions in each category. Experience in radiology also shows no significant association with patient protection levels ($p = 0.95$). Participants with 1-5 years of experience consistently account for around 74-77% across all protection levels, while those with 6-10 years and more than 10 years are represented in smaller but relatively similar proportions across all groups. Gender also does not show a significant association with patient protection levels ($p = 0.32$). Males form a slightly higher proportion in the good patient protection group (60.9%), while females are more evenly distributed across all levels, with a slight decrease in representation at the good patient protection level (39.1%). Overall, none of the variables (age, experience, or gender) show a significant impact on patient protection levels.

Table 4 Association between the participant characteristics and their patient protection level:

			Patient Protection Levels			P value ^a
			Poor N=94	Moderate N= 141	Good N=215	
Age in years	21-30	n	72	106	166	0.18
		%	76.6%	75.2%	77.2%	
	31-40	n	18	33	37	
		%	19.1%	23.4%	17.2%	
	41-50	n	4	0	8	
		%	4.3%	0.0%	3.7%	
	>51	n	0	2	4	
		%	0.0%	1.4%	1.9%	

Experience in Radiology	1-5 Years	n	71	105	166	0.95
		%	75.5%	74.5%	77.2%	
	6-10 Years	n	11	19	23	
		%	11.7%	13.5%	10.7%	
	> 10 Years	n	12	17	26	
		%	12.8%	12.1%	12.1%	
Gender	Male	n	49	79	131	0.32
		%	52.1%	56.0%	60.9%	
	Female	n	45	62	84	
		%	47.9%	44.0%	39.1%	

The multivariate linear regression analysis in Table 5 identifies the predictors of the awareness total score. Both the self-protection measures total score ($B = 0.058$, $t = 3.153$, $p = 0.002$) and patient protection total score ($B = 0.062$, $t = 4.672$, $p < 0.001$) are significant positive predictors of awareness, indicating that higher self-protection measures score and patient protection scores are associated with increased awareness levels. Gender does not appear to significantly predict awareness ($B = 0.265$, $t = 1.665$, $p = 0.097$), suggesting that awareness levels are similar between males and females. In terms of experience, participants with 6-10 years of radiology experience ($B = 0.662$, $t = 2.814$, $p = 0.005$) and more than 10 years of experience ($B = 0.469$, $t = 1.981$, $p = 0.048$) show significantly higher awareness levels compared to those with 1-5 years of experience. This analysis highlights that both practical measures and radiology experience contribute to greater awareness, with patient protection showing the strongest impact.

Table 5 Multivariate linear regression of the predictors of the awareness total score :

Predictors	B	t	P value
(Constant)	3.521	12.933**	<0.001
self-protection measures total score	0.058	3.153*	0.002
Patient protection total score	0.062	4.672**	<0.001
Gender(Ref.=Male)	0.265	1.665	0.097
Experience in Radiology (Ref.= 1-5 Years)			
6-10 Years	0.662	2.814*	0.005
>10	0.469	1.981*	0.048

*Significant at $P < 0.05$ **Significant at $p < 0.001$ $F = 17.3$, $p < 0.001$, $Adj.R^2 = 15.4\%$

The multivariate linear regression analysis in the table identified the predictors of the self-protection measures total score. Both the awareness total score ($B = 0.384$, $t = 3.201$, $p = 0.001$) and the patient protection total score ($B = 0.364$, $t = 12.141$, $p < 0.001$) are significant positive predictors of the adoption of self-protection measures, indicating that higher awareness and patient protection scores are associated with better self-

protection measures levels. Gender ($B = 0.061, t = 0.147, p = 0.88$) does not significantly predict self-protection measures scores, meaning that self-protection measures adoption levels are similar between males and females. None of the age groups show a significant association with self-protection measures scores. Participants aged 31-40 ($B = 1.141, t = 1.470, p = 0.142$), 41-50 ($B = 2.065, t = 1.415, p = 0.158$), and over 50 years ($B = 1.068, t = 0.574, p = 0.566$) do not differ significantly from the reference group (21-30 years). Similarly, experience in radiology is not a significant predictor of self-protection measures scores. Those with 6-10 years of experience ($B = -0.862, t = -1.070, p = 0.285$) and more than 10 years of experience ($B = -1.443, t = -1.515, p = 0.131$) do not significantly differ from the reference group (1-5 years). Overall, this analysis highlights that awareness and patient protection scores are the strongest predictors of self-protection measures score, while gender, age, and experience do not have a significant impact. Table (6)

