ORIGINAL ARTICLE

Knowledge and Practice of Healthcare Workers in Diagnostic Radiology Department Towards Ionizing Radiation

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ABSTRACT

Introduction: The use of ionizing radiation in diagnostic radiography might lead to hazards such as genetic work practices on radiation protection could minimize these risks. Thus. Therefore, we conducted this study to assess the knowledge and use of radiation safety precautions among healthcare workers (HCWs) of the Diagnostic Radiology Department who are exposed to ionizing radiation in the workplace. **Methods:** This is a cross-sectional study of 93 HCWs from Egypt. Data collection was through a quasi-self-administered questionnaire and performance checklist. Safety measures in different units of the Diagnostic Radiology Department were assessed using a workplace observation checklist. **Results:** More than 90% of the study participants had good knowledge about radiation hazards, and all HCWs reported good knowledge about exposure dose and monitoring. Furthermore, 87% of participants had good knowledge of personal protective equipment (PPE), and 74.2% adequately used PPE during work. All doors and walls of Diagnostic Radiology Department units were composed of lead material, and a radiation safety officer was available. **Conclusion:** The majority of HCWs were aware of occupational health and safety measures and had good knowledge about radiation hazards. All Diagnostic Radiology Departments need to continue professional development by providing more workshops, training courses, preparation, and posters on the protection and safety toward ionizing radiation regarding the most recent regulations to improve the knowledge and performance of their staff.

Keywords: Knowledge, Practice, Healthcare workers, Ionizing radiation, Radiology

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INTRODUCTION

Use of ionizing radiation in the medical field is increasing worldwide. More than 3000 million diagnostic imaging examinations and over 5 million radiation therapy treatments are performed annually worldwide (1). Occupational health and safety require all employers to provide a safe working environment for their employees. Healthcare workers (HCWs) in radiation wards should have satisfactory knowledge regarding the risks and safety precautions of radiation exposure to protect their health and provide patients with correct data about radiation exposure (2).

Recently, there has been concern regarding radiation protection (RP) among radiographers. Adequate use of personal protective equipment (PPE) and requirements for RP can reduce excess exposure (3). The level of knowledge regarding RP affects the behavior of staff, and lack of information about this issue will result in unsafe actions leading to adverse health effects (4). Ionizing radiation may affect the gastrointestinal system, central nervous system, gonads, or even the whole body. These effects may appear as a somatic effect, or in the next generation as a genetic effect (1).

Therefore, the knowledge, attitude, and practice regarding the risks of radiation among radiographers play an effective role in RP. A previous study showed an unsatisfactory level of awareness about RP among radiographers, whereas other studies have shown the importance of awareness of the risks of radiation (3, 5). In Egypt, RP is specified in the legislative Egyptian Law No. 59/1960, according to both Ministry of Health and the Egyptian Atomic Energy Authority, which are the official authorities that regulate the accreditation and use of radiation sources. Closed sources and X-ray technologies are the responsibilities of the Ministry of Health (6). Previous Egyptian studies have reported inadequate use of safety measures and practices in most ionizing radiation facilities (6, 7).

Regarding radiation exposure during diagnostic procedures, there has been improved awareness regarding inadequate knowledge of HCW. A previous

study was done to determine the knowledge and practices of radiation safety precautions among HCW in Trinidad and found a low level of knowledge and they neglected safety practices (8). However, no study has been done among HCWs exposed to ionizing radiation at the diagnostic radiology department, in XXX university hospitals. University Therefore, this study was conducted to assess knowledge and use of radiation safety measures among them.

MATERIALS AND METHODS

Study Setting and Population

A cross-sectional study was conducted at the Diagnostic Radiology Department, Zagazig University Hospitals from February 2019 to February 2020. This study included all HCWs who were working from February 2019 to February 2020 (physicians, nurses, technicians, and physicists) and were occupationally exposed to ionizing radiation. The target population consisted of 58 physicians, 20 nurses, 15 technicians, and physicists. Inclusion criteria: All (physicians, nurses, technicians, and physicists) occupationally exposed to ionizing radiation with work experience at least one year and who accepted to participate in the study were included. Exclusion criteria: Any healthcare worker who attended less than one year in radiology departments. Any healthcare 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).

