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IMPLEMENTATION PRIORITIES FOR SAFER PEDIATRIC BRAIN CT IN NIGERIA: EVIDENCE SYNTHESIS FROM A SYSTEMATIC REVIEW AND LOCAL OPTIMIZATION STUDY

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ABSTRACT

Background: *Pediatric brain computed tomography (CT) is a critical diagnostic tool in acute pediatric care, yet avoidable radiation exposure is a prominent patient-safety and public-health concern in low-resource environments. Because children possess high tissue radiosensitivity and a longer life expectancy, they face an elevated cumulative risk for radiation-induced malignancies,*

making dose optimization an ethical imperative. ***Aim:*** *To synthesize global evidence from a systematic review with local empirical data from an optimization initiative to establish strategic implementation priorities for safer pediatric brain CT practice in Nigeria.* ***Methods:*** *This paper utilizes a contextual synthesis design linking a systematic review and a local quasi-experimental study. The systematic review component evaluated 12 high-quality quantitative studies extracted via a PRISMA-compliant search across PubMed, Web of Science, and Google Scholar. The local interventional component compared retrospective, pre-optimization baseline data (158 examinations) with prospectively collected post-optimization data (327 examinations) across selected hospitals in South-West Nigeria to analyze changes in Volumetric CT Dose Index {CTDI. vol} and Dose-Length Product {DLP}.* ***Results:*** *The systematic review identified multiple effective optimization technologies worldwide, including automatic exposure control, age- or size-based technical parameter adjustments, and advanced reconstruction algorithms. Locally, the implementation of redesigned pediatric protocols yielded profound, statistically significant reductions ($p < 0.001$) in exposure. Mean {CTDI. vol} decreased by approximately 67%, dropping from 69.22 ± 0.78 to 23.13 ± 1.01{mGy}. Similarly, mean {DLP} fell by approximately 62%, decreasing from 1589.61 ± 0.74{mGy-cm} to $602.70 ± 1.02{ mGy-cm}.* ***Conclusion:*** *Substantial pediatric dose reduction can be achieved in everyday Nigerian clinical practice through structured protocol redesign, tighter scan coverage, and adjusted exposure parameters without requiring high-cost technologies. To sustain these improvements, pediatric radiation safety must be managed as a health-system quality and governance issue. Five core implementation priorities are recommended: establishing age- or size-specific protocols, developing local diagnostic reference levels, driving continuous workforce training, formalizing routine dose audits, and integrating pediatric safety into national quality policies.*

Keywords: Pediatric imaging, CT optimization, radiation safety, public health, Nigeria, implementation

Background

Computed tomography (CT) is an important diagnostic tool in pediatric imaging yet, empirical data raise serious concerns about radiation exposure risks for children (Aziz et al, 2025). Computed tomography is vital for rapid diagnosis of pediatric head trauma, hydrocephalus, brain tumors, congenital anomalies, and intracranial infection. Yet children are more susceptible to radiation-induced harm because of greater tissue radiosensitivity and longer life expectancy, making dose optimization an ethical and public-health priority. Where protocols are inconsistent or adapted from adult practice, unnecessary exposure can occur even when scans are clinically justified. According to Adejoh et al, (2018), children's developing tissues and longer life expectancy make them more radiosensitive than adults, increasing the risk of radiation-induced cancers. Research has connected cumulative radiation exposure from CT scans to an increased risk of brain tumours, leukaemia, and other cancers; even low-dose scans may pose long-term health hazards (Little et al., 2022; Smoll et al., 2023).

Despite increased awareness, shortcomings exist in the standard application of radiation dose optimization procedures (Opele, & Tomori, 2024). Many medical institutions continue to use adult-derived CT procedures for pediatric imaging, increasing stochastic hazards and unnecessarily exposing patients (Dudhe et al., 2024). The lack of consistency in procedural standardization across medical facilities creates a significant obstacle to pediatric CT optimization (Whitebird et al., 2021). Recommendations for pediatric-specific CT optimization are frequently absent in resource-constrained settings such as Nigeria, whereas developed countries have embraced dose reduction measures. Variations in scanner technologies, radiographer experience levels, and institutional policies all contribute to dosage management disparities (Rehani et al., 2025). It is critical to assess and improve CT techniques specific to pediatric needs, as the absence of a coordinated strategy leads to poor radiation safety standards (Olateju et al. 2020). This paper identifies several system-level problems in Nigeria such as inconsistent protocol standardization, absence of local pediatric guidance, operational disparities across institutions, and limited local data on optimized pediatric CT practice, which are not only technical deficiencies but also governance and health-system issues, since they affect patient safety, quality assurance, professional accountability, and equitable protection of children. This study thee investigated implementation priorities for safer pediatric brain CT in Nigeria from a systematic review and local optimization investigation.

Methods

This paper is a contextual synthesis derived from two linked components in the dissertation: a systematic review and a quasi-experimental pre-post hospital study. For the review, the current study searched PubMed, Web of Science, and Google Scholar and initially identified 720 records. After removal of 497 duplicates, 223 records were screened, 55 full texts were assessed, and 12 quantitative studies were included in the final review according to the dissertation's PRISMA-based process. The study also appraised included studies with the Joanna Briggs Institute checklist and judged them generally to be of good methodological quality, while noting recurrent weaknesses in confounder identification and management. The interventional component compared 158 pre-optimization pediatric brain CT examinations with 327 post-optimization examinations in selected hospitals in South-West Nigeria. The current paper synthesizes both components to identify evidence-based implementation priorities for safer pediatric CT practice.

