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Assessment of Radiation Protection Knowledge among Radiology Professionals and Students: A Study Conducted at a Medical College

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Abstract: ***This survey investigates the level of knowledge and awareness regarding radiation protection among radiology professionals and students at a medical college in Mosul, Iraq. Using a structured questionnaire administered to 55 participants, including radiologists, physicists, and students, the study evaluated responses through descriptive and inferential statistics. The overall mean knowledge score was 68.57%, with significant variation observed across academic qualifications. Medical physicists showed the highest awareness, while diploma graduates demonstrated inadequate understanding. The findings underscore the need for enhanced radiation protection training and curriculum revision, particularly for lower academic tiers. The study advocates for periodic workshops and stronger national legislation to reinforce safety practices.***

Keywords: radiation protection, radiology education, radiation awareness, healthcare safety, Iraq

1. Introduction

The use of ionizing radiation in medicine has rapidly expanded since the discovery of X-rays by Wilhelm Conrad Roentgen in 1895, mainly due to recent advances in imaging technologies, which offer promising solutions to a wide range of clinical challenges (Paolicchi et al., 2016; Donya et al., 2014). Radiation accidents have been instructive with respect to high radiation doses and the basis of a radiation risk assessment model called the linear-no-threshold model, LNT. In the LNT model, it is assumed that even minimal doses of radiation carry an associated risk (Szarmach et al., 2015). Some critics of the science maintain that LNT overestimates risk because it needlessly creates fear and higher-than-necessary safety costs. Yet, this theory remains the legal basis for most radiation safety regulations (Faggioni et al., 2017). Moreover, there is recent evidence that even low-dose ionizing radiation used in imaging can have carcinogenic effects (Ünal et al., 2018). The use of radiation therefore has to be really prudent and optimized (Mynalli et al., 2010).

Optimization of radiation use in medical imaging involves a coordinated approach among several major stakeholders, including the referring physician, radiologist, radiologic technologist, other health care professionals, and the patient (O'Sullivan et al., 2010). The referring physician will have to ensure that a justification is made in the use of ionizing radiation; that is to say, the benefits derived will have to outweigh the risks involved (Yunus et al., 2014). Radiologists and radiographers will also be involved in ensuring the necessity of the examination (Badiee Nejad et al., 2015). By nature of their professional training, they are expected to know all issues related to radiation safety and optimization principles (Pursamimi et al., 2018). Moreover, they have to encourage awareness about the safe use of radiation; not only within the radiology department but also among patients and the general public (Herbst et al., 2012). Therefore, radiation awareness is needed to ensure the rational and safe application of ionizing radiation in medicine (Van der Merwe et al., 2017).

Although the academic curriculum and training of the radiation professionals are growing in the field of radiology, actual application in Iraq is extremely limited. According to the International Atomic Energy Agency, every country should have a radiation and nuclear safety authority which can protect the domestic as well as the international communities from the problems of radiation safety (Alavi et al., 2017).

There is a serious problem in ensuring radiation safety in Iraq due to the lack of such regulatory practices (Furmaniak et al., 2016). In the absence of legal regulatory bodies, the awareness of the radiation workers as well as the general public about radiation becomes of utmost importance. Still, many studies conducted globally show that the radiation protection knowledge is below expectations (Ribeiro et al., 2020). Only a few studies in Iraq have assessed the level of radiation awareness among radiation professionals, and they all indicated that the current level of knowledge is insufficient for the assurance of well-being with regard to radiation protection maintains to be a lowly regarded issue in this country. The purpose of this study is to assess the level of knowledge and awareness of radiation protection among radiology professionals and students at a medical college in Iraq. Understanding gaps in radiation safety knowledge among medical personnel is critical for enhancing patient care, protecting healthcare workers, and informing policy decisions on medical imaging practices.

Questionnaire

A survey with a questionnaire was used to check how much radiology professionals know about radiation protection. The participants included radiologists, medical physicists,

medical imaging teachers, technologists, radiographers, residents, and students in this field. The idea of this survey was to outline some kind of picture of their perception about radiation protection principles. Demographic data regarding age, gender, qualifications, and experience on the job were provided. Participants were given a set of multiple-choice questions on the knowledge of radiation safety.

The total number of items in the questionnaire was 17. Three questions were asked to collect basic information about the participants' training, familiarity, and experience with medical radiation imaging. The other 14 multiple-choice questions were used to assess their level of understanding of radiation protection principles and safety practices. The survey was carried out at the Department of Radio-Diagnosis, Mosul. University of Mosul is one of the premier institutions in medical education. Being one of the pioneering institutes in the country, University of Mosul should be more significant in shaping health professionals concerning radiation safety awareness. The present survey represents an important step in assessing the current status of radiation safety awareness within this academic and clinical setup.

Data Collection

All staff members and students from the Department of Radio-Diagnosis actively took part in the survey at Mosul University. Data collection occurred between October 1st to October 10th, 2024. The department comprises a heterogeneous group of professionals and students such as radiologists, medical physicists, faculties in medical imaging, radiologic technologists, radiographers, residents in MD Radio-Diagnosis.

