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Assessment of Awareness and Practice of Ionizing Radiation Protection Procedures among Exposed Health Care Workers

Saad Ali gram Alomari[1], Mazen Abdul Ali Al-Harbi[2], Ahmed Mohammed Nasser Amri[3], Aali Mesfer Aali Alkhathami[4], Sarah Ibrahim Abdulmajeed Alshallali[5], Defallah Ali Defallah Alshehri[6], Lamia Lebnan Dafer Aldossri[7], Alanoud Mohammed Kader Alhosawi[8], Fahad Mohmmed saeed Alqhtani[9], Ali Zaher Abdulrahman Albariqi[10], Meshal Eid Abdul Rahman Al-Osaimi Al-Otaibi[11]

Abstract

Background: Access to ionizing radiation has become widely available for diagnosis and treatment. The increased use of ionizing radiation has been associated with radiation exposure hazards for patients and radiation workers. Raising the level of radiation protection awareness is important to maintain the safety of healthcare settings. Aim of work: To assess awareness and practice of ionizing radiation protection procedures among (HCWs). Materials and methods: A cross-sectional study was carried out from January to March 2023. All HCWs at Abdulaziz King University Hospitals (technicians, nurses, physicians, and physicists) occupationally exposed to ionizing radiation in diagnostic radiology (DR) department, Clinical Oncology and Nuclear Medicine (CO&NM) department, and Nuclear Medicine (NM) unit who accepted to share in the study were included as study population (No=195). A self-administered, structured questionnaire composed of three sections. First section: comprised questions regarding demographic data, second section: included questions about awareness of radiation protection procedures, and third section: composed of questions about safe practices of HCWs regarding ionizing radiation exposures. Results: The study revealed that satisfactory awareness of radiation protection procedures among HCWs in the three departments was (51.3 %) with no statistically significant difference between different radiation units. But HCWs had inadequate practice score (18%) regarding the use of safety measures of radiation exposure. Satisfactory awareness of radiation protection procedures of exposed workers was highly significantly associated with higher educational level (44.2%), years of experience ≥ 10 years (36.8 %), being a physician (73.7%) and getting training courses (61.1%). Also, adequate practice of radiation protection procedures among exposed workers was found to be highly significantly associated with higher educational level (74.3%), years of experience ≥ 10 years (68.6%), being a physician (80.0%) and getting

[1] X-ray Technician, Makhwah General Hospital, Saudi Arabia.
[2] X-ray Technician, Makkah Health Complex - Al-Shumaisi Medical Complex, Saudi Arabia.
[3] Radiology Technologist, Durma General Hospital, Saudi Arabia
[4] Radiology Technician, Ad Diriyah Hospital, Saudi Arabia.
[5] Radiology Technologist, Durma General Hospital, Saudi Arabia
[6] Radiology Technician, Riyadh First Health Cluster, Saudi Arabia.
[7] Radiology Technician, Durma General Hospital, Saudi Arabia.
[8] Radiology Technician, Riyadh First Health Cluster, Saudi Arabia.
[9] Radiology Technician, Riyadh First Health Cluster, Saudi Arabia.
[10] Radiology Technician, Durma General Hospital, Saudi Arabia.
[11] X-ray Technician, Quality officer for radiology departments in the Dawadmi zone, Saudi Arabia.

training courses (71.4%). Conclusion: satisfactory awareness about radiation protection procedures among exposed HCWs was noted while inadequate practices of radiation protection procedures in the workplace were found.

Key words: *Ionizing Radiation, Radiation Hazards, Radiation Protection Procedures, Awareness and Personal Protective Equipment.*

Introduction

Access to ionizing radiation for diagnosis and treatment purposes has become widely available [(1)]. Increased use of ionizing radiation has been associated with radiation exposure hazard for patients as well as radiation workers [(1-3)]. The average radiation dose to the public is 2.5 mSv per year, 15% of which is related to medical exposure [(4, 5)]. Excessive exposure to ionizing radiation can cause biological harm [(6)]. Imaging procedures involving the use of ionizing radiation should be carried out by expert professionals to minimize risks [(7)]. Justification, optimization, and As Low As Reasonably Achievable (ALARA) principles are considered the main principles that support radiation dose reduction [(8)].

