Knowledge of Radiation Safety Among Medical Interns in Saudi Arabia

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Research Article

Keywords: radiation safety, medical intern training, knowledge, radiation dose, Qassim Saudi Arabia

Posted Date: March 15th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-293951/v1

Abstract

Background: Exposure to high-dose radiation is linked to an increased risk of cancer. The use of good radiation protection protocols improves the quality of education and research.

Methods: This cross-sectional study was conducted among medical interns in Saudi Arabia during the period from 2019-2020. A cluster multistage random sampling technique was used to recruit medical interns. All the participants were contacted through e-mail and asked to participate in the study. After informed consent was completed, the questionnaire was administered.

Results: Among 346 participants, 64.2% were male and 35.8% were female. The most common age group was 25 years old, which accounted for 36.7%. In total, 38.7% of the participants had a sufficient level of knowledge about ionizing radiation (IR)-related risks, while the vast majority (76%) had never attended events and/or refresher courses on radiation protection. The knowledge score for radiation protection was classified into two levels: poor (0 to 2), which was achieved by 69.7% of the participants, and good (3 to 7), which was achieved by 30.3%. Chi-square tests indicated that there is a significant association between the knowledge score and age ($p \le 0.01$) in favour of the participants who were 25 years old and that there is a significant association between the knowledge score and attendance at training events and/or refresher courses on radiation protection ($p \le 0.01$) in favour of the participants who frequently attended training. The assessment score was classified into two levels: poor (0 to 2), which was achieved by 80.9% of the participants, and good (3 to 7), which was achieved by 19.1%. Chi-square tests indicated that there is a significant association between radiation dose assessment and age ($p \le 0.01$) in favour of the participants who were 24 years old.

Conclusions: This study revealed that the vast majority of interns have insufficient knowledge of radiation protection, which is related to a lack of attendance at training events. Overall, our study results underscore the need for more successful education and training of radiology professionals with regard to radiation protection.

Clinical Trial Registration: Not applicable.

Background

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) states that the highest rates of exposure to radiation from artificial sources occur among patients who are subjected to an estimated 3.6 billion diagnostic X-ray examinations annually worldwide [1, 2]. This exposure, especially at higher doses, has been linked to an increased risk of cancer [3–6]. One study suggested that the assumption of a lower risk for adults is not accurate and that the risk may be twice as high as previously thought [7]. However, other studies have suggested that the risks of developing cancer due to irradiation are often exaggerated [8, 9]. These disparate findings have compelled the scientific community, via the International Atomic Energy Agency (IAEA), to support multiple projects and release guidelines that have helped more than 80 countries decrease radiation doses without reducing image quality [10]. The awareness and training of radiology professionals regarding computed tomography (CT) examinations have generally been found to be lacking, and there is an urgent need for strict monitoring and training [11]. These IAEA projects have raised awareness and facilitated the reduction of problems regarding radiation protection in Eastern European countries [12, 13].

In the education and research sectors, different entities, such as universities, research organizations, and research projects, and especially stakeholders and senior administrators, who are not well acquainted with the hazards of inadequate protection against radiation, have been inclined to encourage radiation protection to obtain certain advantages. However, these perceived advantages are financially, socially, and scientifically not effective enough. Research shows that developing a good radiation protection culture improves the quality of education and research as well as the long-term reputation of the institution [14].

One study reported that medical students had more adequate knowledge of radiation protection issues than radiology students and residents; however, radiology residents and students displayed better awareness of radiation safety and the need for complete patient information, tissue susceptibility to radiation-induced damage, optimization of the professional risk dose, and the doses involved in radiological procedures [15]. Another study in South Korea evaluated practitioner awareness regarding patient radiation exposure in the emergency department and showed a lack of awareness among physicians and radiologists regarding radiation exposure doses and cancer risks [16].

A study from Ottawa, Canada, compared the awareness of radiation exposure risks among radiology residents, technologists, fellows, and staff and showed limited overall awareness of the dosage and risk of radiation [17]. Surprisingly, the author of that study reported that there has been a lack of radiation awareness studies performed among radiology technicians, on whom their study focused.

Another study conducted in South Africa reported that although radiology residents scored higher in terms of knowledge of radiation safety for patients and healthcare workers, their knowledge of the precise expected dose effects was poor regardless of their medical specialty [18]. In a study from Norway, final-year medical students reported that they had limited knowledge about the radiation dose and the risks linked to imaging studies that involve IR [19]. Another study from Italy showed that although 90% of radiographers claimed to have enough knowledge of radiation protection issues, most of them underestimated the radiation dose of almost all radiological procedures [20]. However, young radiographers had more relevant knowledge than experienced radiographers. Overall, these studies indicate insufficient knowledge among medical professionals regarding radiation risks and highlight the need for educational initiatives.

Among locally published health literacy studies, none has examined the knowledge of this topic among medical interns in Saudi Arabia. To fill this knowledge gap and improve radiation safety, in the present study, we investigated the level of knowledge of radiation doses from various imaging modalities and the risks associated with IR imaging procedures among medical interns.

Methods

Study Design

This was a prospective, non-interventional, observational, cross-sectional, descriptive study. The study population included medical interns who had recently graduated from medical colleges in Saudi Arabia. A cluster-multistage random sampling technique was applied in this study. Universities in the region were clustered according to their geographic divisions, and questionnaires were distributed following random sampling. The inclusion criteria included being a medical interns and having graduated from different medical colleges within Saudi Arabia. The exclusion criteria included the lack of response to the e-mail or inability to complete the questionnaire for any reason.

