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Research Article
Knowledge and Adherence to Radiation Protection among Healthcare Workers at Operation Theater

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Abstract

Background and Objective: Diagnostic radiology technology is used to obtain a high-quality image for the patients during surgeries at Operation theater (OT). It is important to ensure low radiation dose by applying the radiation protection and safety principles to the healthcare team. Hence, the aim of this study was to assess the knowledge towards radiation protection and adherence to radiation safety measurements among healthcare workers who employ ionizing radiation in the operating theater. **Materials and Methods:** A cross-sectional study targeted healthcare workers; physicians, nurses and anesthesia technologists working in the operating suite that were exposed to radiation during procedures. The survey asked participants to measure their knowledge and adherence to radiation protection during their presences or practice of radiology procedures. **Results:** The overall mean adherence score was 4.08±1.33 and the overall mean knowledge score was 3.24±0.97 and the two scores revealed a significant positive correlation ($r = 0.226$, $p = 0.035$). The technologists and males showed higher adherence score. Physicians and females showed insignificantly higher knowledge score. Physicians illustrated significantly ($p = 0.006$) higher percentage concerning ensuring a minimum of 1-2 m distance from radiation source during procedures, followed by the technologists (78.6%) and nursing (60%). While there was no association between knowledge and occupation. On the other hand, males were significantly ($p = 0.032$) more likely to wear TLD (97.2%) and lead apron (97.2%) during procedures as compared to females (82.4 and 80.4, respectively). **Conclusion:** Similar to adherence, there was no association between knowledge and sex. Healthcare workers showed good adherence to radiation safety measurements, with less knowledge towards radiation protection. However, there was a positive correlation between adherence and knowledge scores. Adherence was dependent on the health profession and sex while knowledge was independent of both. There is a need to increase knowledge and awareness toward the adherence to the radiation protection guidelines.

Key words: Radiation dose awareness, radiation protection, Ionizing radiation, radiation safety, radiation knowledge, diagnostic radiology, healthcare workers

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Advanced imaging technologies and techniques allowed surgeons to perform complex diagnostic, interventional procedures using C-arm fluoroscopy machine. Healthcare workers in the operating theater are exposed to ionizing radiation during surgical procedures especially in orthopedics, urology, neuro-spine and cardiothoracic surgeries. The high number of performed procedures involving the use of radiation increased dramatically in the last decade[1].

The radiation risks for healthcare workers and patients include immediate and late effects such as cataracts, congenital fetus anomalies, bone marrow suppression, genetic mutations and carcinogenesis. In addition, patients could sustain skin and underlying tissue injuries. Healthcare workers at operating Theater should ensure as low as reasonably achievable (ALARA) principle to protect themselves and the patients from unnecessary radiation dose[2].

All health professionals who are exposed to ionizing radiation must adhere to the radiation protection guidelines when they request and attend radiology procedures. This includes physicians, nurses and anesthesia technologists working at the emergency department and operating theater. All these individuals are considered radiation workers and required monitoring system to ensure their occupational dose within the acceptable limits. Personnel dosimeters such as thermoluminescence dosimeter (TLD) should be used to monitor the occupational radiation dose[3]. The level of awareness towards radiation protections influences the reaction and behavior of the workers, as their actions can be unsafe and lead to adverse results if they have low awareness level[4-8]. Knowledge about the biological effects and radiation safety be evaluated and ultimately improved upon to ensure the prevention of potential hazardous consequences among healthcare workers.

Radiation protection policy and guidelines should be prepared and followed strictly to monitor radiation exposure during operating theater procedures. The radiation exposure reduced by 50% for the healthcare workers who use lead aprons and thyroid shields during procedures. Various techniques such as increase filtration, higher tube voltage, lower tube current and minimum of three feet distant from the radiation sources can reduce radiation dose[9].

Adequate training and education of using the necessary equipment and tools should be provided to the personnel appropriate to their jobs[10-12]. Radiation safety and protection educational programs should be conducted to improve knowledge and awareness of healthcare workers in operation Theater. Although there are multiple studies investigated radiation protection knowledge and practice among radiology workers, there are minimal studies investigated the adherence of medical workers in the operating theater and needs for further studies is prominent. Studying the healthcare worker knowledge and practice across the different working area lead to an adequate understanding of the level of practice and awareness aspects of the context[13-15].