Applying these principles is associated with acquiring an accurate and diagnosable image with the lowest possible dose [(8)]. This cannot be achieved unless there is sufficient knowledge of radiation protection and dose levels [(8)]. Ionizing radiations are emitted from radioactive atoms and the process is known as radioactivity. Ionizing radiations are composed of two types of energy: Electromagnetic radiation (gamma or X-rays) and particulate radiation (neutrons, beta or alpha particles). In medical practice 20% of the total population is exposed to radiation and this is going to continue to increase all over the world. Annually worldwide, more than 3600 million diagnostic radiology examinations are conducted, 37 million nuclear medicine procedures are performed, and 7.5 million radiotherapy treatments are taken [(9)].

In the Nuclear Medicine departments (NMDs), nurses are responsible for patient preparation, organizing the use of radioactive and non-radioactive medications, demonstrating treatment procedures, and ensuring patient safety, which makes them more vulnerable to risks [(10)]. Radiation has different health risks, which are affected by the dose level and exposure time; these include cancer, cataract, infertility and genetically determined ill-health, developmental abnormalities, and degenerative diseases [(10, 11)].

Staff working in radiation wards should have adequate knowledge about the risks and safety measures of radiation exposure to protect their health and help the patient to get the correct data about radiation exposure [(12)]. The risks of radiation are reduced by using different methods of protection like the principles of distance, and time as well as the use of various monitoring devices such as thermo-luminescent dosimeters (TLDs) and Geiger Muller (GM) counters [(13)].

Shielding personal protective equipment include lead aprons, eye goggles, lead gloves, gonad shields, and thyroid shields. Regular use of lead aprons provides an average of 75–80% protection to the bone marrow. Lead shielding is an important protective measure against radiation exposure [(14)].

In KSA, a study conducted by Alyami et al., (2022) [(15)] revealed that the importance of training and continuing to educate nurses about radiation protection and radiological procedures in nuclear medicine departments (NMDs), which improve the levels of radiation protection awareness and safety practices. This study was carried out because it was noted that the level of awareness of the dangerous exposure to high levels of radiation by some health care workers in radiology departments was not adequate. Some neglected the use of personal dosimeters and others did not receive them. Deficiency of some mandatory

radiation protection requirements like goggles and thyroid shields was noted. Other requirements like leaded gloves were very old and no longer useful. Therefore, this study aimed to assess the level of awareness and practices of radiation protection procedures among workers occupationally exposed to ionizing radiation.

Methods

A cross-sectional study was carried out in the Nuclear Medicine (NM) unit of Diagnostic Radiology (DR) department: Diagnostic Radiology (DR) department, Clinical Oncology and Nuclear medicine (CO&N) department in Abdulaziz King University Hospitals, KSA from January to March 2023. All HCWs (physicians, nurses, technicians and physicists) occupationally exposed to ionizing radiation in the above mentioned departments, who agreed to participate in the study were included. The target population consisted of 195 out of 258 with a response rate of (75.5%) including (105 physicians, 57 nurses, 33 technicians and physicists.

Inclusion criteria: All HCWs (physicians, nurses, technicians and physicists) occupationally exposed to ionizing radiation in the three radiological departments with work experience at least one year and who accepted to participate in the study were included. Exclusion criteria: Any HCW who attended less than one year in radiology departments. Any health care workers who were not in contact with radiation sources or with patients when they were being examined, for ex: (senior staff, pregnant female workers and outpatient clinic working nurses).

The study tool in this research included: A self-administered, structured questionnaire comprising of three sections: first section comprised questions regarding demographic data, second section comprised 23 questions about awareness of radiation protection measures, and third section was composed of 7 questions about safe practices of HCWs regarding ionizing radiation exposures. The questionnaire was designed and validated after reviewing previous studies [10, 14], and it was translated into Arabic and revised by three specialists. A pilot study was then conducted on 10% of sample size.

