A Decennial Thermoluminescent Dosimetry Analysis of Occupational Deep and Shallow Doses at a Nigerian Tertiary Hospital (2015–2024)

Salihu A. Yusuf[1*]; Halilu S. Daniel[2]; Abdulmumini K. Yusuf[3]

[1,2,3]Department of Radiology, Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Bauchi, Nigeria

Corresponding Author: Salihu A. Yusuf*

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Abstract:

- ***Background:***

Occupational exposure to ionizing radiation is an unavoidable risk in diagnostic radiology. Long-term monitoring of radiation dose to healthcare workers is essential for ensuring compliance with international safety standards and minimizing deterministic and stochastic health effects (ICRP, 2007; UNSCEAR, 2020).

- ***Objective:***

To evaluate decennial trends (2015–2024) in occupational radiation exposure among diagnostic radiology personnel at Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Bauchi, Nigeria, using thermoluminescent dosimetry.

- ***Methods:***

A retrospective longitudinal study was conducted among 30 radiology personnel with uninterrupted thermoluminescent dosimeter (TLD) monitoring. Quarterly deep dose equivalent ($H_p(10)$) and shallow dose equivalent ($H_p(0.07)$) values were aggregated annually and analyzed descriptively. Observed doses were compared with International Commission on Radiological Protection (ICRP) occupational dose limits.

- ***Results:***

The mean annual effective dose ($H_p(10)$) was 2.00 ± 0.60 mSv, representing approximately 10% of the ICRP annual occupational limit. Radiographers recorded the highest exposure levels, followed by radiologists, while technicians had the lowest doses. Occasional quarterly elevations—particularly in shallow dose—were observed.

Occupational radiation exposure among diagnostic radiology personnel at ATBUTH remained within internationally recommended limits over the ten-year period. However, episodic dose increases highlight the need for continuous optimization of radiation protection practices and sustained training programs.

Keywords: *Occupational Radiation Exposure; Thermoluminescent Dosimetry; Diagnostic Radiology; Deep Dose; Shallow Dose; ALARA; Nigeria.*

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I. INTRODUCTION

Diagnostic radiology plays a central role in contemporary healthcare but exposes medical personnel to ionizing radiation during routine clinical practice. Although individual exposure levels are typically low, cumulative occupational exposure may result in deterministic tissue reactions or increased stochastic cancer risk if not adequately monitored and controlled (ICRP, 2012; UNSCEAR, 2020; National Research Council, 2006).

Thermoluminescent dosimeters (TLDs) are internationally accepted tools for personal radiation monitoring. They provide reliable estimates of deep dose

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equivalent ($H_p(10)$), representing whole-body exposure, and shallow dose equivalent ($H_p(0.07)$), reflecting skin and extremity exposure (Omojola et al., 2018; ICRU, 2011; IAEA, 2014). Continuous monitoring enables institutions to evaluate compliance with the International Commission on Radiological Protection (ICRP) occupational dose limits and to apply the ALARA principle (ICRP, 2007; WHO, 2013).

In Nigeria, the increasing availability of advanced diagnostic imaging modalities has raised concerns regarding occupational radiation safety. However, long-term institutional exposure data remain limited, particularly decennial analyses capable of guiding evidence-based radiation protection policies (Usman et al., 2020; Okawele et al., 2024). This study addresses this gap by providing a ten-year evaluation of occupational radiation exposure at ATBUTH.

II. MATERIALS AND METHODS

- *Study Design and Setting*

This retrospective longitudinal study was conducted in the Department of Radiology, Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Bauchi, Nigeria, a tertiary referral center offering comprehensive diagnostic radiology services.

- *Study Population*

The study population comprised 30 radiology personnel, including radiologists, radiographers, and technicians, who underwent uninterrupted personal dosimetry monitoring between January 2015 and December 2024. Similar population sizes and professional distributions have been reported in occupational exposure studies in comparable settings (Usman et al., 2020; Sultan Qaboos University Hospital Radiation Protection Research Group, 2021).

- *Dosimetry and Data Collection*

Quarterly TLD reports documenting deep dose equivalent ($H_p(10)$) and shallow dose equivalent ($H_p(0.07)$) were retrieved from departmental and regulatory archives. Annual doses were calculated by summing quarterly measurements, in accordance with international dosimetry standards (IAEA, 2014; NCRP, 2007).

- *Data Analysis*

Descriptive statistics were used to compute mean annual and cumulative doses. Observed values were compared with ICRP-recommended occupational dose limits of 20 mSv per year averaged over five years (ICRP, 2007; ICRP, 2012).

- *Ethical Considerations*

Ethical approval was obtained from the ATBUTH Ethical Review Committee. All dosimetry data were anonymized to ensure confidentiality and compliance with ethical research standards.

III. RESULTS

- *Overall Occupational Radiation Dose*

The mean cumulative deep dose over the ten-year period was 20.00 mSv, corresponding to a mean annual effective dose of 2.00 ± 0.60 mSv. This value represents approximately 10% of the ICRP annual occupational dose limit and is consistent with findings from similar studies in Nigeria and internationally (Usman et al., 2020; Sultan Qaboos University Hospital Radiation Protection Research Group, 2021).

