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Assessment of occupational radiation exposure and evaluation of the radiation protection awareness among medical staff in radiological facilities in the Southern Province of Saudi Arabia

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Abstract: Unquestionably, one of the most effective medical diagnostic methods is ionizing radiation in radiography, despite its possible hazards. This study aims to evaluate occupational radiation exposure and radiation safety assessment for medical staff working in HCFs in the Southern Province of the Kingdom of Saudi Arabia. Three hospitals were randomly selected from January to December 2021 to conduct the study. The radiation survey was carried out to measure radiation levels at different points inside the radiology departments of the targeted hospitals. A questionnaire was carried out to assess radiation protection safety, and the TLD of the workers was collected and analyzed to gauge their occupational exposure dose. The annual average effective dose of the selected hospitals (Hospitals 1, 2, and 3) varied in the range of 0.98, 0.96, and 1.32 mSv, respectively. Even though the results are well below the allowed annual limit of 20 mSv in a single year, it is considered high if we know that the selected hospitals do not have nuclear medicine or radiotherapy departments. The radiation survey showed a dangerous rise in the level of radiation in the CT scan room of one of the hospitals. Regarding the radiation safety questionnaire, there is a lack of understanding of radiation protection measures. 45 % of the workers stated that some radiation protection tools (lead gowns, lead gloves, lead glasses, and lead thyroid cover) were unavailable. 13% of workers have never attended a radiation protection lecture, and 34% have received it for over two years.

Keywords: Occupational exposure, Radiation safety, Exposure dose, Radiation survey, Knowledge and Awareness.

1. Introduction

The tremendous expansion in use of ionizing radiation in both the diagnostic and therapeutic sides significantly burdens workers in radiological facilities. Approximately 10 million worldwide diagnostic radiology procedures and 100,000 nuclear medicine procedures are performed daily using ionizing radiation [1]. At high doses, ionizing radiation is known to cause cancer, and clinical symptoms have been linked to chronic low-dose exposure [2].

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Dose estimation for radiation workers is essential for evaluating radiation risks and establishing protective measures for governments and organizations. As a result, many hospital employees are subjected to regular monitoring of their professional occupational exposures. The phrase "occupational exposures" is defined by the International Commission on Radiological Protection (ICRP) as "the exposure of persons at work to ionizing radiation from natural and man-made sources as a result of operations within a workplace" [3].

Staff radiation exposure can be lower than the dose limitations for the general public in a well-regulated X-ray department with current design and skilled workers [4]. This may not be true in a nuclear medicine and radiotherapy department, where staff must deal with the additional risks of contamination, high-energy radiation, and patients who continuously emit radiation. Still, in X-ray and CT scan diagnosis, complete containment of unwanted scattered radiation is a realistic goal that should be pursued at all times.

Studies estimated that 20% of medical x-ray examinations are unnecessary and that these and other needless exposures cause 100-250 cancer cases in the UK annually among staff and patients [5]. The reasons for doing the unnecessary imaging are due to a lack of awareness of the treating physician. The awareness about radiation protection plays a considerable role effect either positively or negatively the decisions of radiological orders, the methods of implementation, and the extent of the patient's actual need for them.

The radiation dose given during any diagnostic procedure should be sufficient to answer the clinical question but as low as reasonably achievable (ALARA) to reduce the patient's risks.

This study aims to assess occupational radiation exposure and evaluate radiation protection awareness among medical staff in radiological facilities in the Southern Province of Saudi Arabia.

2. MATERIALS AND METHODS

A comprehensive research study covering aspects of radiation protection in health facilities in the Southern Province, specifically the Asir region, was carried out. Three significant hospitals were selected carefully (depending on the capacity, availability of different radiology subspecialties, and their high crowd): Asir Central Hospital, Khamis Mushayt General Hospital, and Khamis Mushayt Maternity and Children Hospital.

The data were collected relating to the research objectives, which are:

- Surveying radiation from different points inside radiology departments (imaging rooms, control panels, corridors, the patient's waiting areas).
- Analysis of TLD readings of workers dealing with radiation (Physicians, Technologists, Radiologists).
- Questionnaire to show radiology staff awareness about radiation protection.