The principal investigator personally distributed hard copies of the questionnaire to all participants and requested that they complete the survey in his presence to ensure immediate completion and accuracy. Responses were scored based on accuracy, with one point awarded for each correct answer, with each correct answer receiving a score of "1." No negative marking was applied for incorrect answers, ensuring that participants were not penalized for wrong responses.

It therefore ensured that the response rate was high, thus enabling a thorough assessment of the knowledge in radiation protection.

Data Analysis

All the data collected were analyzed using SPSS provided by IBM, Chicago, United States, version 27. The tests applied to assess knowledge on radiation protection among respondents were descriptive statistics and various statistical tests. Knowledge was categorized into three levels: inadequate (less than 60%), adequate (60–80%), and excellent (80–100%). In addition, the Shapiro-Wilk test was performed in order to assess whether data follow a normal distribution, while Levene's test was used for assessing the equality of variances.

Since the distribution of the data wasn't normal, the data were analyzed using non-parametric statistical methods. Precisely, the Mann-Whitney U test and Kruskal-Wallis H test were performed. When the result from Kruskal-Wallis H test was significant, pairwise post-hoc test with Bonferroni adjustment was performed for further comparison. A p-value ≤ 0.05 was regarded as significant throughout this analysis.

Principal Component Analysis (PCA) was applied to the responses of the 14 multiple-choice questions in order to reduce its dimensionality to two principal components, which enable easy interpretability.

The study received ethical approval from the College of Medical Sciences, Mosul, Iraq. All participants provided informed written consent prior to their involvement, and their anonymity was rigorously preserved throughout the research.

2. Results

A total of 55 individuals participated in the study, consisting of 44 males and 11 females. The participants had an average age of 26.09 ± 7.18 years. Among the participants, 37.1% (n = 13) were students, and 62.9% (n = 22) were staff members. Detailed demographic information is shown in Table 1.

Table 1: Demographic properties

Demographic properties	Occurrence	Ratio %
Gender		
Male	44	80.0
Female	11	20.0
Age Groups		
≤ 20	18	32.7
20 – 26	9	16.3
25 – 32	17	30.9
≥ 350	11	20.0
Academic Criterion		
BSc Student	26	47.2
BSc Graduate	8	14.5
Periodic Resident	3	5.4
Senior Resident	12	21.8
Board Graduate	4	7.2
Medical Physicist	2	3.6
Experience		
Yes	19	34.5
No	36	65.4
Student		
Yes	20	36.3
No	35	63.6

Out of 14 radiation protection knowledge-testing questions, the minimum and maximum scores of the participants were 4 and 13, respectively. The mean score on the awareness of radiation was 9.6, which accounts for 68.57%. All participants indicated the receipt of formal education through either lectures or training courses on the use of radiation protection. Conversely, 10 participants, which is 18.18% of the total number of participants, indicated inadequate knowledge of the risks of radiation and radiation safety. However, all participants had some clinical experience or occupational exposure to X-ray-related procedures. The individual correct responses are summarized in Table 2 below.

Table 2: Correct response of questionnaire survey

SN	Questions	Frequency of correct answer	Percentage (%)
1.	What is the SI unit used to measure the absorbed dose equivalent of ionizing radiation?	16	29.1
2.	Does a CT (Computed Tomography) scan use x-rays in its imaging process?	46	83.6
3.	What material is commonly used to make protective clothing for individuals during x-ray examinations?	37	67.2
4.	Is mammography a medical imaging technique that involves the use of x-rays?	53	96.3
5.	What is the recommended minimum safe distance to maintain from an x-ray machine during portable or bedside x-ray procedures?	34	61.8
6.	What is the highest permissible level of radiation exposure allowed for occupational workers in radiology?	37	67.2
7.	Do MRI (Magnetic Resonance Imaging) machines utilize x-rays for producing images?	40	72.7
8.	When fluoroscopy is being used, and you are not actively participating in the procedure, is it advised to leave the room for safety?	42	76.3
9.	Does the ultrasound imaging technique involve the use of ionizing x-rays?	49	89
10.	Which SI unit is used for measuring radioactivity in medical imaging or nuclear medicine?	25	45.4
11.	Is radiation continuously emitted from a CT scanner, even when it is not actively scanning, 24 hours a day?	43	78.1
12.	What is the chance of getting cancer after having a routine chest X-ray?	38	69
13.	Is it safe for a nurse who is in her first trimester of pregnancy to work in an environment where fluoroscopy is being conducted?	30	54.5
14.	Are gamma rays used in medical treatments or imaging procedures, and if so, for what purposes?	44	80

Table 3 describes knowledge scores by demographic characteristics. Results of the Mann-Whitney U test based on male and female participants indicated no statistically significant differences: $U = 75.50$, $p > 0.05$. The Kruskal-Wallis H test showed that there was no statistically significant difference in the variation in the knowledge score among the different age groups.

However, academic qualifications had a significant impact on knowledge scores ($\chi^2(5) = 16.43$, $p < 0.05$). Pairwise post-hoc analysis using the Bonferroni correction showed that the knowledge scores of diploma graduates were significantly different from those of MD Radiodiagnosis residents ($p < 0.05$). From Table 3, it can be observed that the lowest average knowledge score is possessed by diploma graduates with 7.76 (55.42%), while the highest average was recorded among medical physicists with 13.00 (92.85%).