Sample Size and Selection

The study population included interns who graduated in July 2019 from different medical colleges within Saudi Arabia, for a total of 3391 interns. The required sample size was calculated using the standard sample size equation: $n = [z^2p\ (1 - p)]/e^2$, where z is the z-score associated with a level of confidence, p is the prevalence, and e is the margin of error. The following assumptions were made: a prevalence of good knowledge of radiation safety among medical interns of 50%, a precision of 4%, and a confidence interval of 95%. Thus, the minimum sample size needed was 276. The sample size was increased by 20% to compensate for nonresponding participants, so the final sample size was 346 interns.

Data Collection

Data were collected from interns from different cities within Saudi Arabia by a researcher using a valid, pretested, structured questionnaire. All the participants were contacted through e-mail and asked to participate in the study. After informed consent was completed, the aforementioned questionnaire was administered. Ethics approval was obtained from the Research Ethics Committee at Qassim University before starting data collection (#560241) to ensure the confidentiality of the collected data and privacy of the medical interns. Finally, the entire completed questionnaire was sealed after use.

Research Instrument (Questionnaire) and Validation

A self-administered, valid, pretested questionnaire was sent and received by e-mail. The questionnaire had three parts.

PART I

The demographic data collected by the questionnaire were as follows: sex (male/female, one question), age (one question), and background knowledge (two questions addressing IR and prior radiation protection courses attended).

PART II

Seven questions addressed knowledge of radiation protection. The interns were asked whether it is necessary to inform the patient about risks related to IR, whether there is any relationship between patient age and radiation sensitivity, which medical professional is responsible for unnecessary patient exposure, and which professional is more likely to be exposed to IR. One question addressed stochastic radiation, and another question asked the intern to define “dose optimization.”

PART III

Knowledge about the radiation doses involved in different common radiology examinations was assessed. Nine questions addressed chest/lumbar X-ray, chest CT, positron emission tomography (PET)-CT, and scintigraphy.

Data Management and Statistical Analysis

The collected data were entered into and analysed with Statistical Package for the Social Science (SPSS) software version 21.0 and are presented graphically. Descriptive statistics (means, standard deviations, frequencies, and percentages) were used to describe the quantitative and categorical variables. Student’s t-test for independent samples was used to compare mean values. Pearson’s chi-square test was used to assess associations between categorical variables, and odds ratios were calculated to measure these associations. Multivariate analyses were performed to identify the independent variables associated with outcomes. A p-value of ≤ 0.05 and 95% confidence intervals were used to indicate statistical significance and the precision of the results.

Results

Demographics of the Study Participants

Three hundred sixty-four medical interns completed the questionnaire (response rate of 100%).

Table 1 shows the demographic characteristics of the interns: 64.2% of the participants were male, and 35.8% were female. Their distribution according to age was as follows: 15% were 24 years old, 36.7% were 25 years old, 15.9% were 26 years old, and 32.4% of the participants were younger than 24 years or older than 26 years. The participants’ distribution according to level of knowledge of IR-related risks was as follows: 4.9% had excellent knowledge, 20.8% had good knowledge, 38.7% had sufficient knowledge, and 35.5% had insufficient knowledge. Their distribution according to their attendance at training events and/or refresher courses on radiation protection was as follows: the vast majority, 76%, had never attended any, 20.8% had seldom attended, and only 3.2% had frequently attended (See Table 1).

Table 1
Distributions of the participants according to demographics (n = 346)

Variable		n	%
Sex	Male	222	64.2
	Female	124	35.8
Age, years	24	52	15.0
	25	127	36.7
	26	55	15.9
	Other	112	32.4
Level of knowledge of ionizing radiation (IR)-related risks	Excellent	17	4.9
	Good	72	20.8
	Sufficient	134	38.7
	Insufficient	123	35.5
Attended training events and/or refresher courses on radiation protection	Yes, frequently	11	3.2
	Yes, seldom	72	20.8
	No, never	263	76.0

Radiation Protection Knowledge

Table 2 shows the distributions of the participants according to their responses to the questions about radiation protection knowledge. The vast majority (74%) believe that it is necessary to advise patients about the risks related to the use of IR for medical purposes. A total of 14.2% believed that the most sensitive patients to IR were 1-year-old females. A total of 61.8% believed that all professionals listed are considered legally responsible (in Saudi Arabia) for unnecessary exposure to IR and/or improperly performed radiological examinations. A total of 34.7% believed that interventional cardiologists and radiologists are more likely to be exposed to IR because of their job. Thirty-nine percent believed that breasts are relatively more susceptible to IR-related damage. A total of 25.4% believed that leukaemia may be a result of stochastic radiation damage and with regard to the concept of “dose optimization”, 35.3% believed that the dose delivered by IR-based examinations must be kept as low as reasonably achievable while still enabling the required diagnostic information to be obtained (See Table 2).