Study Tools

Questionnaire

A semi-structured questionnaire adapted from Eze et al. (9) and Awosan et al. (10) was prepared and used among HCWs to obtain information on the following:

- Sociodemographic characteristics such as age, sex, job, marital status, and duration of work.
- Knowledge about radiation health hazards, including nausea, vomiting and diarrhea, dermal effects, cataract, bone marrow suppression, sterility, teratogenicity, and cancer.
- Knowledge about radiation dose and monitoring of exposure, the thermoluminescent dosimeter (TLD), radiation exposure dose, periodicity, and periodic examinations (e.g., chest X-ray, complete blood picture [CBC], including dermal and eye examinations, and others).
- Knowledge about PPE, including eye goggles, lead apron, lead gloves, thyroid collar, and gonadal shield.

Performance checklist

A checklist adapted from Ahmed et al. (11) to assess the practice and use of PPE among HCWs. The checklist had the following items:

- Wearing TLD daily during work
- Wearing a lead apron daily during work
- Using lead gloves during work
- Using lead googles during work
- Wearing a thyroid colar during work
- Wearing a gonad shield during work
- PPE is checked for cracks

Workplace observation checklist

To check the safety measures in different units of the Diagnostic Radiology Department (X-Ray Unit, Contrast Radiology Unit, Intervention Radiology Unit, Angiography Unit, and Radioisotopes Unit) a checklist adapted from El-Feky et.al. (6) was used. The checklist had the following items:

- Doors and walls consist of isolated materials such as lead for greater protection
- Radiation Safety Officer available
- Radiation warning signs available
- Radiation warning written in local languages
- Food and drinks are prohibited in working areas
- Hands are washed before the existing work area

Pilot study

Before the start of the study, the predesigned questionnaire was tested on nine of the sample participants to explore any modifications that were required. The questionnaire was tested many times to ensure its validity and confidentiality. During each successive test, feedback was obtained to help to refine the quality of the questionnaire. Questionnaires were translated into Arabic and then back-translated into English by a different language expert. A group of bilingual professionals assessed the Arabic versions for content validity. The necessary corrections, modifications, and rewording were performed to ensure that the questions were clear and easy to understand. The internal consistency (Cronbach's alpha) was >0.70 for all questions.

Data management

The collected data were entered, checked, and statistically analyzed using the SPSS program (Statistical Package for Social Science program "version 22.0 (12). " Qualitative variables were expressed as numbers and percentages, and quantitative variables were expressed as mean ± SD. The level of significance was considered as a p-value < 0.05. Chi-square and t-test were used to test the association between variables.

Scoring system of the frequency of knowledge of radiation health hazards, radiation dose and monitoring of exposure, and PPE was as follows: participants were deemed to have inadequate knowledge if they answered <50% for each section, and adequate knowledge if they answered ≥50% for each section.

The scoring system used for the total knowledge was as follows: of the 19 questions for all sections, participants were deemed to have inadequate knowledge if they answered <9 (<50%), and adequate knowledge if they

answered ≥9 (≥50%).

The scoring system used for the total practice was as follows: of the seven practices, participants were deemed to have inadequate practice if they performed <3 (<50%) correctly, and adequate practice if they performed ≥3 (≥50%) correctly.

Ethical approval

The questionnaire and methodology for this study were approved by the Human Research Ethics committee of the Faculty of Medicine Zagazig University (#4209/18-2-2018). A formal letter from the hospital manager was taken to get their permission to collect data from the hospital. Informed consent was obtained from all participants after explaining the aim of the study and that the data would be for scientific purposes. Privacy and confidentiality were respected and the study was performed according to the Declaration of Helsinki.

