

Adherence and Barriers to Effective CT Dose Management Among Radiographers in Northeastern Nigeria: A Multicentre Study

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ABSTRACT

Computed Tomography (CT) accounts for a substantial proportion of medical radiation exposure globally. Although the International Commission on Radiological Protection (ICRP) recommends structured dose management strategies, including the use of Diagnostic Reference Levels (DRLs) and dose monitoring systems, implementation remains inconsistent in many low-resource settings, with limited evidence from northeastern Nigeria. This study assessed adherence to recommended CT dose management practices and identify challenges to the effective implementation among radiographers in northeastern Nigeria. A cross-sectional study was conducted among radiographers working in public and private facilities with functional CT scanners across selected northeastern states. Data was collected using a validated questionnaire and structured observational checklist (S-CVI/Ave of 0.87), (Cronbach's $\alpha = 0.724$). Descriptive statistics and the Mann-Whitney U test was used for data analysis. A total of 110 radiographers participated (64.5% male; mean experience 6.21 ± 4.39 years). Only 36.7% reported active patient dose monitoring, 38.2% acknowledged established DRLs, and 30.9% regularly reviewed dose reports. Protocol selection based on clinical indication was observed in only 4.5% of cases. Patient dose tracking was absent in 90.9% of observed examinations. Major barriers included lack of training (75.5%), limited awareness (62.7%), time constraints (40.0%), equipment limitations (38.2%), and resistance to change (30.9%). CT dose optimization in northeastern Nigeria remains suboptimal and requires structured training, institutional reform, and mandatory dose monitoring frameworks to align practice with international standards.

Keywords: Benchmarking, Dose Management, Dose Matrix Optimization, Radiographers

1.0 INTRODUCTION

Computed Tomography (CT) is an indispensable imaging modality in modern medicine, but it delivers relatively high radiation dose to patients, and an increased risk of cancer is of significant concern (Jasieniak *et al.*, 2023; IAEA, 2023). Media coverage of radiation overexposure incidents (e.g., FDA alerts in 2010) and subsequent ICRP publications heightened public and professional awareness (Kalra *et al.*, 2015). In response to these concerns, CT vendors, healthcare institutions, and regulatory bodies employed various techniques and protocols to reduce radiation dose while maintaining image quality (Kalra *et al.*, 2015). Despite these advancements, evidence suggests a persistent gap between available dose-reduction innovations and their routine application in clinical practice (Joyce *et al.*, 2020; Adejoh 2022; Bamanga *et al.*, 2026). Effective dose management is therefore, essential in minimizing patient radiation dose while maintaining high-quality diagnostic images (ICRP 2007). Proper dose management involves understanding and applying various dose metrics, using dose reduction techniques, and continuously monitoring and optimizing radiation dose (Joyce *et al.*, 2020). A dose reduction program cannot be successful without an effective method of

managing protocols and Radiographers' practice (Eastman *et al.*, 2024). Global best practice recommends consistent application of dose optimization strategies (ICRP 2017, Seeram 2023). Radiographers, as frontline gatekeepers of radiation protection in diagnostic imaging, often possess the knowledge and skills for CT dose optimization, including integrating cutting-edge innovations with global standards (Bamanga *et al.*, 2026, ISRR 2018). Yet, they struggle to translate this expertise into practice due to systemic challenges and an unsupportive environment (Bamanga *et al.*, 2026). There is a paucity of studies on challenges affecting CT dose management practice in northeastern Nigeria. Therefore, this study aimed at assessing adherence and challenges to effective CT dose management practice among Radiographers in northeastern Nigeria.

2.0 MATERIAL AND METHOD

A cross-sectional quantitative study using questionnaire surveys and observational components, among Radiographers performing CT scan in Public and private healthcare facilities with functional CT scanners across selected states in Northeastern Nigeria.

2.1 Study Population and Sampling

The study population comprised 317 radiographers working with health facilities across Northeastern Nigeria. The number of radiographers was obtained from the records of the Radiographers Registration Board of Nigeria (RRBN), Maiduguri Zonal Office (June 6, 2025). Given the manageable size of the target population, a census approach was adopted.