Table 2
Distribution of participant responses regarding radiation protection knowledge (n = 346)

		n	%
According to current Saudi Arabian legislation, is it necessary to advise patients about the risks related to the use of IR for medical purposes?	**Yes, always**	**256**	**74.0**
	Yes, but only for patients younger than 18 years old	16	4.6
	Yes, but only for patients who are going to have a CT scan	43	12.4
	Yes, but only for patients younger than 65 years old	15	4.3
	No, never	16	4.6
Which of the following patients is the most sensitive to IR?	1-year-old males	31	9.0
	1-year-old females	**49**	**14.2**
	20-year-old females	34	9.8
	40-year-old males	15	4.3
	IR damage risk is unrelated to a patient's age or sex	217	62.7
Which of the following professionals is considered legally responsible (in Saudi Arabia) for unnecessary exposure to IR and/or improperly performed radiological examinations?	Referring physician	42	12.1
	Radiologist	54	15.6
	Medical specialist (other than the radiologist) who performs interventional radiology procedures	24	6.9
	Radiographer	12	3.5
	All of the above	**214**	**61.8**
Which of the following professionals are more likely to be exposed to IR because of their job?	Nuclear medicine physicians	59	17.1
	Radiographers	144	41.6
	Interventional cardiologists and radiologists	**120**	**34.7**
	Non-interventional radiologists	9	2.6
	Surgeons	14	4.0
Which of the following tissues is more susceptible to IR-related damage?	Kidney	72	20.8
	Breast	**135**	**39.0**

Bold text indicates the correct answer.

		n	%
	Bone	79	22.8
	Liver	31	9.0
	Muscle	29	8.4
Which of the following diseases may be a result of stochastic radiation damage?	Dermatitis	25	7.2
	Leukaemia	**88**	**25.4**
	Alopecia	14	4.0
	Cataract	15	4.3
	All answers are correct	204	59.0
Which of the following best describes the concept of “dose optimization”?	IR-based examinations should be prescribed and performed only when indispensable.	37	10.7
	The dose delivered by IR-based examinations must be kept as low as reasonably achievable, consistent with obtaining the required diagnostic information.	**122**	**35.3**
	The scan volume for IR-based examinations should be as large as possible, to maximize diagnostic information from a single acquisition.	23	6.6
	An IR-based examination is optimized when spatial and contrast resolution is maximized to assess even the finest image details.	19	5.5
	All statements are correct.	145	41.9
Bold text indicates the correct answer.			

Radiation Dose Assessment

Table 3 shows the distributions of the participants according to their responses regarding radiation dose assessment. The distribution of answers were as follows: 27.5% responded that 0.01–0.1 mSv is the average radiation dose of a posteroanterior (PA) chest radiograph; 8.1% responded that 100–500 is the average dose due to natural background radiation in Saudi Arabia, if a PA chest radiograph represented 1 unit; 17.1% indicated that 50–100 is the average dose due to a lumbar X-ray examination, if a PA chest radiograph represented 1 unit; 30.6% selected 10–50 as the average dose due to mammography (bilateral, two projections each, i.e., four images in total), if a PA chest radiograph represented 1 unit; 20.8% chose 100–500 as the average dose due to a noncontrast chest CT examination, if a PA chest radiograph represented 1 unit; 36.7% indicated that 0 was the average dose due to a pelvic MRI (Magnetic resonance imaging) examination, if a PA chest radiograph represented 1 unit; 24.3% selected > 500 as the average dose due to a whole-body PET-CT examination if a PA chest radiograph represented 1 unit; 39.3% chose 0 as the average dose due to an abdominal ultrasound examination, if a PA chest radiograph represented 1 unit; and 12.7% responded that > 500 was the average dose due to myocardial scintigraphy (2-day protocol with 99mTc-sestamibi), if a PA chest radiograph represented 1 unit (See Table 3).

Table 3
Distribution of participants' responses regarding radiation dose assessment (n = 346)

		n	%
What is the average radiation dose of a PA chest radiograph?	< 0.01 mSv	35	10.1
	0.01–0.1 mSv	**95**	**27.5**
	0.1–1 mSv	74	21.4
	1–10 mSv	82	23.7
	10–100 mSv	46	13.3
	> 100 mSv	14	4.0
If a PA chest radiograph represents 1 unit, what is the average dose due to natural background radiation in Saudi Arabia?	0	26	7.5
	1–10	129	37.3
	10–50	94	27.2
	50–100	58	16.8
	100–500	**28**	**8.1**
	> 500	11	3.2
If a PA chest radiograph represents 1 unit, what is the average dose due to a lumbar X-ray examination?	0	32	9.2
	1–10	110	31.8
	10–50	100	28.9
	50–100	**59**	**17.1**
	100–500	32	9.2
	> 500	13	3.8
If a PA chest radiograph represents 1 unit, what is the average dose due to mammography (bilateral, two projections each, i.e., four images in total)?	0	20	5.8
	1–10	90	26.0
Bold text indicates the correct answer.			