No significant differences in knowledge scores were observed based on the work experience groups, $U = 171.00$, $p > 0.05$. However, the student group had a significantly higher knowledge score compared with the non-student group, $U = 69.50$, $p < 0.05$.

Table 3: Average knowledge score with statistical significance

Variables	Knowledge	*p*-value
Gender		
Male	9.53	0.425
Female	9.18	
Age Groups (in years)		
≤ 20	8.68	0.072
20 – 25	9.84	
25 – 30	11.95	
≥ 30	13.78	
Academic Qualification		
BSc Student	8.42	0.007
BSc Graduate	12.83	
Periodic Resident	12.32	
Senior Resident	11.74	
Board Graduate	13.56	
Medical Physicist	13.9	
Work Experience		
Yes	12.48	0.375
No	10.32	
Student		0.013
Yes	12.82	
No	9.64	

3. Discussion

This research is one of the major attempts to explore the awareness of radiation protection within a private institution in Iraq. In the current study, the overall mean score of radiation awareness was 68.57%, indicating satisfactory overall knowledge. However, graduates from diploma studies demonstrated a lower level of knowledge, which was 8.42 (55.42%). The study also established that students had a higher degree of knowledge than non-students, implying that continuous professional staff may not be updated in the concepts of radiation safety practices. For this reason, regular training programs should be instituted both at the institutional and national levels.

Indeed, the previous studies confirm that increasing radiographers' awareness about issues of radiation protection at all levels of education is important. On-site training for the medical workers has to be updated regularly with fresh materials; complete packages of radiation protection protocols and guidelines should be implemented.

For medical physicists, radiation protection lies at the very heart of their professional responsibilities, and ignorance on their part may result in patients receiving unjustified radiation doses. It has to be borne in mind that the dangers from ionizing radiation were acknowledged within one year of the discovery of X-rays, and the use of radiation in a safe way has been a cause for concern ever since. Considering the rapid growth in medical applications of ionizing radiation, issues related to radiation protection became even more urgent. The regulatory mechanisms were established with a view to providing guidelines that ensure justified and optimum use of radiation. Technology advancement also helped in monitoring

and controlling radiation exposure for patients, the public, and radiation workers without compromising image quality. This study was done in a resource-limited country like Iraq but found adequate knowledge on radiation protection, despite the country facing resource limitations to radiation safety and dosimetry. Previous studies on this subject showed how radiation protection is grossly neglected in Iraq despite the use of X-rays in medical imaging in this country for more than nine decades.

Given the emerging challenges, urgent attention is needed for quality assurance and safety standards. A radiation survey showed that 67% of the radiation workers were never subjected to radiation monitoring; similarly, all the diagnostic hospitals did not perform any quality control tests.

Besides the challenges brought about by the COVID-19 pandemic, there have been growing risks of radiation exposure in Iraq. All these issues require collaboration among different stakeholders through the involvement of the Government of Iraq, international organizations, and local stakeholders in collaboration with radiological technology educators. The only way to create awareness on radiation protection is the regular implementation of training sessions, workshops, seminars, and conferences. However, this would be a milestone toward alleviating this pressing issue with good radiation practices based on legal framework. The present study may not be the first one to evaluate the status of radiation protection awareness in Iraq; however, it stands at the cornerstone of improving the situation since the study was led in a private institution. In the present study, the overall knowledge levels were found to be adequate; however, the authors recommend revising the curriculum for diploma graduates by inducting more sophisticated modules on radiation protection in order to upgrade their awareness levels to match the contemporary standards of safety.

4. Limitations of the Study

This study involved only one institution and had a relatively small sample size, n = 55, which presents a limitation in the generalization of the results. As a result, the findings cannot be representative of the overall knowledge in radiation protection throughout the country. Incorporating more participants from multiple institutions could have provided more representative and stronger results with a larger sample size. Moreover, future research should not be limited to radiology departments but should also include medical doctors, dentists, referring physicians, nurses, and other health professionals whose tasks in any way involve radiology either directly or indirectly. This would indeed offer a more panoramic understanding of the knowledge on radiation protection across a wide spectrum of healthcare professionals.

5. Conclusion

This study is considered to be a vital development towards the insights in radiation protection knowledge among radiology staff and trainees from a medical school in Iraq. The discoveries from the study reveal that the knowledge state is somehow good but the research team was also able to uncover many gaps in the knowledge, with diploma holders having very little acquaintance with the radiation safety basics. Knowledge levels to some extent are still good; nevertheless, the research revealed certain disturbing points, one of which is that the diploma graduates do not even have the most basic knowledge of radiation safety principles. A solution would be to create continuous professional development courses that would help bring up the knowledge level of the staff in general and also regularly held refresher courses for the students. Curiously enough, the study also suggests it is necessary to have a redefined curriculum that includes radiation protection for both the radiology professionals and the diploma students. To summarize, it is highly recommended to incorporate more radiation protection modules into the original curricula of the radiology and diploma programs.

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