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RADIATION DOSE OPTIMISATION FOR PEDIATRIC BRAIN COMPUTED TOMOGRAPHY IN SELECTED HOSPITALS IN SOUTH-WEST NIGERIA

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ABSTRACT

Background: *Computed tomography (CT) provides invaluable high-resolution cross-sectional neuroimaging during pediatric emergencies, but it utilizes ionizing radiation. In many developing nations, a lack of clinical standardization and an absence of localized guidance mean pediatric patients are frequently exposed to uncalibrated adult-derived scanning protocols, resulting in unnecessary stochastic health risks.* ***Aim:*** *To evaluate whether the targeted optimization of pediatric brain CT protocol parameters effectively minimizes radiation doses in ordinary hospital settings in South-West Nigeria.* ***Methods:*** *A quasi-experimental pre-post study was conducted at Obafemi Awolowo University Teaching Hospitals Complex and Biket Medical Centre. The study involved a cohort of 485 pediatric patients aged 0–18 years, comparing 158 retrospective pre-optimization baseline examinations with 327 prospective post-optimization scans. The intervention actively revised protocol parameters including reducing tube voltage {kVp} and tube current-time product {mAs}, increasing pitch, and strictly narrowing scan length boundaries. Primary outcomes were evaluated using independent t-tests to measure shifts in {CTDI vol} and {DLP} ($p < 0.05$).* ***Results:*** *The participant demographics showed a higher prevalence of males (59.4%) and a dominant adolescent subpopulation (42.7% aged 13–18 years), highlighting trauma-related imaging trends. Following protocol optimization, independent t-tests confirmed massive, statistically significant exposure declines ($p < 0.001$). Mean {CTDIvol} plummeted by 67%, dropping from 69.22 mGy before optimization to 23.13 mGy after optimization, representing an approximate 67% reduction. Mean DLP decreased from 1589.61 mGy-cm to 602.70 mGy-cm, representing an approximate 62% reduction.Narrow post-intervention standard deviations demonstrated high, institutional adherence to the newly optimized guidelines.* ***Conclusion:*** *Redesigning scanning protocols and standardizing pediatric-specific parameters yields substantial radiation dose reductions in low-resource clinical environments. This evidence dismantles the assumption that dose reduction is exclusively dependent on premium, expensive hardware upgrades. Nigerian radiology departments and regulatory frameworks should actively adopt child-specific protocols, enforce routine dose auditing, and develop localized pediatric diagnostic reference levels to promote safety.*

Keywords: pediatric CT, brain CT, radiation dose, optimization, CTDIvol, DLP, Nigeria

Introduction

Computed tomography (CT) has transformed pediatric imaging by allowing for rapid and accurate visualization of internal structures, making it an indispensable diagnostic tool for infectious diseases, major injuries, cancers, and congenital defects in children (Hussain et al., 2022). CT provides greater cross-sectional imaging when compared to conventional radiography, allowing clinicians to make more accurate diagnoses and initiate treatments on time (Lebastchi et al., 2020). Its non-invasive nature and capacity to generate high-resolution images of soft tissues, bones, and vascular structures make it very useful in pediatric emergency care and general clinical

practice (Umirzakova et al., 2024). Computed tomography remains central to pediatric neuroimaging because it offers rapid cross-sectional imaging in emergencies such as trauma, hydrocephalus, brain tumors, and intracranial infection (Olateju et al., 2020). Its diagnostic speed is particularly valuable in children who may be unstable, uncooperative, or in urgent need of treatment decisions (Adejoh *et al*, 2018). However, the same technology uses ionizing radiation, and children are more vulnerable to radiation-related harm because of higher tissue radiosensitivity and longer life expectancy (Ainsbury et al, 2023). The linking pediatric CT exposure with increased long-term risks of leukemia, brain tumors, and other malignancies, although absolute risk remains low on a per-scan basis. These concerns justify continued emphasis on radiation protection principles such as justification and optimization in pediatric imaging (Malik *et al*, 2024). They are especially relevant in settings where protocol standardization is weak and equipment, staffing, and local guidance vary across institutions (Priyanka et al, 2022). Nigeria has increasing CT availability, nonetheless, there is a shortage of local evidence on pediatric dose optimization and a lack of context-specific protocol benchmarks (Adejoh *et al*, 2018). This gap limits the development of standardized practice and may contribute to unnecessary radiation exposure among children (Pearce, *et al*,2012). The current study therefore seek to radiation dose optimisation for pediatric brain computed tomography with a view to contributing to the existing body of knowledge, theory and practice

Methods

Study design and setting: A quasi-experimental pre-post design was used to evaluate pediatric brain CT protocol optimization in selected hospitals in South-West Nigeria, including Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, and Biket Medical Centre, Oshogbo. The study compared retrospective baseline examinations with prospectively collected post-intervention examinations after implementation of optimized pediatric protocols.

Participants: The study population comprised pediatric patients aged 0-18 years who underwent brain CT scanning for different clinical indications. The findings established that 158 pre-optimization records and 327 post-optimization records were analyzed, giving a total of 485 examinations.