2.2 Instrument of Data Collection

The observation checklist and questionnaire were extracted from ICRP publications on Dose management in CT and dose reference levels (ICRP 2017; ICRP 2018) and Dose optimization in digital radiography and CT by Seeram, (2023). consisting of three sections: demographic characteristics, adherence to recommended CT dose optimization, and barriers to CT dose management techniques. The observational checklist focusses on compliance with established CT imaging standards, including protocol selection, use of ATCM, patient positioning, quality control procedures, and radiation dose monitoring practices.

2.3 Validity and Reliability of the Instrument

Content validity of the instrument was established through expert review by three specialists in radiography and radiation protection. Items were assessed using a four-point relevance scale, and content validity was evaluated using the Item-Level Content Validity Index (I-CVI) and Scale-Level Content Validity Index (S-CVI/Ave). The S-CVI/Ave of 0.87 indicated good content validity, confirming the instrument's relevance and appropriateness. It was then pilot-tested with 20 radiographers outside the main study, showing acceptable reliability (Cronbach's $\alpha = 0.724$).

2.4 Recruitment Procedure

Six CT-equipped facilities across four states in Northeastern Nigeria met the study eligibility criteria and were included in the study. These comprised two centres in Gombe, two centres in Adamawa, one centre in Bauchi, and one centre in Yobe State. States without functional CT scanners during the study period were excluded. Participants were recruited through visits to the radiology departments of the selected facilities. Following eligibility assessment, the study objectives

were explained, informed consent was obtained, and questionnaires were distributed to consenting radiographers. To complement the self-reported data, an observational component was conducted involving 44 radiographers selected purposively from the survey participants. Selection was based on active involvement in routine CT examinations, availability during the observation period, willingness to participate, and representation across all participating facilities. Non-participant observations were conducted during routine clinical practice without researcher intervention.

2.5 Data Analysis

Descriptive statistics and the Mann–Whitney U test was used for data analysis. Statistical significance was set at $p < 0.05$, and levels of adherence was assessed using a scoring system adapted from Yusof *et al.*, (2011) Each correct response was assigned one point, while incorrect responses received zero points. Scores were converted to percentages and categorized as poor (0–49%), moderate (50–69%), or good (70–100%). Analyses were performed using IBM SPSS Statistics version 27.0.

2.6 Ethical Consideration

Ethical approval was obtained from the relevant research ethics committee (NHREC/FUHSTHA/11/11/24). Informed consent was obtained from all participants.

3.0 RESULTS

A total of 160 questionnaires were distributed, of which 110 were completed and returned, yielding a response rate of 68.8%. Additionally, 44 non-participant observations were conducted across the six participating hospitals.

The study population (N = 110) was predominantly male (64.5%) and government-employed (95.5%), with the majority holding a Bachelor of Radiography degree (76.4%) and averaging 6.21 ±4.39 years of experience using various GE, Fujifilm, and Toshiba CT scanners installed between 2016 and 2025. During the study period, only six scanners were operational within the region as shown in Table 1.

Table 1: General Demographic Characteristics of Participants

Variable		Frequency (%)
Gender	Male	71 (64.5%)
	Female	39 (35.5%)
Qualification	B. Rad	84 (76.4%)
	PGD	8 (7.3%)
Place of work	M.Sc.	18 (16.4%)
	Government Institution	105 (95.5%)
	Private Institution	5 (4.5%)
Years of experience	1yrs	19 (17.3%)
	2-5yrs	42 (38.2%)
	6-10yrs	25 (22.7%)
	11-15yrs	23 (20.9%)

	16–20yrs	1 (0.9%)
	Mean, Std. Deviation 6.21 ± 4.39	
Scanner model and Year of installation	Fujifilm 32	2024
	GE, 16,32, 128,128	2016, 2020,2024,2025
	Toshiba	2017

Most participants 84 (77.1%) reported that the CT protocols being used in their departments were tailored to specific clinical indications, although 16 (14.7%) indicated otherwise, and 9 (8.3%) had no idea. Only 40 (36.7%) of respondents stated that their facilities actively monitored patient dose, while 49 (45.0%) reported no such practice and 20 (18.3%) were uncertain. With respect to DRLs, 42 (38.2%) acknowledged their existence, whereas 49 (44.5%)

denied it while 19 (17.3%) of them had no knowledge. Similarly, regular review of patient dose reports was reported by only 34 (30.9%) of participant, compared to the 45 (40.9%) who stated no regular patient dose review is done and 31 (28.2%) who were unsure. The overall adherence score ranged from 0 to 4, with a mean of 1.8 (45.2%), representing poor adherence to patient dose management practices (Table 2).