- *Dose by Professional Category*

Radiographers recorded the highest mean annual deep dose (2.60 mSv), followed by radiologists (1.50 mSv), while technicians had the lowest exposure (1.10 mSv). This pattern reflects task-related exposure differences and has been widely reported in occupational dosimetry literature (Omojola et al., 2018; Okawele et al., 2024; Vañó et al., 2010).

- *Quarterly Dose Variations*

Isolated quarterly dose elevations were observed, particularly in shallow dose equivalents, with peak values reaching 2.5 mSv. Such episodic increases are commonly associated with periods of increased workload, closer operator positioning, or inadequate shielding (Abuzaid et al., 2024; Miller et al., 2010).

IV. DISCUSSION

This decennial analysis demonstrates that occupational radiation exposure among diagnostic radiology personnel at ATBUTH remained consistently within ICRP-recommended limits throughout the study period. The mean annual effective dose was substantially below the 20 mSv occupational threshold, aligning with reports from other Nigerian centers and international institutions (Usman et al., 2020; Sultan Qaboos University Hospital Radiation Protection Research Group, 2021).

Radiographers exhibited higher exposure levels than radiologists and technicians, reflecting their direct involvement in equipment operation and patient positioning. Similar exposure distributions have been documented globally, particularly in high-workload diagnostic and interventional environments (Omojola et al., 2018; Vañó et al., 2010; Miller et al., 2010).

Although quarterly dose spikes were infrequent and remained within permissible limits, their occurrence underscores the importance of continuous adherence to radiation protection principles, including optimization of work practices, use of personal protective equipment, and regular training (ICRP, 2017; WHO, 2013; IAEA, 2018).

V. CONCLUSION

Occupational radiation exposure among diagnostic radiology personnel at ATBUTH from 2015 to 2024 remained within internationally accepted safety limits. However, higher exposure levels among radiographers and

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episodic dose elevations highlight the need for sustained monitoring, optimization of high-dose procedures, and reinforcement of radiation safety culture.

RECOMMENDATIONS

- Implementation of dual dosimetry (under-apron and collar badges) for staff involved in fluoroscopic and high-dose procedures (ICRP, 2017).
- Periodic review and optimization of high-exposure procedures to further reduce occupational dose (IAEA, 2018).
- Continuous radiation protection training and administrative monitoring in line with ALARA principles (WHO, 2013).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

- Salihu A. Yusuf: Conceptualization, supervision, correspondence, critical manuscript review.
- Halilu S. Daniel: Radiation protection analysis and technical input.
- Abdulmumini K. Yusuf: Data acquisition, analysis, and manuscript drafting.

REFERENCES

[1]. Abuzaid, M. M., Noorajan, Z., Elshami, W., & Ibham, M. (2024). Monitoring occupational radiation dose in radiography students: Implications for safety and training. Safety, 10(2), 35. https://doi.org/10.3390/safety10020035

[2]. International Atomic Energy Agency. (2014). Occupational radiation protection in diagnostic and interventional radiology (Safety Standards Series No. GSR Part 3). IAEA.

[3]. International Atomic Energy Agency. (2018). Radiation protection and safety in medical uses of ionizing radiation (GSG-2). IAEA.

[4]. International Commission on Radiological Protection. (2007). The 2007 recommendations of the International Commission on Radiological Protection (ICRP Publication 103). Annals of the ICRP, 37(2–4), 1–332.

[5]. International Commission on Radiological Protection. (2012). ICRP statement on tissue reactions and early and late effects of radiation in normal tissues and organs (ICRP Publication 118). Annals of the ICRP, 41(1–2), 1–322.

[6]. International Commission on Radiological Protection. (2017). Occupational radiological protection in interventional procedures (ICRP Publication 135). Annals of the ICRP, 46(2).

[7]. International Commission on Radiation Units and Measurements. (2011). Operational quantities for radiation protection (ICRU Report 85). Journal of the ICRU, 11(1).

[8]. Miller, D. L., Vañó, E., Bartal, G., et al. (2010). Occupational radiation protection in interventional radiology: A joint guideline. Journal of Vascular and Interventional Radiology, 21(5), 607–615.

[9]. National Research Council. (2006). Health risks from exposure to low levels of ionizing radiation: BEIR VII Phase 2. National Academies Press.

[10]. Okawele, K. N., Nathaniel, E. U., & Ekanem, A. M. (2024). Occupational radiation dose absorbed by radiographers in Port Harcourt, Rivers State. Researchers Journal of Science and Technology, 4(1), 21–31.

[11]. Omojola, A. D., Onoride, M. A., Akpochafor, S., et al. (2018). Personnel radiation dose assessment using a novel dosimeter in Nigeria. The European Research Journal, 4(2), 70–78.

[12]. Sultan Qaboos University Hospital Radiation Protection Research Group. (2021). Assessment of occupational radiation doses in Oman. Radiation Protection Dosimetry, 197(1), 36–45.

[13]. United Nations Scientific Committee on the Effects of Atomic Radiation. (2020). Sources and effects of ionizing radiation: UNSCEAR 2020 Report. United Nations.

[14]. Usman, S., Joseph, D. S., Muhammad, B. G., & Joseph, D. Z. (2020). Evaluation of occupational radiation exposure in Katsina, Nigeria. FUDMA Journal of Sciences, 4(2), 722–729.

[15]. World Health Organization. (2013). Guidance on the implementation of the ALARA principle in medical exposure (WHO Technical Report Series No. 972). WHO.