Intervention: The optimization strategy involved revision of pediatric brain CT parameters to reduce radiation output while preserving diagnostic adequacy. The intervention targeted key protocol variables, including tube voltage, tube current-time product, pitch, and scan length. The study notes that reductions in kVp and mAs, together with tighter scan coverage and protocol redesign, were central to the optimization process.

Outcome measures: The primary dose outcomes were CTDIvol and DLP. These indices were used to compare radiation

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exposure before and after implementation of the optimized protocol.

Data analysis: Descriptive statistics summarized dose measures before and after optimization, and independent t-tests were used to test differences between phases. Statistical significance was reported at $p < 0.05$, with the main results showing $p<0.001$ for both CTDIvol and DLP comparisons.

Results

Table 1: Demographic characteristics of participants

Variable	Frequency	Percent (%)
Age		
Neonate (0–28 days)	24	4.9
Infant (1–12 months)	97	20
Child (1–12 years)	157	32.4
Adolescent (13–18 years)	207	42.7
Sex		
Female	197	40.6
Male	288	59.4
Total	**485**	**100**

Table 1 reveals that the age distribution found that adolescents (13-18 years) made up the highest number (42.7%), followed by children aged 1-12 years (32.4%), infants (20.0%), and newborns (4.9%). This pattern implies that CT use increases with age, most likely because to the complexity of clinical grounds and the higher prevalence of trauma-related cases in older children. In terms of gender distribution, males (59.4%) outnumbered females (40.6%).

Table 2: Comparison of radiation dose indices before and after pediatric brain CT protocol optimization

Variable	Phase	n	Mean	SD	Minimum	Maximum
CTDIvol (mGy)	Pre-intervention	158	69.22	0.78	68.40	70.10
CTDIvol (mGy)	Post-intervention	327	23.13	1.01	20.33	32.07
DLP (mGy-cm)	Pre-intervention	158	1589.61	0.74	1586.40	1591.40
DLP (mGy-cm)	Post-intervention	327	602.70	1.02	600.10	613.12

Table 2 revealed a mean CTDIvol decreased from 69.22 mGy before optimization to 23.13 mGy after optimization, representing an approximate 67% reduction. Mean DLP decreased from 1589.61 mGy-cm to 602.70 mGy-cm, representing an approximate 62%

reduction. The study interprets the small standard deviations as evidence that the optimized protocol was applied consistently across post-intervention examinations.

Table 3: Independent t-test comparing radiation dose indices before and after optimization

Variable	Pre-optimization mean ± SD	Post-optimization mean ± SD	t-value	p-value
CTDIvol (mGy)	69.22 ± 0.78	23.13 ± 1.01	550.04	<0.001
DLP (mGy-cm)	1589.61 ± 0.74	602.70 ± 1.02	12098.28	<0.001

Table 3 show that the optimized protocol significantly reduced both CTDIvol and DLP. The magnitude of reduction suggests that protocol redesign rather than random variation accounts for the observed change.

Discussion

This study demonstrates that pediatric brain CT dose optimization can produce large and statistically significant reductions in radiation exposure in a real-world Nigerian setting. The observed 67% reduction in CTDIvol and 62% reduction in DLP indicate that protocol review and parameter adjustment can markedly improve radiation safety even without assuming access to the most advanced high-cost technologies. The findings are consistent with optimization studies reported in several studies. Findings from the study of Morel et al (2016) showed that automatic tube potential selection reduced CTDIvol by 21% in infant head CT without significant loss of diagnostic image quality. Priyanka et al, (2022) reported dose reduction of 62% in children aged less than one year and 51% in those aged one to five years using age-based protocols and iterative reconstruction in a phantom study. Nagayama et al (2022). Also reported that deep learning-based reconstruction could reduce radiation dose by 54% while improving image quality metrics.

The present study extends this evidence by showing that strong gains are achievable in routine clinical practice within South-West Nigeria. This is particularly important because the study identified inconsistent standardization, absence of local guidelines, and operational disparities as major barriers to safer pediatric CT practice in Nigeria (Adepoju & Opele, 2021). The results therefore contribute local evidence that can support institutional protocol development and future national diagnostic reference levels. The study also has broader service-delivery importance. Radiation safety in children is a public health issue because small individual risks translate into avoidable population harm when imaging volume increases over time. By embeddings optimization into routine CT practice, hospitals can improve quality assurance, reduce unnecessary exposure, and align more closely with the ALARA principle already emphasized in international guidance and in the dissertation's theoretical framing.

A limitation in this study is that the study was quasi-experimental and not randomized, so it is best interpreted as strong practice-improvement evidence rather than a fully controlled efficacy trial. In addition, while this study states that diagnostic adequacy was maintained, future journal publication would be strengthened by fuller reporting of formal image-quality scoring and interobserver reliability.

Conclusion

This study revealed that structured protocol review, child-specific parameter selection, and routine dose monitoring can substantially improve pediatric radiation safety in low-resource environments. The study concluded that substantial dose optimisation is possible without sacrificing clinical results, which contradicts the widely held belief that dose reduction is mostly driven by technology or limited to high-income settings. Thus, hospitals and regulators should strengthen local protocol standardization, staff training, and dose auditing to sustain these gains.

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