RESULTS

Some socio-demographic and occupational data of the participants

Our study showed that the mean ± SD age of the studied group was 35 ± 6.9 years. The majority of them were females, doctors, and married (54.8%, 62.4%, and 71% respectively). The mean ± SD of the duration of work was 12.39 ± 6.16 years (Table I).

Knowledge of ionizing radiation hazards among the participants

All of the participants reported that sterility, teratogenic, and cancer were the most common health hazards of ionizing radiation, and >90% of them had adequate knowledge regarding ionizing radiation health hazards (Table II).

Table I: Some socio-demographic and occupational data among the studied group

Item	N (93)	%
Sex:		
Male	42	45.2
Female	51	54.8
Occupation:		
Doctor	58	62.4
Nurse	20	21.5
Technician	15	16.1
Marital status:		
Single	15	16.1
Married	66	71
Divorced	6	6.5
Widow	6	6.5
Age (years):		
Mean ± SD	35 ± 6.9	
Range	24-55	
Duration of work (years):		
Mean ± SD	12.39 ± 6.16	
Range	5-30	

Table II: Knowledge of ionizing radiation hazards among the studied group

Item	N (93)	%
Nausea, Vomiting & Diarrhea (NVD):		
No	78	83.9
Yes	15	16.1
Dermal effects:		
No	54	58.1
Yes	39	41.9
Cataract:		
No	36	38.7
Yes	57	61.3
BM suppression:		
No	6	6.5
Yes	87	93.5
Sterility:		
No	0	0
Yes	93	100
Teratogenic:		
No	0	0
Yes	93	100
Cancer:		
No	0	0
Yes	93	100
Total hazards knowledge:		
Inadequate	6	6.5
Adequate	87	93.5

Knowledge of the exposure dose, monitoring exposure, and PPE among the participants

All of the HCWs reported adequate knowledge about exposure dose and monitoring the exposure using different periodic examinations (Table III). All of the participants stated that lead aprons and lead gloves were the most common form of PPE, and >85% of them had adequate knowledge regarding ionizing radiation PPE (Table III).

Workplace observation checklist in the Diagnostic Radiology Department

The doors and walls were comprised of a lead material in all Diagnostic Radiology units, and a radiation safety officer is available (Table IV).

Performance checklist among the participants

The majority (90.3%) of HCWs wore lead gloves during work and none of them wore gonad shields during work. Approximately 75% of the HCWs had adequate personal practice (Table V).

Association between knowledge and practice and sociodemographic and occupational factors

Satisfactory knowledge of RP procedures among exposed workers was highly significantly associated with being a physician (69.1%), increased with work experience, but age was not significantly associated with knowledge. Adequate practice of RP procedures among exposed workers was highly significantly associated with being a physician (78.3%), and increased with age and work experience (Table VI).

Table III: Knowledge of exposure dose, monitoring the exposure, and personal protective equipment (PPE) among the studied group

Item	N (93)	%
Knowledge of use of trans-luminescent dosimeter (TLD):		
No	0	0
Yes	93	100
Knowledge of exposure dose:		
No	36	41.9
Yes	57	58.1
Knowledge of periodic examination every 6 months:		
No	0	0
Yes	93	100
Knowledge of periodic examinations: Chest X-ray		
No	81	87.1
Yes	12	12.9
CBC:		
N0	0	0
Yes	93	100
Others: dermal, eye examination:		
No	42	45.2
Yes	51	54.8
Total examination knowledge:		
Inadequate	0	0
Adequate	93	100
Eye googles		
No	18	19.4
Yes	75	80.6
Lead apron		
No	0	0
Yes	93	100
Lead gloves		
No	0	0
Yes	93	100
Thyroid cola		
No	66	71
Yes	27	29
Gonadal shield		
No	66	71
Yes	27	29
Total PPE knowledge:		
Inadequate	12	12.9
Adequate	81	87.1