The radiation surveying was done using the portable radiation measuring instrument MicroRem (Thermo Scientific™). The measurement unit was in count (µrem/hour) and converted into (µSv/hour) and then to (µSv/week).

Radiation safety is evaluated based on an electronic questionnaire distributed to radiology staff in the concerned hospitals. The questionnaire includes 16 multiple-choice questions divided into three parts: background, equipment, and knowledge. The responses were recorded by Google DOCS while analyzed by using SPSS. The data was collected during the official working hours from 7 am to 3 pm.

The TLD readings have been collected and analyzed for the year 2021.

3. RESULTS

The radiography technique includes a crucial safety measure called personnel radiation monitoring. It cannot shield you from ionizing radiation on its own. Its primary objective is to assess the radiation dosage received by the medical staff, the appropriateness of radiation protection infrastructure, and the efficacy of radiation protection methods.

The rationale for a medical practice involving radiation exposure should be based on the concept that no procedure should be carried out unless it benefits the exposed people or society enough to compensate for the radiation harm it causes.

3.1. TLD readings analysis

Figure 1 shows the effective annual dose for the different categories of radiology workers in the three hospitals. The effective dose levels in hospital 3 are significantly higher than in hospitals 1 and 2. Hospital 2 has a higher effective dose than hospital 1 in the radiologists' category. In the category of physicians and operating room technologists, hospital 1 has a higher dose than hospital 2. The category of operation room technicians received the highest average effective dose in Hospitals 1 and 3. Hospital 2 had the highest effective dose in the category of radiology technologists.

The annual average effective dose for the chosen hospitals (hospitals 1, 2, and 3) is shown in Figure 2 and ranges from 0.98, 0.96, and 1.32 mSv, respectively. The average dose for all the employees is 1.08 mSv, which is less than the ICRP's annual occupational limit. Table 1 compares the annual effective dose of our study with the range of annual effective doses for studies conducted in other nations.

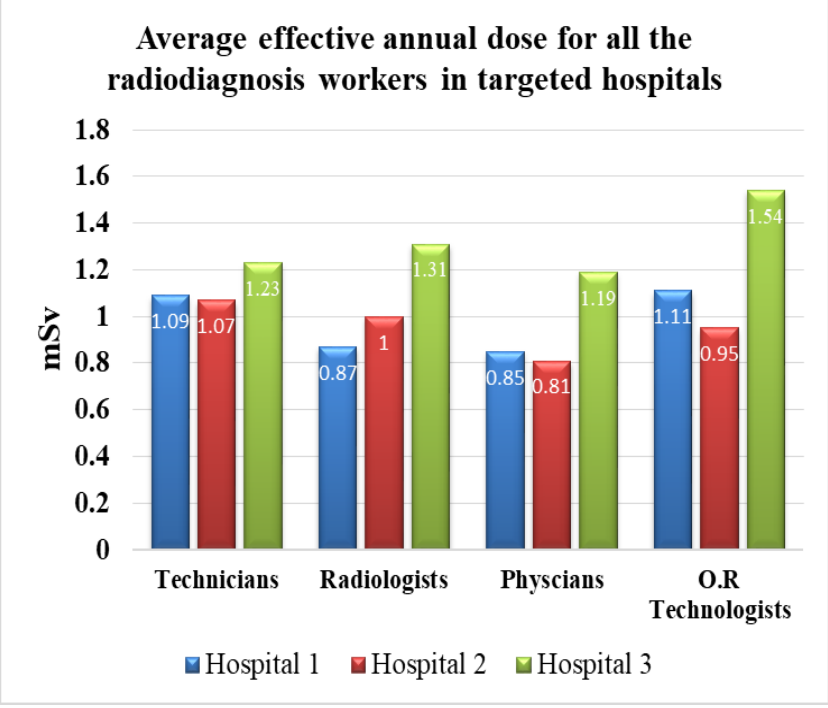

Figure : ١ Average annual effective dose for radiodiagnosis workers in targeted hospitals.

