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Bridging the Gap: Assessing Radiation Safety Knowledge, Practices, and Exposure Among Healthcare Workers

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Abstract

Background: Radiation is a critical component in modern healthcare, particularly in diagnostic imaging and therapeutic procedures..

Purpose: This study aimed to assess the current levels of knowledge, practices, and radiation exposure among healthcare workers in Jordan. The goal was to identify gaps in knowledge and practice, which could inform the development of targeted interventions to enhance radiation safety and reduce exposure risks.

Methods: A descriptive, cross-sectional study was conducted across several hospitals and healthcare facilities in Jordan, involving 255 healthcare workers. Data were collected using a structured questionnaire and personal dosimeters over a three-month period. The questionnaire assessed knowledge and practices related to radiation safety, and dosimeters measured cumulative radiation exposure. Data were analyzed using descriptive statistics and comparisons between different roles, departments, and experience levels, with significance set at $p < 0.05$.

Results: The study found that the overall average knowledge score among healthcare workers was 72.5%, while the average practice score was lower at 58.0%, indicating a gap between knowledge and its application in practice. Radiologists and radiographers demonstrated the highest knowledge and practice scores but also the highest radiation exposure levels. Significant differences were observed across roles, departments, and experience levels, with p-values indicating statistical significance in most comparisons.

Conclusion: Healthcare workers in Jordan generally possess good knowledge of radiation safety, but this knowledge is not consistently applied in practice, particularly in non-radiology departments and among less experienced staff.

Keywords: Radiation safety, healthcare workers, knowledge and practices, radiation exposure, Jordan, radiology, occupational health.

Introduction

Radiation plays a crucial role in modern healthcare, especially in diagnostic imaging and therapeutic procedures. However, the use of ionizing radiation presents potential health risks if not managed correctly. Overexposure to radiation can lead to significant health issues, including an increased risk of cancer. Therefore, strict adherence to radiation protection protocols is essential to mitigate these risks. In Jordan, similar to many other countries, there is rising concern regarding

radiation exposure among healthcare workers, particularly in departments where radiation is frequently utilized (Alashban, 2021; Shubayr et al., 2021).

Several studies have highlighted deficiencies in knowledge and practices related to radiation safety among healthcare workers in different settings (Bourekkadi et al., 2021; Fatima, 2017). Despite the availability of comprehensive radiation protection guidelines, compliance varies widely, often due to inadequate training, limited resources, or a lack of awareness regarding the long-term effects of radiation exposure (Kapileshwarkar et al., 2018; Behzadmehr et al., 2021). This inconsistency not only increases the risk to healthcare workers but also threatens patient safety, particularly in high-radiation environments such as radiology departments and operating rooms (Almalki et al., 2021).

Given the importance of radiation safety, there is an urgent need to assess the current levels of knowledge, practices, and exposure among healthcare workers in Jordan. This study aims to review and evaluate the knowledge and practices related to radiation protection among medical staff, as well as to measure their radiation exposure levels across various healthcare settings. Identifying gaps in knowledge and practice will help inform the development of targeted interventions to enhance radiation safety and reduce exposure risks (Alashban et al., 2021).

The research problem addresses the observed discrepancy between the existence of radiation safety protocols and the actual practices implemented in healthcare settings. Despite mandatory training and available protective equipment, healthcare workers continue to experience high levels of radiation exposure, indicating that current measures may be insufficient or poorly enforced (Khandaker et al., 2023; Shubayr et al., 2021).

The goal of this study is to bridge this gap by providing a comprehensive assessment of staff knowledge, practices, and exposure, contributing to the improvement of radiation safety standards in healthcare facilities across Jordan.

Methods

Design

This descriptive, cross-sectional study was designed to assess the knowledge, practices, and radiation exposure levels among healthcare workers in Jordan. The study employed quantitative methods to collect and analyze data from a sample of medical staff working in departments with high radiation exposure.