Table IV: Workplace observation check list in Diagnostic radiology departments

Item	X-ray unit	Contrast radiology unit	Intervention radiology unit	Angiography unit	Radioisotopes unit
Doors and walls consist of lead material	Yes	Yes	Yes	Yes	Yes
Radiation safety officer available	Yes	Yes	Yes	Yes	Yes
Radiation warning signs available	Yes	Yes	Yes	No	Yes
Radiation warning written in local languages	Yes	Yes	No	No	Yes
Food and drinks are prohibited in working areas	No	No	Yes	Yes	Yes
Hands are washed before existing work area	No	Yes	Yes	No	Yes

Table V: performance check list among the studied group

Item	N (93)	%
Wearing TLD daily during work	72	77.4
Wearing lead apron during work	72	77.4
Using lead gloves during work	84	90.3
Using lead goggles during work	36	38.7
Wearing thyroid collar during work	42	45.2
Wearing gonad shield during work	0	0
Personal protective equipment (PPE) are checked for cracks	72	77.4
Total Personal practice:		
Inadequate	24	25.8
Adequate	69	74.2

Table VI: Association between knowledge and practices and some sociodemographic and occupational factors

Demographic variable	Knowledge				Practice			
	Satisfactory (81)		Unsatisfactory (12)		Adequate (69)		Inadequate (24)	
Occupation:	N	%	N	%	N	%	N	%
Doctor (58)	56	69.1	2	16.7	54	78.3	4	16.7
Nurse (20)	16	19.8	4	33.3	8	11.6	12	50
Technician (15)	9	11.1	6	50	7	10.1	8	33.3
P-value	χ^2 =15.3		**0 .000***		χ^2 =28.9		**0 .000***	
Age (years): Mean ± SD	35± 6.9		32 ± 4.3		36 ± 5.4		33 ± 4.6	
P-value	t =-1.5		0 .147		t =-2.4		**0 .018***	
Duration of work (years): Mean ± SD	12.4 ± 4. 6		9 ± 2.6		13.6 ± 3.3		7.5 ± 2.2	
P-value	t =-2.5		**0 .014***		t =-8.4		**0 .000***	

DISCUSSION

Regarding the knowledge of ionizing radiation hazards, we found that all of the HCWs reported that sterility, teratogenic effects, and cancer were the most common health hazards of ionizing radiation exposure, and the majority had adequate knowledge. These results are in agreement with the study of Briggs-Kamara et al. (13), which reported an adequate level of knowledge among radiographers regarding knowledge of the hazardous effects of ionizing radiation in Nigeria. Furthermore, Awosan et al. (10) found that a large proportion (59.1%) of the participants in their study demonstrated good knowledge of radiation hazards. The adequate knowledge of HCWs could be attributed to their training regarding radiation hazards.

Our findings were in contrast with those reported by Alzubaidi et al. (14), which found that the risk of cancer and death were underrated among the majority of nurses. Moreover, in their study the majority of the nurses were found to have adequate knowledge regarding the symptoms of acute radiation sickness, skin injuries, bone marrow depression, eye cataracts, and infertility hazards. Another study conducted by Morishima et al. (15) reported that the awareness of nurses regarding

radiation safety and hazards was inadequate.

The International Commission on Radiological Protection (ICRP) recommends that the annual occupational exposure dose limit to ionizing radiation should not exceed 20 mSv. Therefore, the use of personal dosimeters is mandatory to measure the amount of radiation received by HCWs (16).

The current study also showed that all HCWs reported knowledge on TLDs, periodicity of examinations, and CBC as a periodic examination. Moreover, all of the HCWs had adequate knowledge regarding exposure dose and its monitoring. The results of this study followed the study of D'souza et al. (2), which reported that the majority of the respondents had awareness of wearing the radiation safety badge, the typical dose level, and periodic health checkup for staff. Furthermore, Ahmed et al. (11) observed that 74.7% of their participants knew the annual limitation dose for individuals, and 98.7% of the staff had periodical radiation dose check from their TLDs.