The questions were answered by 'Yes' or 'NO'. Each positive answer was scored as 1 point and each negative answer was scored as 0 point. The awareness score ranged from 0 to 23. Regarding practice, the score ranged from 0 to 7. HCW who achieved more than two-thirds of the score of awareness or practice (> 66.7%) were considered to have satisfactory awareness or adequate practice of radiation protection procedures.

Before the start of work, an informed verbal consent was taken from subjects who agreed to participate in the study with assurance of confidentiality and anonymity of data. Approval from the Ethical Committee of University Hospitals was obtained.

Data were presented and statistically analyzed using SPSS version 28. Descriptive variables were expressed as numbers and percentages, and mean ± S.D. Chi-square was used to test for association between categorical variables. Pearson's correlation analysis was done to test the correlation between awareness and practices of health care workers. The level of significance was considered at p- value less than 0.05.

Results

Table (1) showed a summary of demographic data of exposed HCWs. Over forty five percent (48.7%) were aged between 20 and 30 years. The majority of HCWs (59%) had bachelor degree. About (46 %) had less than five years of experience, and most of them (66.7%) did not have training courses on radiation safety.

Table (2) showed the number of HCWs who were highly aware of radiation protection procedures regarding the transference of female HCWs to another department when they

get pregnant (99.5%) followed by awareness of infertility in men and women HCWs as a risk of occupational radiation exposure and familiarity with the terms RSO (Radiation Safety Officer) (93.9% and 89.7%, respectively) followed by knowing what TLD badge or pocket dosimeter are (84.1%), familiarity with terms of distance and shielding (82.1% and 83.6%) and lead apron as a protective tool reducing radiation exposure (82.1%).

However, the number of HCWs who responded that radiation departments make sure that all HCWs should wear TLD is low (28.2%). Familiarity with the 10 days rule concept (33.3%), of the fact that cataract of the eye lens is a risk of occupational radiation exposure (40.0%) and of goggles, gonad shields and thyroid shields as protective tools against radiation exposure (35.4%, 36.9% and 28.2%, respectively) (Table 2).

Table (3) showed that there is a large number of HCWs using safe practices to keep enough distance from radiation source and using minimal procedure time (74.4% and 63.1% , respectively) but a small number of workers practice wearing lead gloves and lead apron (11.3 % and 13.9 %, respectively) and no body wears thyroid shield or eye goggles.

Table (4) revealed that total satisfactory awareness score among HCWs is (51.3%) with no significant difference between different radiation units (54.2% in radio-diagnosis, 52.8% in radiotherapy and 31.8% in nuclear medicine departments) and the mean awareness score is 16.05 ±3.5 (out of 23). Only 18.0% of HCWs had adequate practice regarding radiation protection procedures with no significant difference between different radiation units and the mean practice score was 3.3 ±.3 out of 7.

Table (5) showed that satisfactory awareness of radiation protection procedures among exposed HCWs was highly significantly associated with higher educational level (44.2%), years of experience ≥ 10 years (36.8 %), being a physician (73.7%) and getting training courses (61.1%) but age was not significantly associated with awareness. Also, adequate practice of radiation protection procedures among exposed HCWs was highly significantly associated with higher educational level (74.3%), years of experience ≥ 10 years (68.6%), being a physician (80.0%) and getting training courses (71.4%) while age was not significantly associated with practice.

The present study also revealed non-significant correlation between awareness and practices of radiation protection procedures among HCWs in different departments; out of 95 HCWs who had satisfactory awareness, only 35 had adequate practice; with a ratio of 36.8%.