Table 6 Multivariate linear regression of the predictors of the self-protection measures total score :

Predictors	B	t	P value
(Constant)	2.926	3.636	<0.001
Awareness total score	0.384	3.201	0.001
Patient protection total score	0.364	12.141	<0.001
Gender(Ref. group= Males)	0.061	.147	0.88
Age groups (in years)(Ref. group= 21-30 years)			
31-40 years	1.141	1.470	.142
41-50 years	2.065	1.415	.158
>50 years	1.068	.574	.566
Experience in Radiology (Ref.= 1-5 Years)			
6-10 Years	-.862	-1.070	.285
>10 years	-1.443	-1.515	.131

*Significant at $P < 0.05$ **Significant at $p < 0.001$ $F = 105.1, p < 0.001, \text{Adj.}R^2 = 31.7\%$

The multivariate linear regression analysis in the table identifies the predictors of the patient protection total score. Both the awareness total score ($B = 0.190, t = 4.658, p < 0.001$) and the self-protection measures total score ($B = 0.430, t = 12.141, p < 0.001$) are significant positive predictors of patient protection, indicating that higher awareness and better adoption of self-protection measures are associated with better patient protection. Gender ($B = -1.430, t = -0.805, p = 0.421$) does not significantly predict patient protection scores, meaning that there is no substantial difference between males and females in terms of patient protection. Similarly, none of the age groups shows a significant association with patient protection. Participants aged 31-40 ($B = -3.071, t = -0.918, p = 0.359$), 41-50 ($B = -1.487, t = -0.237, p = 0.813$), and over 50 years ($B = 6.889, t = 0.862, p = 0.389$) do not significantly differ from the reference group (21-30 years).

Experience in radiology is also not a significant predictor of patient protection. Those with 6-10 years of experience (B = -0.421, t = -0.121, p = 0.904) and more than 10 years of experience (B = -1.377, t = -0.335, p = 0.738) show no significant differences compared to the reference group (1-5 years). Overall, this analysis highlights that awareness and self-protection measures scores are the strongest predictors of patient protection, while gender, age, and experience do not significantly influence patient protection levels. Table (7)

Table 7 Multivariate linear regression of the predictors of the Patient protection total score :

Predictors	B	t	P value
(Constant)	27.017	8.270	<0.001
Awareness total score	0.190	4.658	<0.001
self-protection measures total score	0.430	12.141	<0.001
Gender(Ref. group= Males)	-1.430	-0.805	0.421
Age groups (in years)(Ref. group= 21-30 years)			
31-40 years	-3.071	-0.918	0.359
41-50 years	-1.487	-0.237	0.813
>50 years	6.889	0.862	0.389
Experience in Radiology (Ref.= 1-5 Years)			
6-10 Years	-0.421	-0.121	0.904
>10 years	-1.377	-0.335	0.738

*Significant at P<0.05 **Significant at p<0.001 F=76.4 ,p<0.001, Adg.R2= 33.5%

4. DISCUSSION

Regardless of the level of radiation exposure, working in such situations could have a serious biological impact on HCWs; however, this health risk could be avoided with the right safety training and adherence to protocols [26, 27]. Thus, while accounting for factors like general characteristics and the length of time they worked in a department where radiation was involved, the current study aimed to evaluate compliance with radiation safety among healthcare workers in radiology departments to investigate the relationship between radiation safety awareness and participants' adherence to safety protocols.