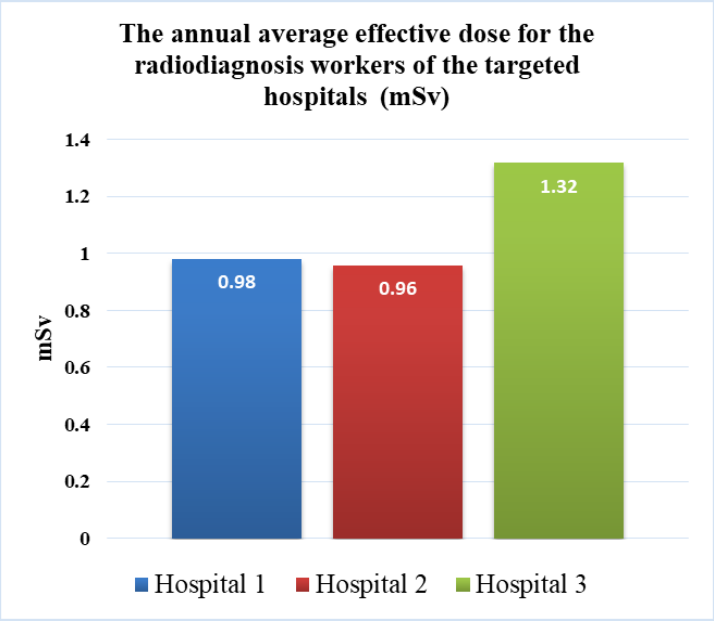

Figure 1:Average annual effective dose for all the radiodiagnosis workers in targeted hospitals.

Table 1: A comparative review of average effective doses (mSv) in different Countries [1].

Time Period	*Country*	*Average effective dose (mSv)*
2012-2013	South korea	1.8
2009	Japan	0.93
2007-2011	Pakistan	0.52
2011-2013	lithuania	0.62
2008 -2009	kuwait	1.05
2000-2009	Ghana	1.05
2015-2019	Saudi Arabia	0.82
2022	Saudi Arabia- sothern provience (current study)	1.08

3.2. Radiation Survey

Figure

3 shows the effective dose rate of the CT scan room in (µSv /week). Hospital 1 has a higher effective dose than the other hospitals' CT rooms (56 times greater than the CT scan in Hospital 3, and 6 times greater than Hospital 2). The significant variation in radiation levels in CT scan rooms among hospitals is caused by a broken door handle in the hospital 1 CT scan

room. This flaw caused radiation leakage, which was evident in the readings taken.

Despite the varying readings of radiation, all hospitals remained under the standard. The weekly effective dose should not exceed 100 µSv for the controlled areas.

Figure 4 shows the load for each unit regarding total exposure dose inside the targeted hospitals. In hospital 1, the CT is responsible for 97 % of total radiation exposure. CT was responsible for about 65% of the total exposure in hospital 2, while fluoroscopy was responsible for 25%. In hospital 3, angiography is represented by about 30%, CT is in charge for 35%, and x-ray and fluoroscopy are in charge of the rest.

3.3. The Questionnaire

Figure 5 shows all the hospital workers' responses to when was their last lecture about radiation protection attended. 13% never participated in a lecture. 34% attended since more than two years. 24% responded that they participated in a course within six months.