Table 2: Adherence and Implementation of Patient Dose Management

Variable		Frequency (%)
CT protocols Are tailored to specific clinical indications	Yes	84(77.1%)
	No idea	9 (8.3%)
	No	16 (14.7%)
Monitor patient dose	Yes	40 (36.7%)
	No idea	20 (18.3%)
	No	49 (45.0%)
Established Dose referencing level	Yes	42 (38.2%)
	No idea	19 (17.3%)
	No	49 (44.5%)
Regularly review patient dose reports	Yes	34 (30.9%)
	No idea	31 (28.2%)
	No	45 (40.9%)
Score	Mean ± SD	1.8 ±1.42
	Total score (%)	(45.2%)

Table 3 shows direct observation by the researcher which indicated that no DRLs were established across all six facilities. Equally, no departmental standard protocol was established in any of the settings, likewise protocol selection practices were also suboptimal; In 95.5% of observations (n = 42), participant did not select protocols based on clinical indication, with only 2 (4.5%) complying. In contrast, protocol selection was

observed to be appropriate for patient size in 42 (95.5%) of cases, and similarly, paediatric protocols were correctly selected in 5 (83.3%) out of six cases observed. Regarding equipment safety, routine quality control checks were observed in 42 (95.5%) of cases. However, patient dose monitoring (tracking) was not conducted in 40 (90.9%) of the observations.

Table 3: Observed Dose Management Practice

Variables		Frequency n (%)
Facility-level observations (N = 6 facilities)		
Facility	Government owned	5 (83.0%)
	Private owned	1 (17.0%)
Departmental DRLs established	No	6 (100.0%)
Departmental Standard protocol established	No	6 (100.0%)
Procedure-level observations (N = 44 observations)		
Selected appropriate protocol based on clinical indication	No	42 (95.5%)
	Yes	2 (4.5%)
Selected protocol appropriate for patient size	No	2 (4.5%)
	Yes	42 (95.5%)
Paediatric protocol selection (N = 6 paediatric examinations observed)	No	1 (16.7%)
	Yes	5 (83.1%)

Utilized ATCM appropriately	No	33(75.0%)
	Yes	11 (25.0%)
Positioned patient correctly to minimize radiation exposure	No	15 (34.1%)
	Yes	29 (65.9%)
Used appropriate shielding when indicated	No	42 (95.5%)
	Yes	2 (4.5%)
Explained the CT examination to the patient	No	34 (77.3%)
	Yes	10 (22.7%)
Discussed radiation dose with the patient	Yes	4 (9.1%)
	No	40 (90.9%)
Routine quality control checks on CT equipment	Yes	42 (95.5%)
	No	40 (90.9%)

Table 4 demonstrated a Mann–Whitney U test to compare CT dose management adherence between respondents working in government and private institutions. The analysis showed no statistically significant differences between the two groups in tailoring CT protocols to specific clinical indications

($U = 32.50$, $p = 0.300$), establishing Dose Reference Levels ($U = 37.50$, $p = 0.531$), regularly reviewing patient dose reports ($U = 42.00$, $p = 0.770$), or using patient dose monitoring systems ($U = 43.00$, $p = 0.805$).