Table (1): Demographic characteristics of HCWs

	No	(%)
Age (years)		
20-30	95	48.7
31-40	60	30.8
>40	40	20.5
Mean ± SD: 35.38 ± 8.5 Range (years): 23-56		
Educational level:		
- Diploma	35	17.9
- Bachelor	115	59
- Higher educational degree	45	23.1
Occupation:		

	No	(%)
Age (years)		
- Physician	105	53.9
- Nurse	57	29.2
- Physicist and technicians	33	16.9
Years of experience:		
- (< 5 years)	90	46.2
- (5-10 years)	63	32.3
- (> 10 years)	42	21.5
Training courses on radiation safety:		
- Yes	65	33.3
- No	130	66.7

Table (2): Awareness of health care workers about radiation protection procedures (No =195)

Radiation protection awareness	Yes		No	
	No	%	No	%
Are you familiar with radioactive materials half-life (T1/2)?	121	62.1	74	37.9
Do you know the term ALARA?	92	47.2	103	52.8
Do you know what TLD badge or pocket dosimeter is?	164	84.1	31	15.9
Are you familiar with Geiger-Muller survey meter?	96	49.2	99	50.8
Do you know how to decontaminate radioactive spills?	113	57.9	82	42.1
Are you familiar with the term radiation safety officer (RSO)?	175	89.7	20	10.3
Are you familiar with the 10 days rule concept?	65	33.3	130	66.7
Are you familiar with the following terms? Time,				
Distance	142	72.8	53	27.2
Shielding	160	82.1	35	17.9
	163	83.6	32	16.4
Do the radiation departments make sure that all HCWs wear TLD?	55	28.2	140	71.8
If one of the female of HCWs gets pregnant; will she be transferred to another department?	194	99.5	1	0.5
Do you have an idea about different radiation risks which you are exposed to at the workplace? Example				
	85	43.6	110	56.4
-Acute radiation sickness such as nausea and vomiting	102	52.3	93	47.7
-Skin injuries: erythema, skin pigmentation, hair loss and desquamation				

Radiation protection awareness	Yes		No	
	No	%	No	%
-Bone marrow depression	123	63.1	72	36.1
-Cataract of the eye lens	78	40.0	121	60.0
-Infertility in men and women	183	93.9	12	6.1
-Cancers such as leukemia	112	57.4	83	42.6
Do you have an idea about different personal protective tools which help to reduce radiation exposure? Example				
- Lead apron	160	82.1	35	17.9
- Lead gloves	98	50.3	97	49.7
- Eye goggles	69	35.4	126	64.6
- Gonad shields	72	36.9	123	63.1
- Thyroid shield	55	28.2	140	71.8

T1/2= Physical half-life TLD=Thermo-Luminescent Detector
RSO=Radiation Safety Officer ALARA: As Low As Reasonably Achievable.

Table (3): Safety practices of workers occupationally-exposed to ionizing radiation

Safe practices of HCWs	Yes (1)		NO (0)	
	No	%	No	%
Do you wear lead apron?	27	13.9	168	86.1
Do you wear lead gloves?	22	11.3	173	88.7
Do you wear thyroid shield?	0	0.0	195	100.0
Do you wear eye goggles?	0	0.0	195	100.0
Do you use minimal procedure time?	123	63.1	72	36.9
Do you keep enough distance from radiation source?	145	74.4	50	25.6
Do you always wear personal dosimeter during work?	67	34.4	128	65.6

Table (4): Level of awareness and practices of radiation protection procedures among exposed workers in the three radiation units

Items	Radio-diagnosis Department (120)		Radiotherapy Department (53)		Nuclear medicine Unit (22)		p-value
	No	%	No	%	No	%	
Awareness							
Awareness Grade	[Mean awareness score 16.05 ±3.5 (out of 23)]						
Unsatisfactory (95) (48.7%)	55	45.8	25	47.2	15	68.2	χ^2=3.8 0.15
Satisfactory (100) (51.3 %)	65	54.2	28	52.8	7	31.8	

Items	Radio-diagnosis Department (120)		Radiotherapy Department (53)		Nuclear medicine Unit (22)		p-value
	No	%	No	%	No	%	
Practice							
Practice grade	[Mean practice score 3.3 ±.3 (out of 7)]						
In-adequate (160) (82.0%)	100	83.3	43	81.1	17	77.3	χ^2= 0.5 0.8
Adequate (35) (18.0)%	20	16.7	10	18.9	5	22.7	

Table (5): Association between radiation awareness and practices of exposed workers and demographic variables

