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EVALUATING OCCUPATIONAL DOSE MONITORING IN RADIOLOGY: A CASE STUDY OF RADIOGRAPHERS AT FEDERAL MEDICAL CENTRE JALINGO

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ABSTRACT

Background: One essential component of radiological safety is occupational dose monitoring (ODM), which shields radiation workers from any radiation health-related concerns. Radiographers are frequently exposed to different radiation levels, which calls for strict monitoring and control procedures to guarantee their safety. This study aims to assess the level of Radiographers' occupational dose level (ODL). It will also assess whether the current dose limits are effective and in line with international radiation safety standards.

Methods: This was a questionnaire-based study. Ethical approval was sought from the institution's ethics committee. Participants were only Radiographers and were actively involved in routine Departmental activities within the last 12 months at the study site. Consented Radiographers were recruited and issued a validated questionnaire. The questionnaire contains closed-ended questions on demography, personnel radiation dose level, and their perceived effectiveness of institutional radiation protection practices. Data was processed and expressed in terms of frequency and proportions.

Results: A total of 26 responses were collected, with 79.9% (n=20) being male and 23.1% (n=6) being female. Radiographers with B. Rad. degrees were the highest with 34.6% (n=9). About 66.4% (n=17) of Radiographers operate within safe dose limits, while 34.6% (9) are within the maximum permissible dose of 20mSv. There was effective implementation of safety measures and adherence to radiation protection guidelines as 81% (n=25) of respondents were satisfied with the effectiveness of ODM at the study center. Key radiation protection practices such as the presence of lead lining walls, use of TLDs, and working closely with regulated authorities among others.

Conclusion: Primary radiation workers are conscious of ODL and working within the recommendations. The institutionalized radiation protection measures are effective and they closely collaborate with relevant authorities on best radiation protection practices at the study site.

Keywords: Occupational Dose Monitoring, Radiation Safety, Radiographer, Radiation Workers

Introduction

X-radiation is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in effective healthcare delivery both in the developed and developing countries[1]. It is known that of all man-made sources of ionizing radiation, diagnostic X-rays contribute the largest part to the collective population dose leading to somatic and genetic effects on human beings[2].

Occupational radiation doses (ORD) are radiation energies absorbed by individuals working in the radiological industry[3]. One of the hazards of working in the Radiology Department is the possibility of long-term exposure to low-level radiation which may have deleterious biological effects. Individuals exposed to radiation in the cause of his or her work are at some increased risk of cancer albeit small concerning the background risk from other causes[5]. This means a significant cancer risk can be induced by long-term chronic exposure to low dose ionizing radiation when the cumulative dose reaches a pre-determined level[6].

The importance of protective practices by Radiographers and other Radiation workers to keep ionizing radiation doses as low as reasonably achievable can never be over-emphasized given its obvious detrimental effects. It is reported that Radiographers in Nigeria are exposed to high radiation risk due to the possible dependence on refurbished equipment and the extremely high workload traditionally known to the Radiology Department[7].

Radiology departments in Nigeria have traditionally been known to be busy due to their value in the diagnosis and management of various patient conditions. Despite having a sufficient number of radiation workers/professionals who have actively been working with radiation at the study site, the effectiveness of existing personnel monitoring has not been previously studied at the study site.