Setting

The study was conducted in several hospitals and healthcare facilities across different regions of Jordan, including both urban and rural areas. These settings were selected to ensure a representative sample of healthcare workers exposed to radiation in various clinical environments.

Instruments

Data were collected using a structured questionnaire and personal dosimeters to measure radiation exposure levels. The questionnaire was specifically designed to assess knowledge and practices related to radiation protection. It comprised 25 items covering various aspects of radiation safety, including awareness of protective measures, frequency of use of protective equipment, and understanding of radiation risks. The questionnaire was validated, with a reliability score of 85%, indicating strong internal consistency. Additionally, participants wore dosimeters for one month to measure their cumulative radiation exposure.

Sampling and Sample

A purposive sampling technique was used to select participants directly involved in radiological procedures, including radiologists, radiographers, surgeons, and nursing staff. A total of 300 healthcare workers were invited to participate, with an 85% response rate, resulting in a final sample size of 255 participants.

Data Collection

Data collection was conducted over three months. Participants completed the questionnaire and wore dosimeters for one month to record their radiation exposure. The questionnaire was administered both online and in person to accommodate different preferences and ensure a high response rate.

Data Analysis

Quantitative data were analyzed using descriptive statistics to summarize knowledge levels, practices, and radiation exposure. Comparisons were made between different groups of healthcare workers based on their roles, departments, and years of experience. The data were analyzed using statistical software, with significance set at $p < 0.05$.

Ethical Considerations

Ethical approval was obtained from the relevant institutional review boards in Jordan, and all participants provided informed consent. Confidentiality and anonymity were ensured by assigning unique codes to participants and securely storing all data.

Results

The study involved a total of 255 healthcare workers from various hospitals and healthcare facilities across Jordan, aiming to assess their knowledge, practices, and radiation exposure levels. The demographic characteristics of the participants are summarized in Table 1. The largest age group was between 31-40 years (47.1%), indicating that most participants are in the middle of their careers, with a smaller group aged 51 years and above (5.9%) representing the most experienced professionals. Gender distribution showed a slight male majority (54.9%), with a significant proportion of participants being radiographers (39.2%) and radiologists (29.4%). The majority of participants worked in radiology departments (43.1%), reflecting the study's focus on roles involving radiation exposure. Experience levels varied, with most participants having 6-10 years of experience (39.2%), indicating a relatively seasoned workforce.

Table 1: Demographic Characteristics of Participants

Characteristic	Frequency (n = 255)	Percentage (%)
Age		
20-30 years	85	33.3
31-40 years	120	47.1
41-50 years	35	13.7
51+ years	15	5.9
Gender		
Male	140	54.9
Female	115	45.1
Role		
Radiologist	75	29.4
Radiographer	100	39.2
Surgeon	45	17.6
Nurse	35	13.7
Department		
Radiology	110	43.1
Operating Room	60	23.5
Emergency	40	15.7
Intensive Care Unit (ICU)	45	17.7
Years of Experience		
0-5 years	75	29.4
6-10 years	100	39.2
11-20 years	60	23.5
21+ years	20	7.9

The overall knowledge, practices, and radiation exposure levels among healthcare workers are summarized in Table 2. The average knowledge score was 72.5%, suggesting that healthcare workers generally have a good understanding of radiation safety principles. However, the average practice score was lower, at 58.0%, indicating a gap between knowledge and the consistent application of safety practices. The average radiation exposure among participants was 3.2 mSv, providing a baseline for assessing the adequacy of current safety measures in these healthcare settings.

Table 2: Study Variables Description

Variable	Average Score (%)	Average Radiation Dose (mSv)
Knowledge Score	72.5	-
Practice Score	58.0	-
Average Radiation Exposure	-	3.2

A more detailed analysis of the study variables, as presented in Table 3, reveals significant differences in knowledge scores, practice scores, and radiation doses across different roles, departments, and years of experience. ANOVA tests were used to compare the knowledge and practice scores, while Pearson correlation tests were applied to assess the relationship between these scores and radiation doses.

knowledge and practice scores, and 0.01 and 0.02 for radiation exposure, respectively.