Table 4: Mann-Whitney U Test Comparing CT Dose Management Adherence Between Radiographers in Government and Private Institutions

Variable	Mann-Whitney U	Z	p-value
CT protocols tailored to specific clinical indications	32.50	-1.037	0.300
Established Dose Reference Level (DRL)	37.50	-0.626	0.531
Regular review of patient dose reports	42.00	-0.293	0.770
Use of patient dose monitoring systems	43.00	-0.247	0.805

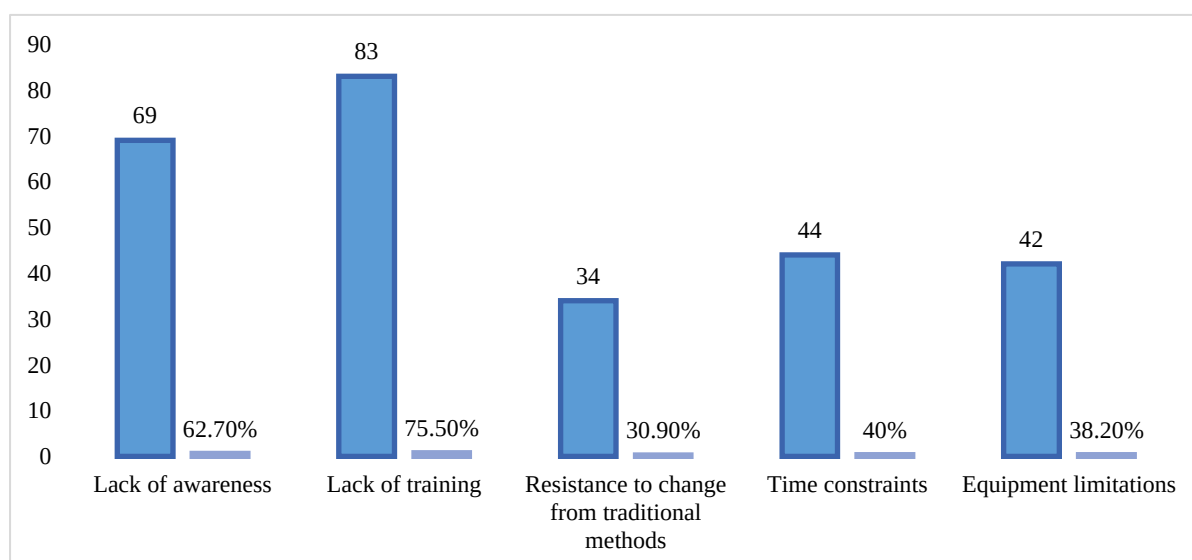


Figure 1: Barriers to effective Dose Management Practice in CT

Figure 1 presents barriers to effective dose management practice in CT, the most frequently reported barrier was lack of training 83 (75.5%),

followed by lack of awareness 69 (62.7%). Other barriers included time constraints 44 (40%), equipment limitations 42 (38.2%), and resistance to change from traditional methods 34 (30.9%).

4.0 DISCUSSION

The present study revealed poor adherence to recommended radiation dose management techniques. Only 36.7% of respondents reported active patient dose monitoring, 38.2% acknowledged DRLs, and 30.9% engaged in regular dose report reviews, these figures lower than those reported in more resourced settings like Jeddah, Saudi Arabia (Aldahery, 2023). Direct observations corroborated the self-reported data, revealing no established DRLs or departmental protocols across all sites, and protocol selection based on clinical indication in just 4.5% of cases. Such discrepancies between self-reported practices and observed behaviours highlights a significant know-do gap which is recognized in prior literature (Mahmoudi *et al.*, 2018), pointing out the limitations of questionnaire-based assessments in accurately capturing radiographers' real-world practices.

The institutional infrastructure for dose monitoring was notably absent or dysfunctional. Direct observation confirmed that no departmental Dose Reference Levels (DRLs) or standard protocols were established. As DRLs are a fundamental tool for radiation dose optimization (ICRP, 2017), the absence of institutionalized reference standards hinders benchmarking and consistent dose optimization across facilities.

In addition, 95.5% of observed scans were not selected based on clinical indication, although protocol selection according to patient category (adult or paediatric) was appropriate in 95.5% of cases. This suggests that radiographers are competent in basic operational adjustments but less consistent in clinically driven protocol justification. Regarding dose optimization tools, ATCM was incorrectly applied in 75.0% of cases, while only 25.0% demonstrated correct usage. This aligns with findings by Kamdem *et al.* (2023), who reported that 75% of technologists lacked accurate knowledge of AEC and only 14.2% used it effectively. Given that ATCM can reduce patient dose by 30–40% per scan sequence (Osborne, 2019; Inoue *et al.*, 2022), its underutilization represents a significant missed opportunity for dose reduction.