Investigation of healthcare worker practices provided quantitative data about the practices and described the factors affecting influencing it ranging from socio-cultural to environmental, economic and structural factors. Although there was an assumption that the results of knowledge and practice studies could be generalized, it is still important to conduct national studies taking into consideration the socio-demographic, educational and experiences factors[16].

Moreover, studying the knowledge and adherence to the optimum practice are the corner stones for optimization and justification in radiation protection[17].

The aim of this study was to assess the knowledge towards radiation protection and adherence to radiation safety measurements among healthcare workers who employ ionizing radiation in the operating theater.

MATERIALS AND METHODS

A cross-sectional study targeted the healthcare workers; physicians, nurses and anesthesia technologists working in the operating suite that were exposed to radiation during procedures. A self-administrated questionnaire and consent form send to the eligible healthcare workers asked them to fill it and give it back within one week. A reminder was sent to the participants to improve the response rate.

The questionnaire developed based on the current scientific evidence about the radiation protection knowledge and practice among healthcare professionals. The draft questionnaire piloted by four expert panels "two medical physicists, a radiologist and an operation theater senior nursing staff" to ensure the validity and reliability of its contents. The panel asked to specify questions, necessity, understandability and whether or not it is applicable to the work.

The questionnaire comprised of three sections: (a) Demographic section including age, experience and job and (b) Knowledge section consists of questions examine the participants knowledge of annual dose limits, ALARA principle and radiation protection training and (c) Personnel's adherence to radiation protection comprising of questions examining the adherence of the participants towards radiation protection during practice.

The participant had to agree in the participation of the study by signing the informed consent form, which clarified the study objectives and approved their participation. The consent form assured that their involvement would be strictly confidential and they were free to withdraw at any point of the study. Ethical approval obtained from the Research Ethics Committee at the Institution and Ministry of Health and Prevention before the study was initiated "MOHAP/DXB/SUBC/No.27/2017".

Statistical analysis: The data was analyzed using SPSS version 19, Chicago, USA. When comparing the mean scores of knowledge and adherence among different health professions, one-way analysis of variance (ANOVA) used. While comparing the mean scores of knowledge and adherence between males and females, independent t-test was applied. The correlation between the knowledge and adherence scores were tested by Pearson correlation coefficient. For the associations between participants 'profession and sex and knowledge and adherence were tested using Chi-square test. The $p<0.05$ were considered statistically significant. A scale was set according to the mean score as (4-5) excellent, (3-4) good, (2-3) fair, (0-1) poor knowledge and adherence.

RESULTS

The data in Table 1 showed the general characteristics of the participants. There were 41.4% (36) males and 58.6% (51) females. The majority were nurses 57.5% (50) followed by physicians 26.4% (23) and only 16.1% (14) were technologists. The mean age of the participants was 35.2±8.9 years with a mean of 11.47±7.44 years of experience. The overall mean adherence score was 4.08±1.33, while the overall mean knowledge score was 3.24±0.97 and the two scores revealed a significant positive correlation ($r = 0.226$, $p = 0.035$). The data in Table 2 showed that technologists had higher adherence score (4.5±1.0) compared to that of nurses (3.7±1.5) and physicians (3.65±0.64) with a significant ($p<0.05$) difference only between the last two occupations. On the other hand, males showed significantly higher adherence score than females (4.52±0.9 vs. 3.76±1.49; $p = 0.08$). There were no significant difference in the knowledge score neither among the three professions nor between males and females.

The data in Table 3 illustrated that 95.7% (22) of the physicians were significantly ($p = 0.06$) adherent to the guidelines of ensuring a minimum of 1-2 m distance from the radiation source during procedures, compared 78.6% (11) of the technologists and 60% (30) of the nurses. Item analysis of the knowledge does not reveal any difference between the three professions.

The results in Table 4 revealed that the majority of males were significantly ($p<0.05$) adherent to the guidelines as compared to the females. About 97.2% (35) of the males were wearing TLD and 97.2% (35) lead apron and 86.1% (31) were ensuring a minimum of 1-2 m distance from the radiation source during procedure compared to 82.4 (42), 80.4 (41) and 62.7% (32) in females respectively.