		n	%
	10–50	**106**	**30.6**
	50–100	81	23.4
	100–500	36	10.4
	> 500	13	3.8
If a PA chest radiograph represents 1 unit, what is the average dose due to a non-contrast chest CT examination?	1–10	53	15.3
	10–50	87	25.1
	50–100	58	16.8
	100–500	**72**	**20.8**
	> 500	63	18.2
	1–10	53	15.3
If a PA chest radiograph represents 1 unit, what is the average dose due to a pelvic MRI examination?	**0**	**127**	**36.7**
	1–10	55	15.9
	10–50	43	12.4
	50–100	65	18.8
	100–500	28	8.1
	> 500	28	8.1
If a PA chest radiograph represents 1 unit, what is the average dose due to a whole-body PET-CT examination?	0	15	4.3
	1–10	39	11.3
	10–50	65	18.8
	50–100	65	18.8
	100–500	78	22.5
	> 500	**84**	**24.3**
If a PA chest radiograph represents 1 unit, what is the average dose due to an abdominal ultrasound examination?	**0**	**136**	**39.3**

Bold text indicates the correct answer.

		n	%
	1–10	52	15.0
	10–50	57	16.5
	50–100	52	15.0
	100–500	27	7.8
	> 500	22	6.4
If a PA chest radiograph represents 1 unit, what is the average dose due to myocardial scintigraphy (2-day protocol with 99mTc-sestamibi)?	0	33	9.5
	1–10	83	24.0
	10–50	66	19.1
	50–100	66	19.1
	100–500	54	15.6
	> 500	**44**	**12.7**
Bold text indicates the correct answer.			

Associations Between Radiation Protection Knowledge and Demographic Variables

The total knowledge score ranged between 0 and 7 out of 7 questions: 14 participants scored 0, 40 participants scored 1, 87 participants scored 2, 100 participants scored 3, 68 participants scored 4, 25 participants scored 5, 11 participants scored 6 and only one participant scored 7 out of 7. Then, the knowledge score was classified into two levels: poor (0 to 2) and good (3 to 7).

Table 4 shows the results of chi-square tests for the association between radiation protection knowledge and demographic variables, which indicate that there is a statistically significant association between radiation protection knowledge and age ($p < 0.01$) in favour of the participants who were 25 years old. Participants who were 25 years old accounted for 42.4% of those who had a good level of knowledge. Additionally, there was a statistically significant association between radiation protection knowledge and attendance at training events and/or refresher courses on radiation protection, in favour of the participants who frequently attended training. A total of 82.9% of the group with good knowledge frequently attended training. Otherwise, there was no statistically significant association between the level of knowledge and other demographics ($p > 0.05$). This is due to the convergence of percentages among groups (See Table 4).

Table 4
Association between radiation protection knowledge and demographic variables (n = 346)

Variable		**Poor (%) (n = 141)**	**Good (%) (n = 205)**	**Chi-square**	**p-value**
Sex	Male	66.0	62.9	.334	0.563
	Female	34.0	37.1		
Age	24	11.3	17.6	16.573	0.001**
	25	28.4	42.4		
	26	16.3	15.6		
	Other	44.0	24.4		
Knowledge level of ionizing radiation (IR)-related risks	Excellent	31.9	38.0	2.630	0.452
	Good	41.8	36.6		
	Sufficient	19.9	21.5		
	Insufficient	6.4	3.9		
Attended training events and/or refresher courses on radiation protection	Yes, frequently	66.0	82.9	13.370a	0.001**
	Yes, seldom	29.1	15.1		
	No, never	5.0	2.0		

**Significant at 0.01 level

Associations Between Radiation Dose Assessment and Demographic Variables

The total assessment score ranged between 0 and 7 out of 9 questions: 47 participants scored 0, 75 participants scored 1, 101 participants scored 2, 57 participants scored 3, 36 participants scored 4, 23 participants scored 5, 5 participants scored 6 and only two participants scored 7 out of 9. Then, the assessment scores were classified into two levels: poor (0 to 2) and good (3 to 7). Table 5 shows the results of chi-square tests for the associations between radiation dose assessment and demographic variables, which indicate that there is a statistically significant association between radiation dose assessment and age ($p < 0.01$) in favour of the participants who were 24 years old. Participants who were 24 years old accounted for 47.2% of the total good assessment group. Otherwise, there was no statistically significant association between radiation dose assessment and other demographics ($p > 0.05$). This is due to the convergence of percentages among groups (See Table 5).

Table 5
Association between radiation dose assessment and demographic variables (n = 346)

Variable		Poor (%) (n = 223)	Good (%) (n = 123)	Chi-square	p-value
Sex	Male	65.9	61.0	.843	0.359
	Female	34.1	39.0		
Age	24	12.6	19.5	17.784	0.000**
	25	30.9	47.2		
	26	17.5	13.0		
	Other	39.0	20.3		
Knowledge level of ionizing radiation (IR)-related risks	Excellent	35.4	35.8	.707	0.872
	Good	38.1	39.8		
	Sufficient	22.0	18.7		
	Insufficient	4.5	5.7		
Attended training events and/or refresher courses on radiation protection	Yes, frequently	72.2	82.9	5.286	0.071
	Yes, seldom	23.8	15.4		
	No, never	4.0	1.6		

**Significant at 0.01 level

Discussion

The safety of patients and radiologists is a priority during all diagnostic and therapeutic procedures involving IR. Therefore, knowledge of radiation protection and dose assessment is essential in the medical community. The current study has several important findings. First, this study showed that more than half (64.5%) of the participants had poor knowledge of radiation protection. Second, more than half (59.2%) of the participants had adequate knowledge regarding the assessment of the radiation dose.