Evidence from the systematic review

The review covered a range of study designs including phantom studies, retrospective observational studies, prospective comparisons, and large cohort analyses. Table 1 condenses the most policy-relevant features of the included studies using the dissertation's extracted data.

Table 1: Key studies on pediatric CT dose optimization

Study	Design	Main optimization approach	Main finding
Morel et al. (2016)	Prospective comparative	Automatic tube potential selection	CTDIvol reduced by 21% without important loss of image quality.
Priyanka et al. (2022)	Experimental phantom	Age-based protocol plus iterative reconstruction	Dose reduced by 62% in <1 year and 51% in 1-5 years while preserving diagnostic quality.
Eddy et al. (2021)	Retrospective multicenter	Audit against French DRLs	CTDIvol and DLP exceeded DRLs by up to 47.73%, showing need for protocol adjustment.
Esser et al. (2018)	Retrospective cohort	High-pitch scanning plus AEC	Radiation dose reduced while image quality remained acceptable.
Nagayama et al. (2022)	Clinical and phantom	Deep learning-based reconstruction	Dose reduced by 54% with improved image quality metrics.
Bonfleur et al. (2023)	Experimental	Pediatric brain CT protocol adjustment by age group	CTDIvol and DLP reduced across age groups without image quality loss.
Santos and Mourão (2022)	Phantom study	kV and mAs optimization by head size	Absorbed dose reduced by up to 57.94%]
Anaafi et al. (2022)	Experimental	Pitch and kernel optimization	High pitch and smooth kernel supported lower dose with acceptable image quality.

As revealed in table 1, these studies point to a consistent conclusion: pediatric CT dose can often be reduced substantially if protocols are adapted to child size, clinical indication, and scanner capability. The review also shows that no single technology solves the problem universally, because effective optimization usually combines protocol customization, technical adjustment, and image-reconstruction support.

Evidence from the Nigerian intervention study

The local quasi-experimental component provides implementation evidence from South-West Nigeria rather than only laboratory or high-income setting data. Table 2 summarizes the primary dose outcomes reported in the dissertation.

Table 2: Dose outcomes before and after protocol optimization in selected hospitals in South-West Nigeria

Variable	Pre-optimization	Post-optimization	Approximate reduction	p-value
CTDIvol (mGy)	69.22 ± 0.78	23.13 ± 1.01	67%	<0.001
DLP (mGy-cm)	1589.61 ± 0.74	602.70 ± 1.02	62%	<0.001

These results in table 2 show that meaningful dose reduction is achievable in ordinary Nigerian clinical practice. This matters for public health because it weakens the argument that safer pediatric CT is only possible where the newest premium technologies are available. Instead, the study suggests that structured protocol redesign, tighter scan range, lower kVp/mAs selection, and more consistent practice can produce major gains even in constrained systems.

Public health interpretation

Pediatric CT optimization was recognized as a public-health quality issue for four reasons. First, it concerns a vulnerable population with elevated biological susceptibility to harm. Second, the risk is cumulative at population level as imaging access expands. Third, preventable exposure is shaped by institutional systems, training, audit, and policy, not just by individual operator choices. Fourth, disparities between facilities create inequity in protection standards for children with similar clinical needs. The results also reveals that implementation barriers remain substantial. Some reviewed studies were phantom-based and may not fully represent everyday clinical conditions. Other studies documented persistent overexposure in real practice, showing that evidence alone does not guarantee safer care. This evidence-to-practice gap is exactly the kind of systems problem that public-health journals increasingly address.

Implementation priorities

Based on the combined evidence, five priorities emerge for Nigeria and similar settings as presented below:

Pediatric-specific protocols: Hospitals needs to replace adult-derived defaults with age- or size-specific pediatric brain CT protocols. This is the most direct operational step toward safer practice.

Local dose benchmarks: Institutions should use CTDIvol and DLP data to establish local diagnostic reference levels and then contribute to national pediatric benchmarks. Without local reference values, dose auditing remains difficult and uneven.

Workforce development: Radiographers, radiologists, and medical physicists need continuing training on pediatric justification, scan-range limitation, kVp/mAs adjustment, and quality-assured optimization. Human factors are central because scanner capability alone does not guarantee safer use.

Routine audit and governance: Dose monitoring should become part of quality-assurance systems, with regular review of protocol performance and outlier exposures. This turns optimization from a one-time intervention into a sustained safety program.

Policy integration: The outcome of the study identified the need for national and institutional regulators should integrate pediatric imaging safety into broader health-system quality and radiation-protection policy. Doing so would make optimization a governance expectation rather than a discretionary local initiative.

Conclusion

The combined evidence from the systematic review and local hospital intervention indicates that safer pediatric brain CT in Nigeria is both necessary and achievable. Effective dose-reduction techniques are already known, and the Nigerian study shows that large reductions in CTDIvol and DLP can be achieved in practice through structured protocol optimization. The main remaining challenge is implementation: translating evidence into standardized protocols, local reference levels, workforce competence, audit systems, and policy support.

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