DISCUSSION

The use of radiation during procedures in the operating theater becomes necessary to guide and confirm the location and placement of the surgical instrumentations used during surgical procedures as well as documentation the surgical procedures[18]. Healthcare professionals who participate in the procedures are exposed to a significant amount of radiation because of large series of images obtained during the procedures. Therefore, the International Commission of Radiological Protection (ICRP) recommended dose monitoring system such as TLD and radiation dose limits for operating theater staff. The radiation dose should not exceed 20 mSv/year (actually 100 mSv in 5 years-not exceeding 50 mSv in any one year[19]. Studies showed the orthopedic surgeon approximate dose during hip procedures is 5 μSv with screening time 25 sec/patient and can be up to 250 μSv with 10 min screening time per patient during Kyphoplasty[20].

Table 1: General characteristics of the participants (N = 87)

Characteristics	N (%)
Age (year)	35.20±8.9*
Experience (year)	11.47±7.44*
Gender	
Males	41.4 (36)
Females	58.6 (51)
Occupation	
Physicians	26.4 (23)
Nursing	57.5 (50)
Technologists	16.1 (14)

*Mean±standard deviation

Table 2: Comparisons of the adherence and knowledge scores according to occupation and sex

	Occupation			Sex		
	Physicians	Nursing	Technologists	Males	Females	p-value
Adherence score	3.65±0.64[a]	3.7±1.5[b]	4.50±1.0	4.52±0.9	3.76±1.49	0.008
Knowledge score	3.43±0.7	3.3±0.95	2.71±1.2	3.19±0.98	3.27±0.98	0.7

a, b indicate there is a significant difference in the adherence score between physicians and nurses ($p<0.05$)

Table 3: Association of the adherence and knowledge with the profession using chi-square test

	Occupation (%) (N)				
	Physicians	Nurses	Technologists	p-value	Total % (N)
Adherence					
Wearing TLD during procedures					
Yes	95.7 (22)	84 (42)	92.9 (13)	0.3	88.5 (77)
No	4.3 (1)	16 (8)	7.1 (1)		11.5 (10)
Wearing lead apron during procedure					
Yes	95.7 (22)	80 (40)	100 (14)	0.1	87.4 (76)
No	4.3 (1)	20 (10)	0 (0)		12.6 (11)
Wearing thyroid collar during procedures					
Yes	82.6 (19)	70 (35)	92.9 (13)	0.2	77 (67)
No	17.4 (4)	30 (15)	7.1 (1)		23 (20)
Ensure a minimum of 1-2 m distance from radiation source during procedures					
Yes	95.7 (22)	60 (30)	78.6 (11)	0.006	72.4 (63)
No	4.3 (1)	40 (20)	21.4 (3)		27.6 (24)
Adherent to radiation protection guidelines and procedures					
Yes	95.7 (22)	76 (38)	85.7 (12)	0.1	83 (72)
No	4.3 (1)	24 (12)	14.3 (2)		17 (15)
Knowledge					
Track personal occupational dose reports					
Yes	91.3 (21)	76 (38)	85.7 (12)	0.3	81.6 (71)
No	8.7 (2)	24 (12)	14.3 (2)		18.4 (16)
Do you know the occupational annual dose limits					
Yes	91.3 (21)	90 (45)	78.6 (11)	0.4	88.5 (77)
No	8.7 (2)	10 (5)	21.4 (3)		11.5 (10)
Are you aware of ALARA principle					
Yes	87 (20)	82 (41)	57.1 (8)	0.1	79 (69)
No	13 (3)	18 (9)	42.9 (6)		21 (18)
Did you get radiation protection training employment					
Yes	73.9 (17)	82 (41)	50 (7)	0.1	74.7 (65)
No	26.1 (6)	18 (9)	50 (7)		25.3 (22)

The use of fluoroscopic imaging during surgical procedures mandatory during orthopedic trauma surgeries and non-trauma corrective procedures such as joint replacements and pediatric bone and joints alignments. Many interventional procedures in urology "retrograde pyelography and percutaneous nephrolithotomy," abdomen "cholangiogram,"neurospinal surgery "discectomy and fusion, fixation" and interventional angiography require the use of fluoroscopic imaging during the procedures[9,18,21-24].

This study investigated the knowledge and adherence of healthcare professionals working in the operating theater towards radiation protection, occupational radiation dose and practice.