Medical interns' awareness of radiation protection is essential because they are directly involved in imaging procedures involving IR. While most of the participants identified the importance of advising patients about the risks related to the use of IR for medical purposes, we found some important knowledge gaps. The majority of the participants in our study did not know that the patients who are the most sensitive to IR are 1-year-old females. Few participants knew that the breast is more susceptible to IR-related damage and that leukaemia can be a result of stochastic radiation damage.

However, one study by Pearce et al. [6] assessed the excess risk of leukaemia and brain tumours following a CT scan in a cohort of children and young adults. They concluded that the use of CT scans in children delivered cumulative doses of approximately 50 mGy and could nearly triple the risk of leukaemia. They also found that female children were the most sensitive to IR.

A relatively small proportion of participants (35.3%) believed that the statement “the dose delivered by IR-based examinations must be kept as low as reasonably achievable while remaining consistent with obtaining the required diagnostic information” best described the concept of “dose optimization.” Similar to our findings, a large survey conducted by Faggioni et al. [15] showed an inadequate awareness of radiation protection issues in different groups of specialists. Additionally, they had the same opinion regarding the best description of “dose optimization”.

The majority of participants did not know that interventional cardiologists and radiologists are those most likely to be exposed to IR because of their job. In contrast, a study performed by Faggioni et al. [15] showed that the majority of participants knew the correct answer.

Analysing the present study in detail, it is surprising that a high percentage of participants did not attend training events or refresher courses on radiation protection, which was reflected in their knowledge scores.

Regarding radiation dose assessment, our results showed that the majority of participants significantly underestimated the radiation dose received by patients during radiological investigations. Only 27.5% of participants knew that the average radiation dose of a PA chest radiograph was 0.01–0.1 mSv. This number is comparable to that of a recent study conducted in Riyadh, Saudi Arabia, which revealed that 24.5% of radiology staff were aware of the correct radiation dose due to chest X-ray [21]. These results are important because they show that the side effects of radiation exposure are potentially underestimated by clinicians, resulting in an unnecessarily high number of orders. Few participants knew that the average dose due to natural background radiation in Saudi Arabia is between 100–500 units. Similar to our findings, a study by Hall and Brenner showed that only 7.6% of the respondents had poor knowledge of the annual natural background radiation dose [5].

In our study, few participants (20.8%) knew the correct IR dose due to a noncontrast chest CT examination. In contrast, in the Faggioni et al. [15] study, the number of participants who knew the correct chest CT examination dose was high (54.4% of radiology residents, 46.4% of medical students, and 44.2% of radiography students). Few participants identified a pelvic MRI scan and an abdominal ultrasound examination as being radiation-free. In contrast, the study performed by Faggioni et al. [15] reported that almost all the participants knew that IR was not used in ultrasound or MRI. Another study by

Griffey and Sodickson yielded similar results [4]. Few participants knew the correct IR dose used in PET-CT and myocardial scintigraphy, which was more than 500 units. In the study by Faggioni et al. [15], which targeted radiology residents, medical students, and radiography students, those 40.4%, 31.5%, and 16.7% of those subgroups, respectively, correctly chose the radiation dose delivered by myocardial scintigraphy.

The correct mammography dose, 10–50 units, was known by 30.6% of participants in our study. Faggioni et al. [15] found similar results; the correct mammography dose was known by 37.9% of radiology residents, 22.2% of medical students, and 27.9% of radiography students.

Analysing the present study in detail, it is surprising that a high percentage of participants did not attend training events or refresher courses on radiation protection, which was reflected in their knowledge score.

There was a statistically significant association between the knowledge score and attendance at training events and/or refresher courses on radiation protection ($p \leq 0.01$), in favour of the participants who frequently attended training.

The study has some limitations. We used a self-administrated questionnaire in this study, and recall bias cannot be excluded. In addition, the results cannot be generalized to other populations in the country because knowledge, attitudes and practices can be substantially influenced by socio-demographic factors in a population. More studies on radiation protection need to be performed, especially with the increased use of IR during radiology examinations.

Conclusions

This study assessed the levels of awareness of radiation protection and radiation doses among interns from different medical colleges within Saudi Arabia. Based on the data generated from this cross-sectional survey, we concluded that the vast majority of interns have insufficient knowledge of radiation protection, which is related to a lack of attendance at training events or refresher courses pertaining to radiation protection. Overall, our study results underscore the need for more successful education and training of radiology professionals in radiation protection.

Abbreviations

IR: Ionizing Radiation; UNSCEAR: United Nations Scientific Committee on the Effects of Atomic Radiation; IAEA: International Atomic Energy Agency; CT: Computed Tomography; PET: Positron Emission Tomography; PA: Posteroanterior; MRI: Magnetic resonance imaging.

Declarations

Ethics Approval and Consent to Participate

The study was approved by the Institutional Review Board College of Medicine, Qassim University (no. 560241), Saudi Arabia and followed the declaration of Helsinki ethical principles for medical research involving human subjects. All the participants were contacted through e-mail and asked to participate in the study. After informed consent was completed, the aforementioned questionnaire was administered.

Consent for Publication

NA.

Availability of Data and Materials

The data generated or analyzed during this study were included in this published article.

Competing Interests

The authors have declared no competing interests.

Funding

There was no funding for this study.