Similarly, systematic patient dose tracking was absent in 90.9% of observed cases, consistent with the low self-reported rate (48.6%) of dose monitoring. As Mahesh (2016) emphasized, "you cannot manage what you do not measure." Without structured dose audits and tracking systems, facilities lack the data required

to monitor trends, provide feedback, and support continuous quality improvement. Furthermore, a Mann–Whitney U test showed no statistically significant differences in CT dose management adherence between radiographers working in government and private institutions, suggesting that these deficiencies are widespread across both sectors rather than being specific to a particular workplace setting. This finding points to broader systemic challenges, including inadequate training, lack of standardized protocols, limited quality assurance frameworks, and insufficient institutional emphasis on dose optimization.

Quality control is a key component of radiation dose optimization (Bamanga *et al.*, 2023). In contrast to the poor procedural practices observed, equipment-related safety practices were well established, with routine quality control (QC) checks performed in 95.5% of cases, suggesting greater emphasis on technical equipment performance than on patient dose management processes.

This study reveals that the barriers to effective dose management were predominantly human-factor related, with lack of training, and awareness, topping the list, followed by time constraints, equipment limitations, and resistance to change. This mirrors global challenges, several studies in United States, Europe, Japan, and Iran identified resistance to change, limited resources, and complex structures, lack of leadership support as primary barriers, false alarms in dose monitoring systems, training deficits (Szczykutowicz *et al.*, 2018; Whitebird *et al.*, 2021; Kazemi *et al.*, 2023), but is amplified in Nigeria by underutilized manual radiation dose management systems (RDMS) develop by Garba *et al.* (2024) and limited CPD (ISRRT, 2018; Abdulkadir *et al.*, 2021; Garba *et al.*, 2024). Added to these findings, observations, further reveal poor multidisciplinary collaboration and patient communication, which could be due to workflow pressures notwithstanding, potentially undermining justification and optimization which are the cornerstone of radiation protection. These results have profound implications for patient safety in northeastern Nigeria, where CT contributes significantly to medical exposures.

Enhancing knowledge and practices could reduce doses by 40–80% via tools like ATCM and DLRs (Jiang *et al.*, 2022), aligning with ICRP Publication 135 (2017) and national DRLs (NNRA, 2020; Kabeer *et al.*,

2024). For radiographers, targeted CPD could boost job satisfaction and adherence (Seeram, 2023), while institutions benefit from cost savings via equipment longevity (Eastman *et al.*, 2024). Policymakers should prioritize RDMS adoption and regional DRL surveys to address the 82% global CT exam increase (UNSCEAR, 2022). Good management of radiation doses can be achieved by improving the knowledge of radiographers regarding radiation protection, justification, and optimization of protocols through rigorous audits of hospital radiation at the national level (Semghouli *et al.*, 2024b).

This study has limitations. Its cross-sectional design in one region of Nigeria limits generalizability to other contexts. The Hawthorne effect may have influenced observed behaviours, though the stark contrast with self-reported data remains telling. The small number of operational scanners (n=6) and observed departments (n=6) suggests findings may reflect specific institutional cultures, though the survey sample (N=110) provides broader perspective.

5.0 CONCLUSION

This study confirms that the gap between innovation and practice in CT dose optimization is not due to a lack of technology or global guidelines, but rather to a failure in implementation driven by inadequate training, weak institutional protocols, and a unsupportive work environment. Radiographers in northeastern Nigeria possess the basic competence but operate within a system that does not enable or enforce best practices. Bridging this gap requires a coordinated shift from individual knowledge to systemic action, involving committed leadership, targeted education, and the establishment of mandatory safety structures. Future research should explore the impact of specific intervention strategies, such as protocol standardization and audit feedback, in similar resource-constrained settings.

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