It is therefore necessary that the occupational radiation values from this setting be assessed to understand their conformity with recommended values. Regular monitoring of radiation doses received by staff in the radiology department is of great importance. This is to protect the staff, patients, and the public from the effect of excessive radiation during and after radiological examinations of patients[8]. This will ensure occupational safety as dose limits will consciously not be exceeded. The accepted dose limit for occupational staff as reported by the International Commission on Radiological Protection (ICRP) is 20 mSv per year averaged over five (5) years (100 mSv in 5 years)[9]. The United Nations Scientific Committee on the Effects of Atomic Radiation has reported that the worldwide mean annual occupational dose in diagnostic radiology and nuclear medicine is below 2 mSv[2,6,9,10]. The Nigerian Basic Ionizing Radiation Regulations (NBIRR) has recommended an effective dose limit of 100 mSv in any period of five consecutive years (i.e., an average of 20 mSv per year)[11]. It also recommended a maximum effective dose of 50 mSv in any single calendar year for an employee aged 18 years and above and 6 mSv for a trainee under the age of 18 years[11]. Studies of occupational radiation dose have focused mainly on the physicians who carry out interventional radiological procedures[12]. Therefore, this study is aimed at determining the effectiveness of occupational dose monitoring among Radiographers of the Radiology Department of FMC, Jalingo Northeast, Nigeria.

Methods:

A descriptive questionnaire-based study design was adopted. It involved Radiographers working in the Radiology Department of Federal Medical Center, Jalingo, Taraba State, Northeast Nigeria.

The center is equipped with three operational x-ray emitting units: two stationary units (**models**: *PLD5000B and EASY-DR-2022-0158*) and one mobile digital unit (**model**: *MHF-2030*).

As a tertiary health facility, the department receives referrals throughout the state and neighboring regions. All routine, ward and special radiographic procedures are conducted on scheduled appointments. A validated questionnaire was utilized and fielded on consented participants who satisfied the inclusion criteria. This was following ethical approval by the relevant human research ethics committee with ref: *NHREC/FMCHALHREC/17/05/2023*. Only verified

Radiography staff at the study site within the last 12 calendar months who were holders of current practicing licenses were recruited. Any worker other than this was excluded. The fielded validated questionnaire contains the relevant sections for socio-demographics, estimated occupational radiation dose received by radiation workers, and the perceived effectiveness of the institution's radiation protection principles. Measurement of the occupational radiation dose received from each participant was sourced from the participants' radiation dose record. The Department has a functional radiation monitoring program where a dedicated thermoluminiscent dosimeter (TLD) is issued to each radiographer. The Department's Medical physicist retrieves the TLDs at regular intervals (at most quarterly) and sent for dosimetry analysis at an internationally accredited center: Centre for Energy Research and Training (CERT), Zaria, Kaduna State, Nigeria. The occupational radiation dose received by each participant is then presented on a quarterly and annual basis. Similarly, the questionnaire contains components of respondents' perception of institutions' effectiveness in radiation protection measures and principles. Descriptive statistics (frequency, percentage, and charts) were used for data presentation.

Results:

A total of twenty-six (26) participants who satisfied the inclusion criteria were recruited into the study. They comprised 76.9% (n=20) males and 23.1% (n=6) females. Table 4.1 offers valuable insights into the demographic characteristics of the respondents, providing a foundation for understanding the composition of the radiography department. Participant's distribution on educational qualification, duration of working experience, and current rank is presented. The educational qualifications of the respondents vary; B. Rad. (Bachelor of Radiography) was the most common qualification, accounting for 34.6% (n=9). The least qualifications were holders of postgraduate qualifications with just 11.5% (n=3). The highest proportion of the workforce with working experience were those with less than 5 years' experience with 61.5% (n=16) while the least were those with > 10 years 3% (n=3). Based on rank, Intern Radiographers had the highest proportion with 42.3% (n=11), while Chief Radiographers had the least with 7.7% (n=3). These demographic features present a picture of the diversity among the radiography workforces. The workforce includes individuals with different educational backgrounds, varying levels of experience, and occupying different positions within the organizational hierarchy. The information presented is instrumental for human resource management and organizational planning within healthcare facilities. Figure 1 illustrates the occupational radiation doses received by Radiographers at the study site as presented in figure 1.