According to Awosan et al. (10), awareness of the dosimeter as the device used for measuring radiation exposure was high among the participants; however, <30.0% knew the threshold of the effective dose of ionizing radiation for a radiation worker. This was of serious concern because they could develop a positive attitude toward radiation safety challenges at work. Moreover, a study conducted among specialist HCWs found poor knowledge of radiation dose emitted during most radiological procedures and the associated risk to both themselves and their patients (17).

PPE is a basic preventative measure, and should always be worn during radiographic procedures to promote the level of RP. This RP comprises lead aprons, lead eye goggles, lead gloves, gonad shields, and thyroid shields. Regular use of lead aprons provides an average of 75%–80% protection of the bone marrow. Moreover, lead shielding is one of the primary protective measures to reduce unnecessary exposure (18).

In this study, all of the participants stated that a lead apron and lead gloves were the most common form of PPE according to their knowledge, and ~87% of them had adequate knowledge regarding ionizing radiation PPE. Moreover, 90.3% of HCWs wore lead gloves, 77.4% wore a lead apron, and none of them wore gonad shields during work. We found that 74.2% of the HCWs had adequate personal practice.

Our results are supported by the study of Ahmed et al. (11), which reported that 72% of the participants wore a lead apron during work, whereas 28% did not; among HCWs who did not, their reasons for not doing so included lack of lead aprons in their department and the heaviness of the apron. The study by Fatahi et al. (3) also revealed a shortage of lead aprons (29%) and a low level of use even when available.

In agreement with this study, El-Feky et al. (6) revealed that the lead aprons were present in 72.7%, 50%, and 100% of Diagnostic Radiology (DR) departments, Radiotherapy (RT) departments, and Nuclear Medicine (NM) units, respectively. However, only 39.7%, 35.1%, and 53.7% of HCWs in DR, NM, and RT departments used lead aprons, respectively. Moreover, there was a low availability of other personal protective clothing and equipment, and a significant percentage of staff in other working categories did not use eye goggles, thyroid shields, and protective lead gloves. The HCWs justified their poor practice by stating that they preferred to follow the position–distance rule.

Our findings were also in agreement with those reported by Salama et al. (19) (in Saudi Arabia), who found that although many hospitals had lead aprons and thyroid shields, only about half of them had lead eye goggles and lead shields. However, the majority (99%) of medical staff used lead aprons, 37% used lead glasses, and 42% used thyroid shields. Furthermore, Ahmed et al. (11) reported that 72% of the participants used lead aprons, 22.7% used lead gloves, 25.3% used gonad shields, and 36% used thyroid shields.

Our results were also supported by those of Abdellah et al. (7), who reported that physicians used lead aprons more than other personal protective clothes and equipment, and 52.5% of physicians used lead gloves. Moreover, Sharma et al. (4) revealed that lead aprons and thyroid shields were the most common forms of PPE used, whereas A woman et al. (10) reported that 75.5% of HCWs wore at least one type of personal protective device at work. Luntsi et al. (20) reported that almost all of the included participants used lead aprons (93% and 84.5%, respectively) to protect themselves during exposure to radiation.

However, Elamin (21) found that despite the fact that all government and private hospitals are provided with lead aprons, the radiographers did not always use them. Furthermore, Eze et al. (9) and Bhatt et al. (22) reported insufficient availability of lead aprons. In contrast to our study, a study conducted by Noohi (23) in Iran found that the use of gonads shield among participants was as high as 83.1%.

Protection principles of time, distance, and shielding actions minimize radiation exposure. Decreasing the exposure time decreases the dose from the radiation devices. As for distance control, the distance from the source of ionizing radiation devices has to be increased. Shielding barriers comprising lead and concrete protects radiographers from ionizing radiation hazards. Moreover, the ICRP and Radiation Protection Guidance for Hospital Staff recommended the use of a warning

sign above the radiography room entrance (18).