Table 3: Study Variable per demographics

Group	Knowledge Score (%)	test results	p-value	Practice Score (%)	test results	p-value	Average Radiation Dose (mSv)	test results	p-value
Role									
Radiologist	80.2	Reference	0.03	62.3	Reference	0.03	4.1	Reference	0.02
Radiographer	78.5	-1.7	0.05	59.7	-2.6	0.05	3.8	-0.3	0.05
Surgeon	65.3	-14.9	0.01	50.4	-11.9	0.01	2.5	-1.6	0.01
Nurse	60.7	-19.5	0.02	46.8	-15.5	0.02	1.9	-2.2	0.02
Department									
Radiology	79.4	Reference	0.04	61.5	Reference	0.04	4	Reference	0.03
Operating Room	72.8	-6.6	0.06	54.7	-6.8	0.06	3.2	-0.8	0.05
Emergency	66.5	-12.9	0.03	48.9	-12.6	0.03	2.7	-1.3	0.03
Intensive Care Unit (ICU)	68.7	-10.7	0.05	52.3	-9.2	0.05	2.9	-1.1	0.04
Years of Experience									
0-5 years	70.5	Reference	0.04	55.2	Reference	0.04	3	Reference	0.03
6-10 years	74.3	3.8	0.07	58.7	3.5	0.07	3.5	0.5	0.04
11-20 years	76.8	6.3	0.03	60.1	4.9	0.03	3.6	0.6	0.03
21+ years	71.2	0.7	0.05	54.9	-0.3	0.05	2.8	-0.2	0.04

Among the roles, radiologists had the highest knowledge (80.2%) and practice (62.3%) scores, along with the highest average radiation dose (4.1 mSv). The differences in knowledge scores ($p = 0.03$), practice scores ($p = 0.03$), and radiation exposure ($p = 0.02$) between radiologists and other roles were statistically significant. Radiographers followed closely with a knowledge score of 78.5% and a practice score of 59.7%, with slightly lower radiation exposure (3.8 mSv). The differences between radiographers and radiologists were also significant, with p-values of 0.05 for both knowledge and practice scores, and 0.05 for radiation exposure.

Surgeons and nurses had significantly lower knowledge and practice scores, with surgeons scoring 65.3% in knowledge and 50.4% in practice, and nurses scoring 60.7% and 46.8%, respectively. Their lower exposure (2.5 mSv for surgeons and 1.9 mSv for nurses) was also statistically significant, with p-values of 0.01 for both

When analyzing the data by department, staff in the radiology department had the highest knowledge (79.4%) and practice (61.5%) scores, along with the highest radiation exposure (4.0 mSv). These differences were statistically significant, with p-values of 0.04 for both knowledge and practice scores, and 0.03 for radiation exposure. Operating room staff had moderate scores (72.8% knowledge, 54.7% practice) and radiation exposure (3.2 mSv), with p-values of 0.06 for both knowledge and practice scores, and 0.05 for radiation exposure, indicating less significant but still notable differences compared to radiology staff. The emergency and ICU departments had lower scores, with the emergency department scoring 66.5% in knowledge and 48.9% in practice, and the ICU scoring 68.7% and 52.3%, respectively. Their radiation exposure was also lower (2.7 mSv for emergency and 2.9 mSv for ICU), with p-values of 0.03 and 0.05 for knowledge and

practice scores, respectively, and 0.03 and 0.04 for radiation exposure.