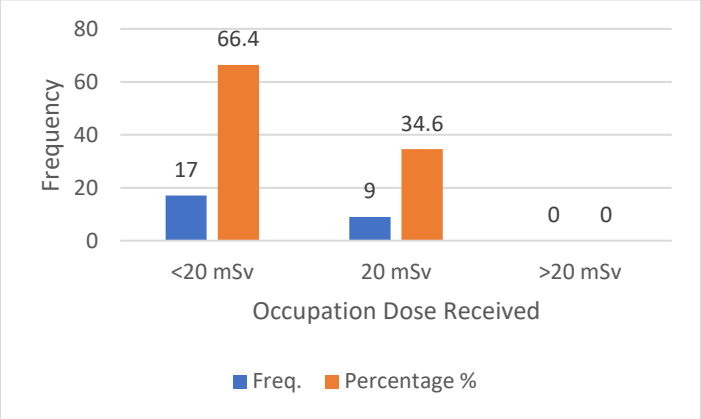

Figure 1: Estimated occupational radiation dose received by Radiographers at the study site

In reference to the international recommendation of the permissible dose limits of not greater than 20mSv, doses received by participants were categorized into three groups namely: less than 20mSv, 20mSv, and >20mSv. About 66.4% of Radiographers received radiation doses below 20mSv, while the remaining 34.6% of the respondents had their doses just within 20mSv. No radiographer received a dose above the 20mSv mark (Figure 1) The perceived effectiveness of occupational dose monitoring was also assessed by the respondents. About 81%(n=25) of the respondents highlighted the existence of an effective monitoring of occupational radiation dose among the practicing Radiographers while only 19% (n=5) responded the opposite (Figure 2).

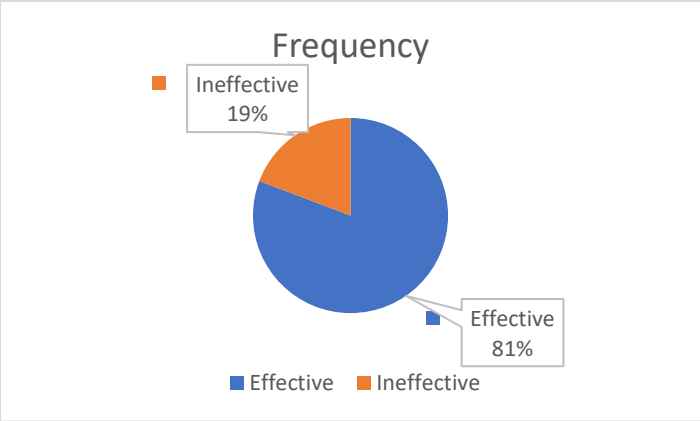

Figure 2: Effectiveness of Occupational Dose Monitoring at the study site

The radiation protection practices reported include making exposure only within the confines of a lead-lined room, working only with a TLD, automatic approval for 60 working days leave, active monitoring and collaboration with regulatory authorities e.g. NNRA and a licensed radiation safety adviser each had a response of 21.5%, 21.5%, 18.6%, 21.5% and 16.9% respectively.

Table 1: Demographic distribution of participants

Variable	Category	Frequency	Percentage (%)
Gender	Male	20	76.9
	Female	6	23.1
Highest Qualification	B.Sc.	4	15.4
	DCR	6	23.1
	B. Rad.	9	34.6
	PGD MRI	4	15.4
	M.Sc	3	11.5
Working Experience	< 5 years	16	61.5
	6-10 years	7	26.9
	>10 years	3	11.5
Position	Intern	11	42.3
	Radiographer I	4	15.4
	Radiographer II	6	23.1
	Senior Radiographer	3	11.5
	Chief Radiographer	2	7.7
	Total	**26**	**100.0**

Discussion:

To protect the health and safety of radiation workers who are frequently exposed to ionizing radiation, occupational dose monitoring is an essential practice. This concept remains valuable especially for radiographers to ensure their exposure remains within safe limits, thereby protecting their health and preventing long-term radiation-related illnesses. The monitoring helps maintain compliance with regulatory standards and ensures a safe working environment. Additionally, it enables early detection and mitigation of any overexposure, promoting a culture of safety and awareness within the radiography profession. To verify adherence to set safety guidelines and dosage limitations, such as those advised by the International Commission on Radiological Protection (ICRP), this monitoring entails the methodical measurement and evaluation of radiation exposures received by employees.