Authors' Contributions

Sharifa Khalid Alduraibi (SD) and Ahmad Alahmad (AA) were responsible for the conception of the research idea and the study design. SD, AA, Darren Alghadhiyah (DG), Maha Algazlan (MG), Alaa Alduraibi (AA), Abdulaziz Alduraibi (AA) were responsible for the supervision, data collection, analysis, interpretation, and drafting of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We would like to thank all medical interns in Saudi Arabia for their volunteering to participate in the study.

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Figures

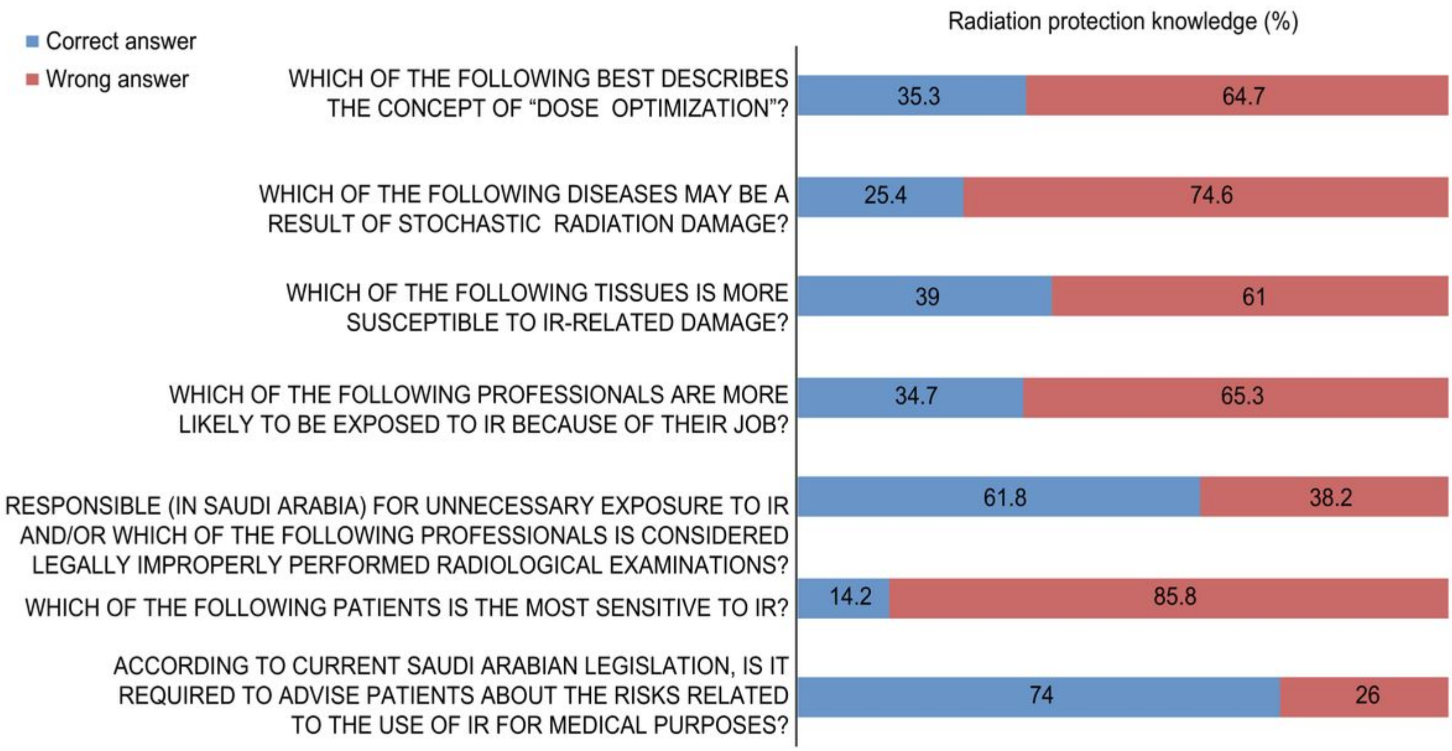

Figure 1

Radiation protection knowledge