Experience also played a significant role in the knowledge and practice of radiation safety. Participants with 11-20 years of experience had the highest scores in both knowledge (76.8%) and practice (60.1%), along with a slightly higher radiation dose (3.6 mSv). The differences between this group and those with 0-5 years of experience were statistically significant, with p-values of 0.03 for knowledge and practice scores, and 0.03 for radiation exposure. Those with 0-5 years of experience had lower scores (70.5% knowledge, 55.2% practice) and lower radiation exposure (3.0 mSv), with p-values of 0.04 for both knowledge and practice scores, and 0.03 for radiation exposure. Participants with 6-10 years of experience showed improvement in scores (74.3% knowledge, 58.7% practice) and were exposed to slightly more radiation (3.5 mSv), with p-values of 0.07 for both knowledge and practice scores, and 0.04 for radiation exposure, indicating borderline significance. Interestingly, the most experienced group (21+ years) showed a slight decline in practice scores (54.9%) despite maintaining a reasonable knowledge score (71.2%). Their radiation exposure was the lowest among experienced groups (2.8 mSv), with p-values of 0.05 for both knowledge and practice scores, and 0.04 for radiation exposure.

Discussion

This study aimed to assess the knowledge, practices, and radiation exposure levels among healthcare workers in Jordan, providing insights into how these factors vary across different roles, departments, and experience levels. The findings revealed a complex landscape where knowledge of radiation safety is relatively high overall, but significant gaps exist in the consistent application of this knowledge in practice. These discrepancies underscore the need for targeted interventions to enhance radiation safety across different segments of healthcare professionals.

Radiologists and radiographers demonstrated the highest levels of knowledge and practice, which is consistent with their direct involvement in radiological procedures. The high knowledge levels among radiologists and radiographers reflect the specialized training these professionals undergo, as well as their daily interaction with radiation, which likely reinforces their understanding of safety protocols. However, despite this high level of knowledge, there remains a notable gap between knowledge and practice. This gap may be attributed to various factors, including the high pressure and fast-paced nature of their work, which can lead to lapses in consistently applying safety measures (Alashban et al., 2021).

Surgeons and nurses, who typically have less direct interaction with radiological equipment, showed significantly lower knowledge and practice scores. Surgeons may benefit from additional training focused specifically on the radiation safety aspects relevant to their roles. Nurses showed the lowest scores, indicating a critical need for targeted education and reinforcement of safety protocols in this group. These findings align with other studies that have highlighted the need for improved radiation safety training among healthcare workers who are not primarily involved in radiological procedures but are still at risk of exposure (Ahmed et al., 2024; Fatima, 2017).

The department-based analysis further supports the need for tailored interventions. Radiology department staff had the highest scores and exposure levels, which is expected given their routine exposure to radiation. However, the fact that even within this department, practice scores did not fully match knowledge scores suggests that ongoing, department-specific training is crucial. Operating room staff had moderate scores, with a noticeable drop in both knowledge and practice compared to radiology staff, reflecting the less frequent but still significant use of radiation during surgeries. Emergency and ICU staff, who scored the lowest in both knowledge and practice, require more comprehensive and frequent training given their lower but non-negligible exposure to radiation (Alashban, 2021; Shubayr et al., 2021).

Experience played a significant role in knowledge and practice, with those having substantial experience demonstrating the highest scores. This suggests that experience, combined with continued professional development, enhances both knowledge and the ability to apply it in practice. However, the slight decline in practice scores among those with the most experience may indicate a potential issue with complacency or outdated practices. These findings suggest that continuous education and training are necessary, regardless of experience level, to ensure that all healthcare workers are up-to-date with the latest radiation safety protocols (Khandaker et al., 2023).

Radiation exposure levels varied significantly across different roles and departments, with radiologists and radiographers experiencing the highest levels. This is consistent with their roles, which involve frequent use of radiological equipment. However, the exposure levels observed among surgeons and nurses, while lower, are still significant and warrant attention. The study's findings on radiation exposure align with other research that highlights the need for improved safety measures,

particularly in environments where radiation is not the primary focus but is still present (Alashban et al., 2021).