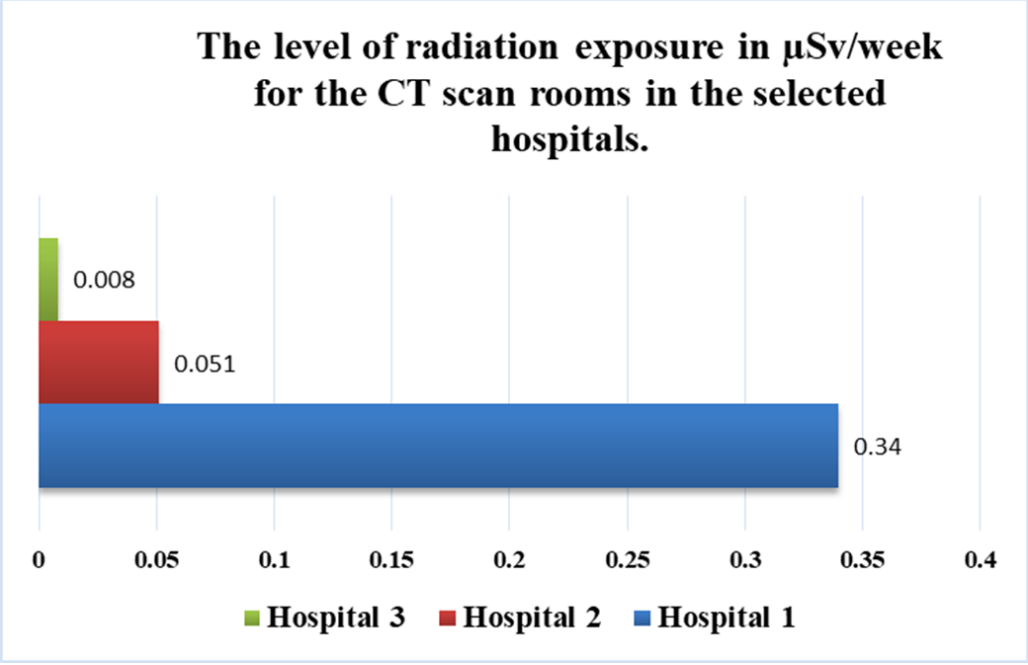

Figure 2:The survey meter of CT scan rooms shows the effective dose.

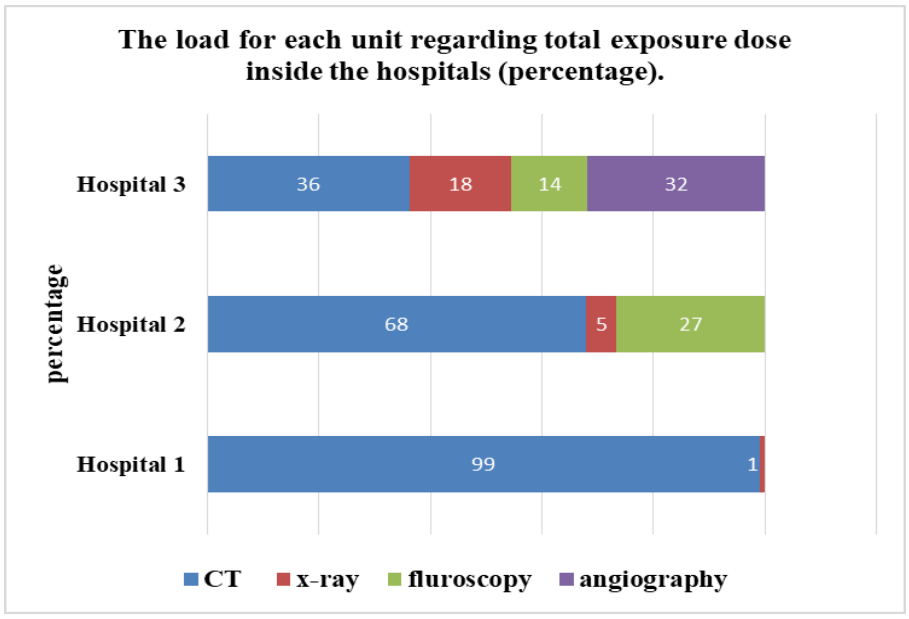

Figure 3: The load for each unit regarding total exposure dose inside the targeted hospitals.