Our results showed that the doors and walls of all DR Department units were made of lead, and there was a radiation safety officer available. Moreover, almost all of the DR Department units had radiation warning signs. Our results are supported by the study of Swanson and Jim (24), which showed that all of the Radiology Departments had warning posters, and both visible and audible warning signs; however, only X-ray labels were used in X-ray rooms, and not standardized warning posters. According to El-Feky et al. (6), caution signs were only present in about half of the DR and RT departments, whereas all units in NM had visible caution signs. Moreover, no automatic audible warning devices were present in DR departments, whereas around half of the RT departments and NM units had these warning devices. Farzaneh et al. (25) and Rostamzadeh et al. (26) reported that these signs were used in most diagnostic imaging centers.

Our results did not coincide with the study of Elamin (21), which revealed that none of the selected settings used radiation warning posters and audible warning signals. Furthermore, El-Hady et al. (27) reported low availability of radiation warning signs, whereas Tamjidi (28) showed that the majority of the studied hospitals did not have adequate warning signs.

El-Feky et al. (6) also reported inadequate shielding of the lead lining of walls and doors in 54.4% of DR and 50% of RT departments; however, the two NM units had good structural shielding and appropriate enclosures. Moreover, Farzaneh et al. (25) reported that only 10% of the entrance doors of the RT rooms in the Radiology Centers in Iran have lead shields.

Our results showed that satisfactory knowledge of RP procedures among exposed workers was highly significantly associated with being a physician (69.1%), and that knowledge increased with work experience; however, age was not significantly associated with knowledge. Moreover, the adequate practice of RP procedures among exposed workers was highly significantly associated with being a physician (78.3%), and it increased with both age and work experience. These results are in agreement with those of Alzubaidi et al. (14), wherein the knowledge and attitude of nurses toward ionizing radiation during radiography in Jeddah city was assessed. The results demonstrated that the level of knowledge was significantly associated with the level of educational degree and the magnitude of practical experience among workers in Radiology Departments. Moreover, Shabani et al. (29) found, in their study in Iran that the RP practice score in the group with >15 years of experience was significantly higher than that in the group with ≤15 years of experience. In addition, Reagan and Slechta (30) revealed that the number of years of employment was significantly related to RP practice. Furthermore, Alavi et al., (31) found that the number of years of experience was significantly related to the practice of RP, which was similar to the results of the present study.

The strengths of this study is it included all HCWs who work or come in contact with the DR Department. This study evaluated the knowledge and practice of individuals relating to radiation hazards and safety measures. Our results demonstrated the need to provide further training courses on ionizing radiation in their regular curriculum of medical staff training.

The limitations of this study include difficulty for the HCWs to complete the questionnaire during the time scheduled due to the stressful work shifts. Furthermore, the lack of similar Egyptian studies among HCWs made it difficult to compare our results with others.

The implications for future practice and research from this study are since the majority of HCWs in our study had poor knowledge about other periodic medical examinations that were required aside from CBC, as well as the importance of wearing a gonadal shield as a component of regular PPE. Therefore, we recommend that these HCWs are given the opportunity to undertake regular training programs. We also recommend that the administrative authority should provide gonadal shields and ensure other periodic examinations, such as examination of the eyes and skin, are performed along with CBC.

CONCLUSION

This study on the awareness of occupational health and safety among HCWs in the DR department revealed that most of the occupational health and safety precautions were present in the department. Majority of HCWs were aware of the occupational health and safety measures and had good knowledge about radiation hazards. Regular job rotation and introductory seminars on radiation safety before HCWs start working with radiation is essential to ensure compliance of HCWs with safety regulations relating to ionizing radiation. HCWs also require continuous education and updates on radiation safety. In addition, we recommend the provision of more high-quality PPE for all HCWs to increase control of ionizing radiation hazards.

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