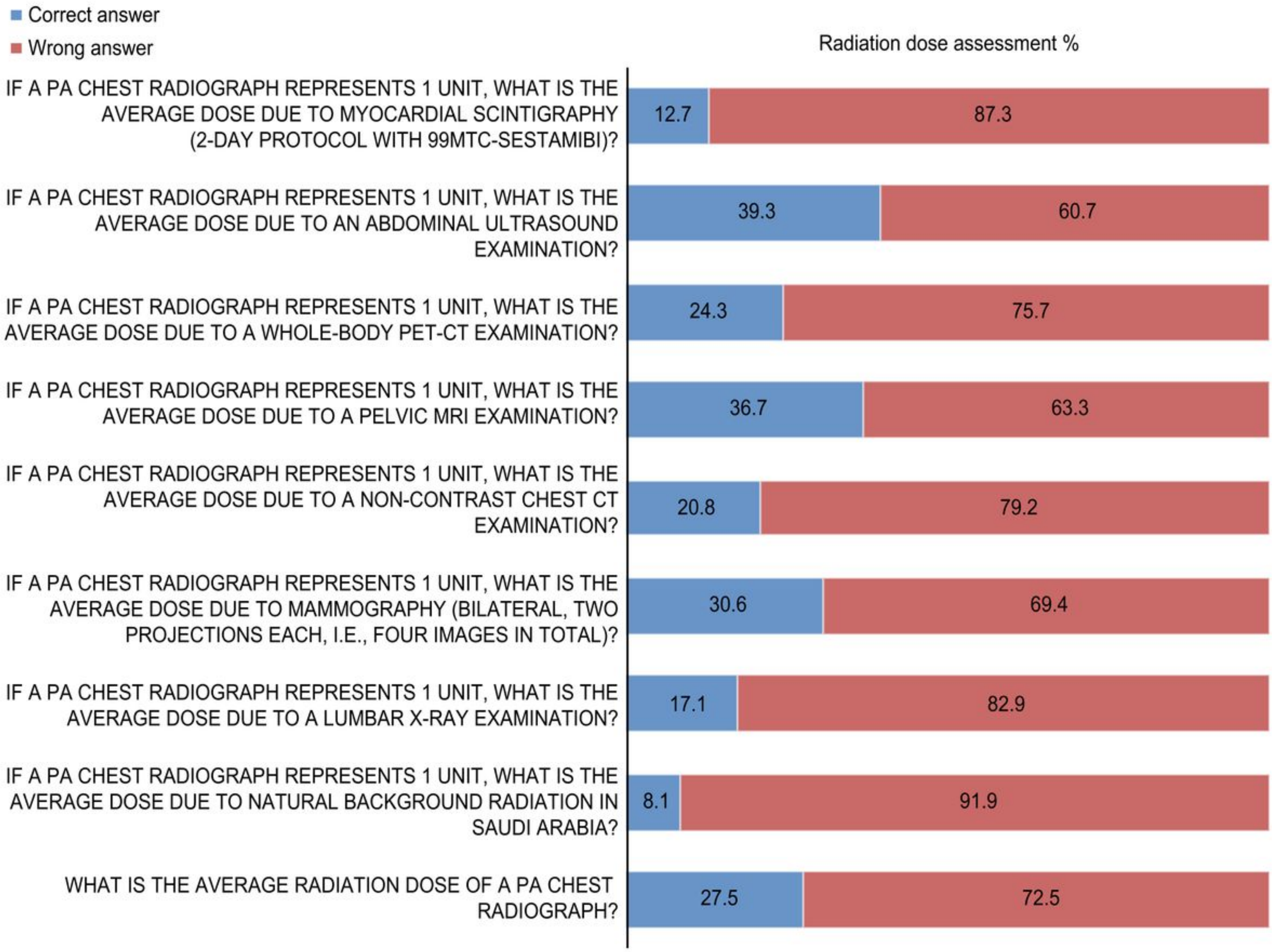

Figure 2

Radiation dose assessment

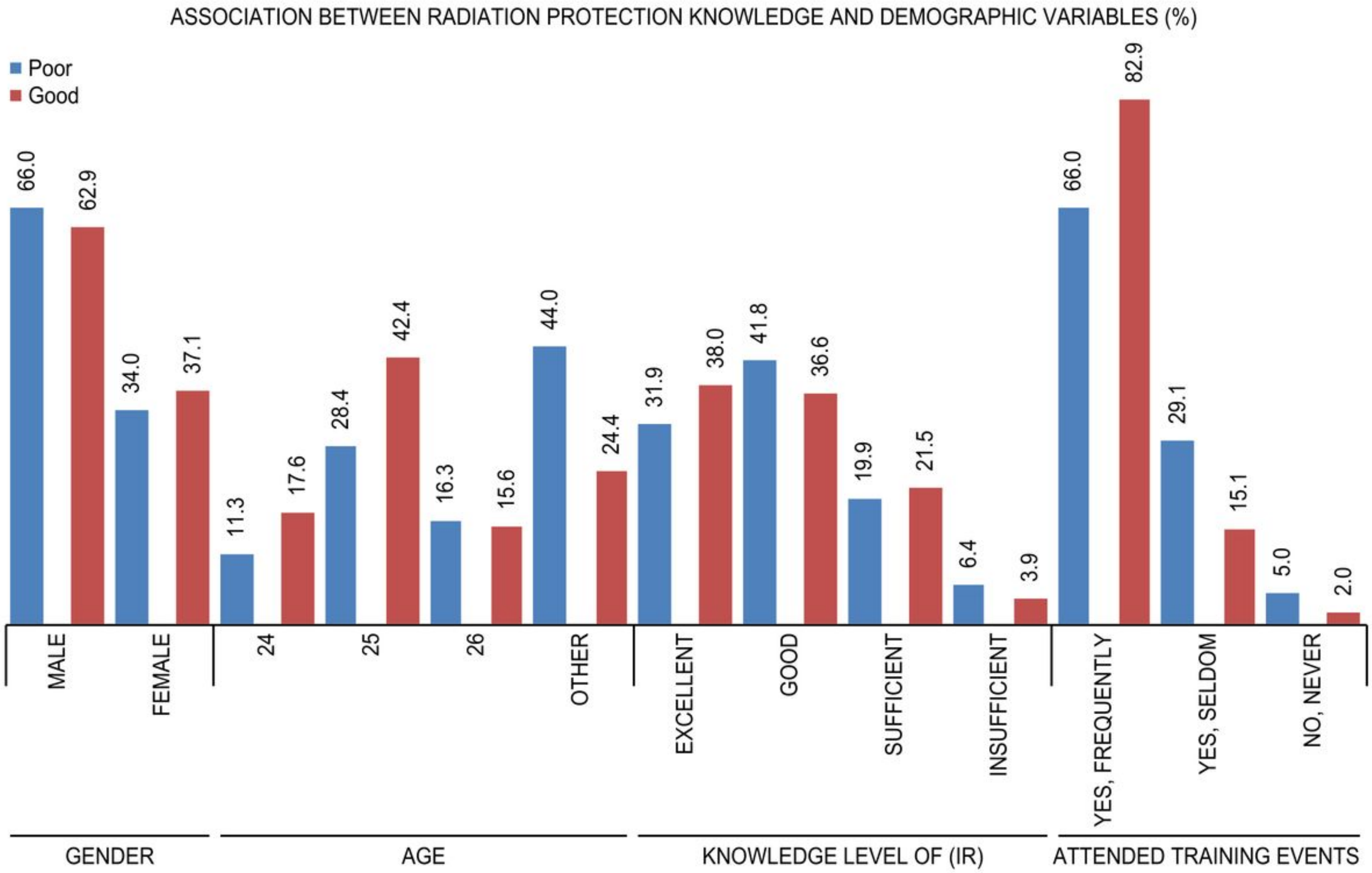

Figure 3

Radiation protection knowledge score according to demographic variables

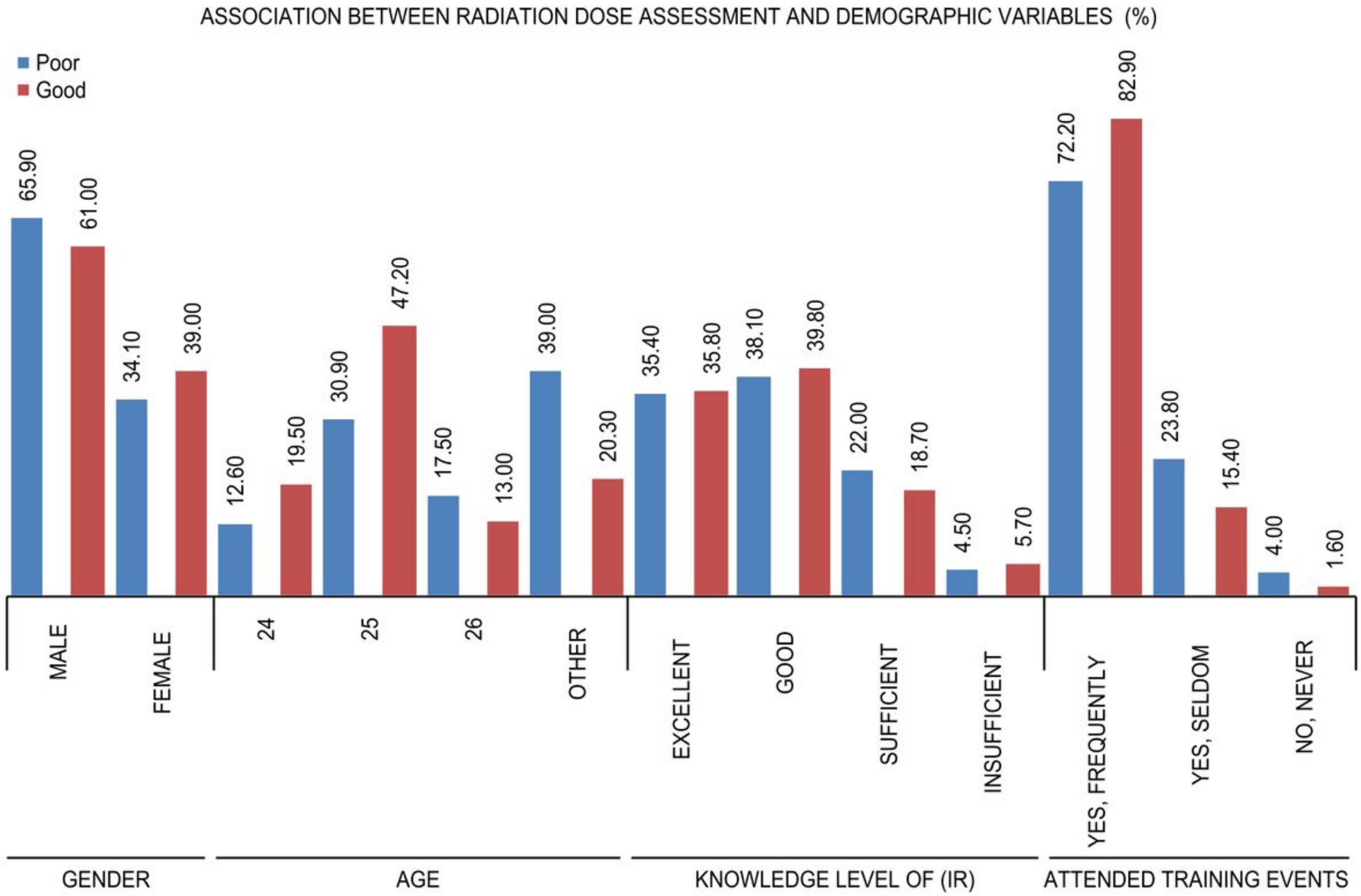

Figure 4

Radiation dose assessment score according to demographic variables