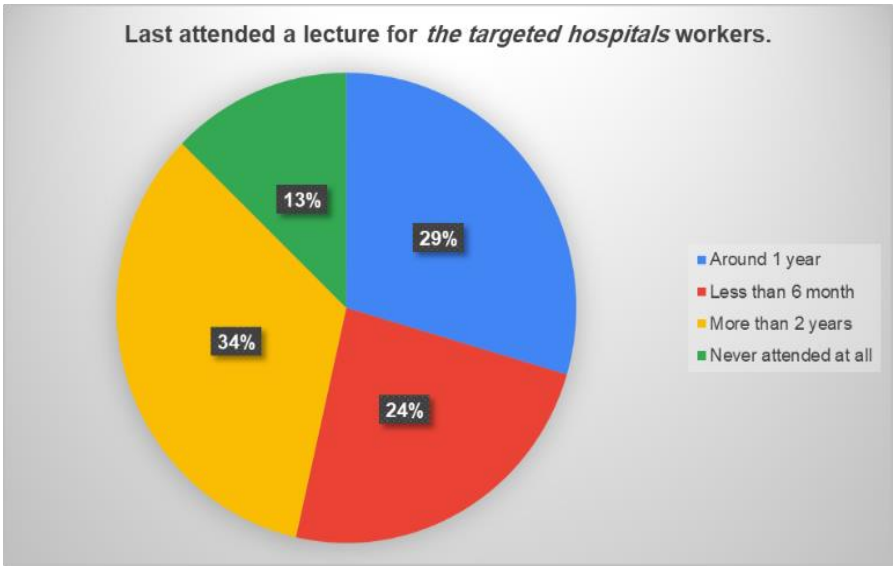

Figure 4: The targeted hospitals workers' response to last time's lecture attendance.

In Table 2, Regarding the knowledge of the allowed annual dose, the answers were yes, with 94%, 82%, and 56% in hospitals 3, 2, and 1, respectively. The answers to the two questions (the extent of knowledge of the basic principles of radiation protection and the degree of understanding of the principle of ALARA) were positive in all hospitals. Regarding the extent of satisfaction with the radiation protection unit in the hospitals, most of the hospital 3 and 2 staff

answered positively. In contrast, the response was dissatisfaction with, 48 % in hospital 1.

Table 3 shows the hospital workers' responses to rate their knowledge and if exposure-outcome was always given. 20% of the workers in hospital 1 answered that their knowledge about radiation protection is insufficient, while 13 % in hospital 2 said the same thing. Almost none of the workers in hospital 3 reported that their knowledge was inadequate. However, most of the workers in all hospitals reported that their knowledge is either good or excellent.

The majority answered affirmatively when asked if the exposure-outcome is always provided. As for the workers who answered no, the average was 18% for all hospitals. And the same for those who stated only sometime.

Table 2: The hospitals workers responses to knowing (allowed annual dose, ALARA principle, protection principle) and satisfaction with the radiation protection unit.

	Hospital 1		Hospital 2		Hospital 3	
	Yes	No	Yes	No	Yes	No
Knowing Allowed Annual Dose (%)	56	44	82	18	94	6
Knowing ALARA Principle (%)	88	12	91	9	100	-
Knowing the 3 radiation protection Principles (%)	80	20	87	13	88	12
Satisfaction with the radiation protection unit (%)	52	48	69	31	77	23

Table 3: The hospital workers responses to rate their knowledge, and if exposure-outcome always be given.

Hospitals	Rate your Knowledge (%)			exposure-outcome be given (%)		
	Excellent	Good	Insufficient	Yes	No	Sometimes
Hospital 1	28	52	20	60	20	20
Hospital 2	47	40	13	65	13	22
Hospital 3	47	47	6	73	10	17

4. Discussion

The public health system in Assir province serves a population of 2.3 million people and performs more than 680,000 imaging procedures each year [6]. Our study's findings are unexpected and concerning. Even though most of the medical team was aware of how vital radiation safety is, there were still considerable gaps in knowledge and practice. Even though it is below the ICRP's allowed annual effective dose, the study's occupational exposure results are considered more than expected if we know that the selected hospitals do not have nuclear medicine or radiotherapy departments. The delay in responding to the problem of breaking the door handle of the CT scan, despite the clarity of the problem, reflects the underestimation of the danger of the radiation and the insufficient qualification of radiation protection officials and radiology employees.