Demographic variables	Awareness				Practice			
	Satisfactory (95)		Unsatisfactory (100)		Adequate (35)		In adequate (160)	
	No	%	No	%	No	%	No	%
Age (years):								
20-30 (95)	50	52.6	45	45.0	18	51.4	77	48.1
31-40 (60)	25	26.3	35	35.0	10	28.6	50	31.3
>40 (40)	20	21.1	20	20.0	7	20.0	33	20.6
	χ^2 =1.8 p- value = 0 .4				χ^2 = .14 p- value = 0 .9			
Educational level:								
- Diploma (35)	15	15.8	20	20.0	3	8.6	32	20.0
- Bachelor (115)	38	40.0	77	77.0	6	17.1	109	68.1
- Higher educational degree (45)	42	44.2	3	3.0	26	74.3	19	11.9
	χ2= 47.6 p- value= 0.0000*				χ2= 63.2 p- value= 0.0000*			
Years of experience:								
≤ 5 years (90)	30	31.6	60	60.0	5	14.3	85	53.1
5-10 years (63)	30	31.6	33	33.0	6	17.1	57	35.6
≥ 10 years (42)	35	36.8	7	7.0	24	68.6	18	11.25
	χ28.7=2 p- value= 0.0000*				χ2= 56.2 p- value= 0.0000*			
Occupation:								
- Physician (105)	70	73.7	35	35.0	28	80.0	77	48.1
- Nurse (57)	15	15.8	42	42.0	4	11.4	53	33.1
- Physicists and Technicians (33)	10	10.5	23	23.0	3	8.6	30	18.8
	χ2= 29.5 p- value= 0.0000*				χ2= 11.8 p- value=.002*			

Demographic variables	Awareness				Practice			
	Satisfactory (95)		Unsatisfactory (100)		Adequate (35)		In adequate (160)	
	No	%	No	%	No	%	No	%
Training courses for radiation safety:								
-Yes (65)	58	61.1	7	7.0	25	71.4	40	25.0
-NO (130)	37	38.9	93	93.0	10	28.6	120	75.0
p- Value:	$\chi 2$= 61.6 p- value= 0.0000*				$\chi 2$= 25.8 p- value= 0.0000*			

* Statistically significant

Discussion

In the present study, satisfactory awareness of ionizing radiation protection procedures among exposed workers was found in all departments (Radiology department, Clinical Oncology and Nuclear Medicine department and Nuclear Medicine Unit). Satisfactory awareness of HCWs concerning the personal radiation exposure measuring devices (TLD) and the safety precautions regarding time distance and shielding was reported. Female HCWs in the three departments showed excellent awareness regarding precautions taken in case of pregnancy. The study also showed satisfactory awareness concerning radiation exposure hazards mainly infertility and also awareness of the different radiation protective tools specially the apron (Table 2).

This good awareness regarding these points may be because of the well-known radiation exposure hazards, the effect on the reproductive state, and the genetic mutations. The low awareness, in the present study, concerning the 10 day rule (Table 2), may be owed to its not being exactly known by the name in spite of its application. In addition, pregnancy blood test is requested as a mandatory test before any procedure in Nuclear Medicine and Radiotherapy departments to exclude pregnancy.

Concerning the unsatisfactory awareness of cataract as a hazard (Table 2), may be because it is an uncommonly seen complication. In addition, eye goggles, like other protective shields as thyroid and gonads' shields, are not available in the investigated departments, hence the low awareness level. The shortage in the supply of personal dosimeters (TLD) and small number of HCWs using them, explains the low awareness level. Satisfactory awareness of radiation protection procedures of exposed workers in this study was highly significantly affected by higher educational level, years of experience ≥ 10 years, being a physician and getting training courses (Table 5).

The present study was in accordance with Alzubaidi et al. (2017) [11] in their study about assessment of knowledge and attitude of nurses towards ionizing radiation during radiography in Jeddah city; who stated that the level of knowledge was significantly associated with the level of educational degree and magnitude of practical experience among workers in radiology departments .