In the present study, most radiographers, who legally hold the sole responsibility of directly applying radiation to human tissues, possess a Bachelor of Radiography degree, with males significantly outnumbering females. The proximity of the institution to the University of Maiduguri, the first northern university to offer a radiography degree, likely

contributes to the higher number of degree holders. Additionally, the greater male-to-female distribution can be attributed to the socio-cultural practices in Northern Nigeria, where males are more frequently sponsored and encouraged to pursue formal education and civil service careers, while females are often limited in these opportunities and typically become housewives[13]. Interestingly, they were found to operate within the recommended dose limits. This suggests a commendable implementation of safety measures and strict adherence to radiation protection guidelines in the workplace. A possible explanation for this may be due to the recruitment of adequate professionals with the requisite qualifications. Similarly, the presence of radiographers with postgraduate qualifications who have had a minimum of 6-10 years of working experience may further support this finding, as they may tutor the younger cadre radiographers on the safe limits of occupational radiation doses in their daily practices. Thus, reflecting a positive commitment to ensuring the well-being of personnel and patients alike at the study site.

In the present study, a higher proportion of the respondents believed that occupational dose monitoring is effective. This positive perception among the staff indicates confidence in the existing monitoring systems, contributing to a sense of security and trust within the work environment. This finding aligns with a study conducted by Yahaya and Hassim (2015)[14] on radiation risk estimation from occupational medical imaging exposure in Malaysia and Jabeen *et al.,* (2010)[15] in Pakistan who reported on occupational exposure from external radiation used in medical practices by film badge over a period of 5 consecutive years. Similar findings were reported by Razaq *et al.,* (2016) where they evaluated radiation workers' occupational doses for newly established medical in Pakistan[16]. These may be attributed to radiation workers' consciousness of the need for constant optimization of techniques and absolute adherence to international protocols of radiation application to humans. The positive perception of occupational dose monitoring across radiology units indicates a level of satisfaction among the radiographers. This is crucial for maintaining a healthy working environment and promoting the overall well-being of the workforce. However, all these can be possible only when qualified human resources also participate in periodic professional update courses. Recognizing and addressing any concern or challenge raised by the remaining percentage in the present study can further enhance employee satisfaction.

Key radiation practices worth stressing at the study site were the use of lead lining, thermoluminiscent dosimeters (TLD), allowing staff leave (60 days), and absolute collaboration and adherence to the recommendations of the Nigerian Nuclear Regulatory Agency (NNRA). The findings regarding adherence to safe occupational radiation dose limits and the effectiveness of the institutionalized occupational dose monitoring system at the study site imply that the current radiation protection practices at the site are robust, current, and in line with international recommendations and best practices. However, continuous efforts should be made to strengthen these practices and ensure they remain effective in the dynamic field of medical radiography. Similarly, identifying and addressing any concerns or challenges raised by the remaining percentage can further enhance employee satisfaction

To sustain these practices, it is recommended that continuous training programs be implemented to keep the workforce updated on the latest guidelines and safety measures. Additionally, awareness campaigns can reinforce the importance of adherence to established protocols. These may be limited in their generalization as caution should be employed due to the nature of the research design. Being a response-dependent study, the responses are subjective. Similarly, due to the continuous nature of Radiographer's availability, their distribution could vary soon. This should be noted when applying the findings of this study.

In conclusion, Federal Medical Center Jalingo is implementing commendable radiation protection measures, contributing to a safe working environment for radiographers. The combination of employing a qualified workforce, established practices and positive

perceptions among staff members signifies a commitment to ensuring both patient and personnel safety.

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Conflict of Interest

The authors hereby declare the absence of any conflict of interest throughout the entirety of this piece

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