Irregularity in providing employees with the results of TLD readings periodically led to discontent among employees. This illustrates how poorly the radiology department employees and the radiation protection officials cooperate and coordinate. The questionnaire revealed a lack of understanding of radiation protection principles, a lack of some conventional radiation protection equipment, and a severe shortage of radiation protection education courses. Radiation protection is a shared obligation at all levels of the hospital, from the hiring authority to the staff performing imaging procedures [7]. Once the protective equipment has been placed, radiation protection should not be overlooked. Its goal must be comprehended, and proper radiation safety measures must be promoted until they become habitual. Staff behaviour is affected by their level of awareness about radiation protection. The level of occupational dose could decrease with good staff awareness and the provision of all personal radiation protective equipment.

We suggest conducting professional courses in radiation safety immediately and encouraging radiation protection officers and radiology personnel to attend to help them better understand radiation safety and health physics principles.

There were several general limitations; It is questionable if the given mA or kV values displayed in the panel are accurate because no verifying tool was available. The questionnaire had 71 participants, representing almost half of the radiological workers in the targeted hospitals. However, if we had been able to poll a larger group of workers, the outcomes would have been more accurate.

5. Conclusion

Every member of the medical staff and patient faces the risk of radiation exposure, and the levels are higher than anticipated. A quick prompt of radiation protection for all the staff and patients is necessary.

There is a severe shortage of radiation protection education courses, a lack of knowledge of radiation safety procedures, and dissatisfaction with radiation protection units inside hospitals. Many hospitals also lack some types of radiation protection equipment.

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تقييم التعرض المهني للإشعاع وتقييم الوعي بالوقاية من الإشعاع بين الكوادر الطبية في المرافق الإشعاعية في المنطقة الجنوبية من المملكة العربية السعودية

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الملخص:

مما لا شك فيه أن أحد أكثر طرق التشخيص الطبي فعالية هو الإشعاع المؤين في التصوير الإشعاعي ، على الرغم من مخاطره المحتملة. تهدف هذه الدراسة إلى تقييم التعرض الوظيفي في مكان العمل وتدابير السلامة للموظفين الطبيين العاملين في مرافق الرعاية الصحية في المنطقة الجنوبية من المملكة العربية السعودية. تم اختيار ثلاثة مستشفيات عشوائياً في الفترة من يناير الى ديسمبر ٢٠٢١ لاجراء الدراسة. تم إجراء مسح إشعاعي لقياس مستويات الإشعاع في نقاط مختلفة داخل أقسام الأشعة في المستشفيات المستهدفة. كما تم إجراء استبيان لتقييم مدى معرفة العاملين باجراءات وأساسيات الحماية من الإشعاع، علاوة على ذلك, تم جمع قراءات ال TLD للعاملين باقسام الاشعة وتحليلها لقياس جرعة التعرض المهني. النتائج أظهرت تفاوت متوسط الجرعة الفعالة السنوية للمستشفيات المختارة (المستشفيات ١ و ٢ و ٣) في النطاق ٠,٩٨ و ٠,٩٦ و ١,٣٢ ملي سيفرت على التوالي. على الرغم من أن النتائج أقل بكثير من الحد السنوي المسموح به البالغ ٢٠ ملي سيفرت في عام واحد ، إلا أنه يعتبر مرتفعًا إذا علمنا أن المستشفيات المختارة لا تحتوي على أقسام للطب النووي أو العلاج الإشعاعي. أظهر المسح الإشعاعي ارتفاعا خطيرا في مستوى الإشعاع بغرفة الأشعة المقطعية بإحدى المستشفيات. اما فيما يتعلق بنتائج استبيان السلامة من الإشعاع ، أتضح ان هناك نقص في فهم تدابير الحماية من الإشعاع. كما ذكر ٤٥٪ من العمال أن بعض أدوات الحماية من الإشعاع (عباءات الرصاص ، قفازات الرصاص ، نظارات الرصاص ، وغطاء الغدة الدرقية) غير متوفرة. كما ذكر ١٣٪ من العاملين بأقسام الاشعة انهم لم يحضروا اي محاضرة عن الحماية من الإشعاع مطلقًا ، وقال ٣٤٪ منهم أنهم حصلوا عليها منذ أكثر من عامين.

كلمات مفتاحية: التعرض المهني، السلامة من الإشعاع، جرعة التعرض، المسح الإشعاعي، المعرفة والوعي.