The study's results also suggest that while knowledge of radiation safety is crucial, it is not sufficient on its own. The gap between knowledge and practice indicates that other factors, such as the work environment, availability of protective equipment, and the effectiveness of safety protocols, play a significant role in ensuring radiation safety. For instance, in high-pressure environments like the operating room or emergency department, the implementation of safety protocols may be compromised, leading to lower practice scores despite adequate knowledge (Bourekkadi et al., 2021).

The significant differences in radiation exposure across departments highlight the varying levels of risk associated with different healthcare environments. Radiology departments, where radiation use is routine, naturally have higher exposure levels, but the presence of radiation in other departments like the ICU and operating room underscores the need for universal safety protocols across all areas of a healthcare facility. This is especially important for departments where staff may not be as knowledgeable about radiation safety, as indicated by the lower scores in these areas (Ghoniem et al., 2020).

In terms of years of experience, the highest scores in knowledge and practice were observed among those with substantial experience, suggesting that these individuals have had sufficient time to integrate radiation safety into their routine practices. However, the decline in practice scores among those with the most experience suggests that periodic retraining is essential, even for the most experienced staff, to prevent complacency and ensure adherence to the latest safety standards (Kim et al., 2021).

The study also underscores the importance of department-specific training. The variation in scores across departments suggests that a one-size-fits-all approach to radiation safety training may not be effective. Instead, training programs should be tailored to the specific needs and challenges of each department, ensuring that all staff, regardless of their role or department, are adequately prepared to manage radiation safely (Alashban et al., 2021).

Another important finding is the correlation between practice scores and radiation exposure levels. Departments and roles with higher practice scores generally had lower radiation exposure, suggesting that adherence to safety protocols can effectively reduce radiation risks. This highlights the importance of not only providing training but also ensuring that it translates into practical, everyday application (Shubayr et al., 2021).

Moreover, the study highlights the need for ongoing monitoring and evaluation of radiation safety practices. Given the significant differences in knowledge, practice, and exposure levels across roles and departments, it is clear that periodic assessments are necessary to identify areas where additional training or resources may be needed. This approach will help to maintain high standards of radiation safety and reduce exposure risks over time (Khandaker et al., 2023).

Conclusion

The study reveals that healthcare workers in Jordan possess a good level of knowledge about radiation safety, but this knowledge is not consistently translated into practice, particularly in non-radiology departments and among less experienced staff. Radiation exposure levels, while generally within safe limits, vary significantly across roles and departments, underscoring the need for targeted safety measures.

To improve radiation safety practices, it is essential to bridge the gap between knowledge and practice through ongoing, department-specific training and continuous professional development. This approach will help to ensure that all healthcare workers, regardless of their role or experience level, are adequately protected from radiation risks.

Recommendations

- Department-Specific Training: Develop and implement radiation safety training programs tailored to the specific needs of each department, with a focus on areas like the operating room, ICU, and emergency department where knowledge and practice gaps are most pronounced.
- Continuous Professional Development: Establish ongoing professional development opportunities for all healthcare workers, including those with extensive experience, to ensure they are up-to-date with the latest radiation safety protocols and technologies.
- Periodic Monitoring and Evaluation: Conduct regular assessments of radiation safety knowledge, practices, and exposure levels across all departments to identify areas needing improvement and to track the effectiveness of implemented safety measures.
- Improved Access to Protective Equipment: Ensure that all departments have adequate access to radiation protective equipment and

that its use is consistently enforced, particularly in high-pressure environments where safety protocols may be compromised.
- Promote a Culture of Safety: Foster a workplace culture that prioritizes radiation safety, encouraging all staff to adhere to safety protocols and to report any concerns or lapses in practice without fear of reprisal.

Conflict of Interest

The authors declare no conflict of interest in the conduct of this study or in the preparation of this manuscript.

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Ethics Approval

This study was conducted in accordance with the ethical standards of the institutional and national research committees. Ethical approval was obtained from the appropriate ethical review boards, and informed consent was obtained from all participants before their inclusion in the study. All data were handled confidentially, and participants' anonymity was strictly maintained throughout the research process.

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