The results showed that 74.7% of the participants received radiation protection training after employment compared to 11.2% in Egypt (16), 55-82% in Europe[13,25]. According to the current study, 87.4% of the participants use the lead apron and 77% use the thyroid collar during procedure compared to 62.5% in Egypt[16], 99% by Friedman *et al.*[13]. The wearing of a thyroid collar during procedures were reported by 77% of the participants, whereas Friedman *et al.*[13] suggested 73% usage of thyroid collars. The majority of the participants (88.5%) reported that they wear their personal dosimeter "TLD" regularly during their radiation practice. These results were higher than Söylemez *et al.*[26] in Turkey, which stated that more than 70% did not use TLDs.

The mean score of knowledge in this study was 3.43±0.7, 3.3±0.95 and 2.71±1.2 for physicians, nurses and technologist respectively. Overall, the study participants were classified into "good to excellent knowledge" levels. In Egypt, the mean participant's knowledge was 56.5+15.2 and 76% classified as poor knowledge, 23.7 were fair to good knowledge. In Australia, the doctors mean knowledge was 40% of the radiation exposure to the patients[27]. Soylemez *et al.*[25] noted that participants had a low level of knowledge and approximately half of the participant had no idea that radiation has a fatal cancer risk. The current study stated a significantly higher level of adherence in the workers with high work experience. Shima *et al.*[24] compared the knowledge and practice with the experience and found the same result. Overall, participants knowledge about using of ionizing radiation were similar or higher than those reported in previous similar studies confirming that previous education received has a significant relationship with the current practice[16,28].

Table 4: Association of the adherence and knowledge with the sex using chi-square test

	Sex		
	Males	Females	p-value
Adherence			
Wearing TLD during procedures			
Yes	97.2 (35)	82.4 (42)	0.032
No	2.8 (1)	17.6 (9)	
Wearing lead apron during procedure			
Yes	97.2 (35)	80.4 (41)	0.02
No	2.8 (1)	19.6 (10)	
Wearing thyroid collar during procedures			
Yes	80.6 (29)	74.5 (38)	0.5
No	19.4 (7)	25.5 (13)	
Ensure a minimum of 1-2 m distance from radiation source during procedures			
Yes	86.1 (31)	62.7 (32)	0.02
No	13.9 (5)	37.3 (19)	
Adherent to radiation protection guidelines and procedures			
Yes	91.7 (33)	76.5 (39)	0.1
No	8.3 (3)	23.5 (12)	
Knowledge			
Track personal occupational dose reports			
Yes	86.1 (31)	78.4 (40)	0.4
No	13.9 (5)	21.6 (11)	
Do you know the occupational annual dose limits			
Yes	88.9 (32)	88.2 (45)	0.9
No	11.1 (4)	11.8 (6)	
Are you aware of ALARA principle			
Yes	75 (27)	82.4 (42)	0.4
No	25 (9)	17.6 (9)	
Did you get radiation protection after employment			
Yes	69.4 (25)	78.4 (40)	0.3
No	30.6 (11)	21.6 (11)	

The mean adherence score of this study was 3.65±0.64, 3.7±1.5 and 4.5±1 for physicians, nurses and technologist respectively, showing overall "good to excellent adherence" levels. Soylemez *et al.*[25] study in Europe stated that 75% of respondents adhered to radiation protection. About 70.5% adherence to personnel safety and 77.1% patient safety.

Although there is no significant difference between the three professions in knowledge, the technologists had higher adherence scores (4.5±1.0) compared to that of nurses (3.7±1.5) and physicians (3.65±0.64) having a significant difference ($p<0.05$) in scores. This may be due to their age and experience. On the other hand, males showed significantly higher adherence scores than females (4.52±0.9 vs. 3.76±1.49; $p = 0.08$).

CONCLUSION

The study described the radiation protection knowledge and adherence among healthcare workers who were not radiology professionals but using radiation during their daily practice. The results stated that the knowledge and adherence of health care workers to ionizing radiation practice is similar and higher than other studies. Continuous educational and awareness efforts should be employed to ensure better adherence and increase awareness to radiation protection protocols. Regular intervals inspection should be conducted to ensure adherence to radiation protection combined with professional development and training. The highest knowledge and adherence will play a significant role in reducing the radiation to the patients and staff.

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