It was found that while 19.4% of participants had poor awareness of radiation exposure safety precautions, more than two-thirds had good awareness. Of participants, 27.1% had poor self-protection measures adoption, and 20.1% had poor patient protection. These results were consistent with a prior study conducted in the Southern Province of Saudi Arabia that evaluated participants' exposure to radiation at work and their understanding of radiation safety. They noticed that, when imaging is necessary, the majority of participants do not wear

radiation gowns. Over 50% of them stated that certain protective equipment is unavailable. When asked about their awareness and comprehension of radiation protection, the technicians answered with a high degree of understanding [28]. Diverse populations have various degrees of awareness regarding radiation hazards and safety, according to earlier studies. According to a survey, just 40% of healthcare professionals knew enough about radiation risks and safety precautions [29]. This is concerning because healthcare professionals need to be aware of the risks and how to protect both themselves and their patients from radiation exposure, which occurs frequently in their line of work. However, a study that focused only on radiology practitioners—those who work directly with radiation for diagnostic purposes—found that their understanding of radiation protection was higher. The specialized training and instruction that radiology technologists receive regarding radiation safety and protective measures is probably the reason for this [30].

The study found a moderately positive correlation between overall awareness and self-protection measures of radiation exposure safety precautions. Increased awareness leads to better adoption of self-protection measures and implementation of safety protocols. Educational initiatives and training programs can enhance awareness and improve patient protection. The study suggests that greater understanding among healthcare professionals can lead to improved patient outcomes and increased patient protection. Therefore, strict adherence to safety procedures is crucial for improving patient protection. Prior research has consistently demonstrated that better application of safety precautions is correlated with greater awareness of these precautions. Our findings are consistent with the findings of Allam et al. (2024), who identified a correlation between the study's HCWs' compliance with radiation self-protection measures and their overall knowledge score [31]. Additionally, Ahmed et al. (2021) found a significant positive correlation between the overall score of their evaluated sample knowledge and the overall score of radiation safety measure-related practices [32]. The knowledge value and self-protection measures value were shown to have a strong positive association, which is consistent with another finding [33]. Furthermore, Hussein et al. (2022) came to the conclusion that radiation knowledge and radiation protective behaviors had a statistically significant positive correlation [34].

By comparing younger people (those under 20) to older age groups, the data showed an interesting trend: younger people are more aware of radiation safety precautions. Over 40-year-olds had the lowest percentage of high awareness, with the proportion of high awareness

individuals decreasing as age increases. These differences were not statistically significant, despite the observed fluctuations. Talab et al.'s results demonstrated that there was no significant association between the radiographers' age and any of the performance, attitude, or awareness variables [35]; Chaparian et al. came to similar conclusions, but found that age had a negative relationship with their knowledge [36]. According to Paolicchi et al., radiographers' awareness of radiation safety decreased as they became older [37].

The relationship between gender and awareness levels is not statistically significant. This implies that random variation rather than a regular pattern may be the cause of the awareness gaps between males and females. Data analysis revealed that there was no discernible difference between male and female radiographers' average performance, attitude, or awareness level. Previous studies also demonstrated that participants' awareness, attitude, and behaviors are independent of their gender, similar to the current study findings [35, 36, 38].

The results of the study showed a statistically significant association between awareness levels about safety measure compliance and the number of years of radiology experience. In particular, compared to those with more years of expertise, those with 1 to 5 years of radiology experience have higher awareness levels. In contrast to our findings, Shah et al. [39] and Paolicchi et al. [37] showed that radiographers' awareness levels increase with their background knowledge.

This research possesses multiple limitations. The cross-sectional design records participant responses at a singular moment, restricting the evaluation of changes in awareness or compliance across time. Secondly, the utilization of an online self-administered questionnaire may result in response bias, as participants who possess greater engagement or understanding on radiation safety may be more inclined to reply. Third, despite the inclusion of a varied array of healthcare professionals in radiology departments, the heterogeneity of roles may affect the evaluation of compliance, thereby undermining role-specific insights. The study sample was only obtained from government hospitals and health centers, perhaps constraining the applicability of the findings to commercial healthcare environments.

Conclusion

This study emphasizes that although healthcare professionals in radiology departments in the Kingdom Saudi Arabia typically have a commendable understanding of radiation safety, substantial deficiencies persist in the regular use of protective measures. Enhancing education and training programs centered on radiation protection is crucial for improving self-protection and patient safety measures. Enhancing adherence to safety measures can ultimately diminish occupational and patient exposure to ionizing radiation, promoting a safer clinical environment within radiology services.

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