Alotaibi et al. (2015) [10], consistent with this study, in their cross-sectional survey done to explore the awareness level of radiation risks among nurses working in Nuclear Medicine departments in Kuwait, showed that, almost all nurses were not aware of the ALARA (As Low As Reasonably Achievable) principle and they were not familiar with Geiger- Mueller counter. Most of these nurses were not able to read the dosimeter reports and they were not familiar with the terms RSO. This is found to agree with this study, which revealed a low percentage of nurses with satisfactory overall awareness level of radiation protection procedures, except for awareness of the term RSO.

Conversely, a large number of HCWs showed satisfactory awareness regarding keeping enough distance from radiation source and using minimal procedure time and hence they followed safe work practices regarding these two important safety measures(Table 2). However, there were a small number of HCWs who wore lead gloves and lead aprons and no body wore thyroid shields and eye goggles (Table 3). This unsatisfactory result may be attributed to the fact that many items of radiation protection tools are not available like thyroid shields and eye goggles. Other tools had to be replaced by new ones like lead aprons and lead gloves. Lead aprons were not always worn due to their heavy weight and also enough numbers were not available. In accordance with the present study, Bhatt (2013) [16] reported poor practice in not wearing lead aprons and personal dosimeters due to poor availability in his hospitals in Nepal.

El-Feky et al. (2017) [14] reported shortage in the personal monitoring devices in all radiology departments and found a small percentage of HCWs using them in NM departments in spite of the fact that they all received these devices. Similar to results of this study she reported inadequate practice concerning the use of some radiation protection tools like eye goggles and thyroid shields for the same reason (unavailability) in spite of their good awareness of their importance.

A study done in Sudan by Mohamed, (2015) [17] on radiation safety awareness and practice in medical facilities; found that, despite the fact that all governmental and private hospitals were provided with lead aprons, radiographers were poorly using these safety tools which is consistent with the results of the present study regarding this point regarding the use of these devices. Also, in a study in Taif, KSA by Ahmed, (2015) [18] revealed that the majority of participants used lead aprons. However about one fourth used lead gloves and gonad shields, and about one third only used thyroid shields. These results are consistent with the present study in the lack of practice; despite the fact that enough protective tools were available for them.

Awosan et al. (2016) [19] in a cross- sectional study among radiology, radiotherapy and dentistry staff, found that there was good awareness of radiation hazards among the participants but, poor radiation protection practice was noted, which is similar to the present study. An important factor that should be considered in this study is the rotation of nurses from radiological departments and their exchange with nurses from other non-radiological departments without enough training. This might have participated in the unsatisfactory overall results of this study.

However, adequate practice of radiation protection found among exposed HCWs was highly significantly associated with higher educational level, years of experience, being a physician and getting training courses (Table 5). A study done by Alavi, (2017) [20] on radiation-exposed health care workers in 16 hospitals in Tehran University of Medical Sciences, reported poor overall radiation protection awareness and radiation protection practice among participants and, unlike results of the present study, there was no relationship between practice and levels of education or service training. However, the same study found those years of experience was significantly related to practice of radiation protection which is similar to results of the present study.

Consistent with results of this study, Shabani et al. (2018) [21] found, in their study in Iran, that radiation protection practice score in the group with years of experience > 15 year was significantly higher than in the group with years of experience ≤ 15 year. Also, Reagan and Slechta (2010) [22] revealed that years of employment were significantly related to radiation protection practice. Regarding the effect of occupation on practice of radiation protection (Table 5), Abdellah et al. (2015) [23] in their study on assessment of physicians' knowledge, attitude and practices of radiation safety found inadequate practice among physicians and they found only half of the physicians were using lead gloves which was contrary to our results.

Conclusion and recommendations:

This study revealed somewhat satisfactory awareness of safety measures among HCWs (physicians, nurses, physicists, and technicians). It also revealed inadequate implementation of radiation safety measures in the workplace as well as insufficient protective practices by HCWs. These results mandate application of an assessment system to ensure better awareness level of HCWs, updated training courses, strict application of safety measures and ensure availability of all needed radiation protection tools.

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