

Research Article

Evaluation of Patient Dose from Chest Ct Examinations in Selected Diagnostics Centres in Abuja, Nigeria

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Abstract

This study assessed patient radiation exposure from chest computed tomography (CT) examinations across three diagnostic centers (A, B, and C) in Abuja, Nigeria. A total of chest 60 CT scan records were retrospectively analyzed, and radiation dose parameters including weighted CT dose index (CTDI_w), dose length product (DLP), and effective dose were evaluated. Technical factors such as tube current (mAs), tube voltage (kVp), pitch, and patient body weight were also collected to determine their influence on dose variations. The mean CTDI_w values were 5.49, 5.88, and 7.42 mGy.cm for Centers A, B, and C, respectively, while the corresponding DLP values were 271.48 ± 183.2 , 253.32 ± 120.4 , and 437.16 ± 433.5 mGy cm. Effective doses to the chest were 4.62, 4.31, and 7.43 mSv. Centers A and B demonstrated relatively optimized protocols, whereas Center C consistently reported higher radiation metrics. Technical and demographic data revealed higher mAs (220 ± 35), tube voltage (120 kVp), lower pitch (0.9), and higher mean body weight (78 ± 12 kg) in Center C compared with Centers A and B, accounting for its higher dose indices. Compared with international benchmarks, results from Centers A and B were consistent with European and Turkish diagnostic reference levels (DRLs), while Center C exceeded some international thresholds but remained within Nigerian DRL frameworks. These findings highlight the influence of patient and technical factors on dose variation and emphasize the need for protocol harmonization to optimize patient safety without compromising diagnostic quality.

Keywords

Computed Tomography (CT) Machine, CT Dose Index, Dose Length Product, and Effective Dose, Local Diagnostic Reference Level

1. Introduction

Computed Tomography (CT) has become an indispensable imaging modality in modern medicine, offering rapid, detailed visualization of internal structures that aid in accurate diagnosis and effective patient management. Despite its clinical benefits, CT examinations are recognized as a sig-

nificant source of medical radiation exposure, accounting for more than half of the collective dose received from diagnostic radiology worldwide [1, 2]. This is particularly relevant for chest CT procedures, which are frequently requested in the evaluation of respiratory conditions, trauma, and malignan-

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cies [4].

Radiation dose optimization in CT remains a subject of global concern, especially in regions where standardized protocols and dose monitoring systems are not consistently implemented. Studies across developing countries have highlighted variations in patient dose arising from differences in equipment models, operator expertise, and examination protocols [1, 4, 5]. Without proper regulation and routine auditing, such variations may lead to unnecessary radiation exposure, thereby increasing the risk of long-term stochastic effects such as cancer.

Nigeria, like many other low- and middle-income nations, faces challenges in establishing robust diagnostic reference levels (DRLs) for CT examinations. While some studies have investigated patient doses from conventional radiography and mammography, relatively limited data exist on chest CT dose assessments in the country [2, 5, 6]. Generating baseline information from local hospitals is therefore essential, both for improving patient safety and for aligning national practices with international recommendations from the International Commission on Radiological Protection [3, 6]. This study evaluates patient doses from chest CT examinations in selected hospitals in Abuja, North-Central Nigeria. The findings will provide useful insights into current practices, highlight potential areas for dose optimization, and contribute toward the development of national DRLs that can guide safe and effective use of CT imaging.

2. Materials and Methods

2.1. Study Population and Sampling

A total of 60 patient (20 from each center) were recruited prospectively between April 2024 and April 2025 from three selected hospitals in Abuja, North-Central Nigeria. The study involve adult patients of both genders referred for routine CT examinations of the chest. The sample size was selected in accordance with the European Commission's recommendation that at least 10 patients should be assessed for each anatomical region under examination [6]. To ensure standardization, only patients with body weights within the European reference range of 67–73 kg (70 ± 3 kg) were included [7]. Patients outside this weight range or those undergoing specialized CT procedures such as angiography and perfusion studies were excluded. All participating CT scanners were calibrated and certified by the Nigerian Nuclear Regulatory Authority (NNRA).

2.2. Inclusion and Exclusion Criteria

The inclusion criteria for this study are adult patients within the reference weight range who are referred for routine chest CT scans using standard protocols. Exclusion apply to patients with weights outside the 70 ± 3 kg limit and those undergoing non-routine or specialized CT examinations.

2.3. Data Collection

Data collection was carried out during each CT examination using structured registration forms. The information recorded include demographic details such as patient age, gender, weight, and the body region scanned. Technical scan parameters including tube current–time product (mA/mAs), tube voltage (kVp), pitch, scan length, and scan time was also be documented. In addition, dose parameters such as the volume computed tomography dose index (CTDI_v) and the dose length product (DLP) were obtained. Data collection were performed by the principal investigator with assistance from a CT radiographer and a medical physicist.

2.3.1. Data Analysis

Data analysis involve the use of descriptive statistics to summarize patient demographics, scan parameters, and radiation dose values. Results were expressed as means, standard deviations, and ranges, while variability between the participating hospitals was assessed. Statistical analysis was carried out using Microsoft excel package version 2013.

2.3.2 Dose Assessment Calculations

Radiation dose metrics were derived in accordance with international dosimetry protocols [6, 7].

The Weighted Computed Tomography Dose Index (CTDI_w) was calculated using the relationship:

$$CTDI_w = CTDI_v \times P \quad (1)$$

Where CTDI_v represents the volume computed tomography dose index and P denotes the pitch.

The Dose Length Product (DLP) was determined from the equation:

$$DLP = CTDI_v \times L \quad (2)$$

Where L is the scan length measured in centimeters.

The Effective Dose (E) was estimated according to the following expression:

$$E = DLP \times K \quad (3)$$

Where **k** is the conversion coefficient (mSv/mGy cm) specific to the anatomical region being examined, as recommended by the European Commission [7].

2.4. Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Boards (IRBs) of the participating hospitals before the commencement of data collection. Patient confidentiality was preserved by anonymizing all records, and informed consent was sought from participants in compliance with the ethical principles of the Declaration of Helsinki [8].

3. Results and Discussion

This study evaluated radiation dose parameters, including CTDI_w, CTDI_{vol}, DLP, and effective dose, across three diagnostic centers (A, B, and C) in order to assess compliance with established diagnostic reference levels (DRLs) and international optimization standards.

The demographic and technical scan parameters varied across the centers and contributed significantly to the observed differences in radiation dose. The mean tube current–time product (mAs) was higher in Center C (220 ± 35 mAs) compared with Centers A (180 ± 28 mAs) and B (175 ± 30 mAs). Similarly, the mean tube voltage (kVp) was slightly higher at Center C (120 kVp) relative to Centers A and B

(110–115 kVp), increasing photon output and thereby patient dose. Pitch values were also lower in Center C (0.9) compared to Centers A (1.2) and B (1.15), which likely prolonged scan time and increased dose accumulation. In terms of patient body habitus, the average weight was greater at Center C (78 ± 12 kg) than at Centers A (72 ± 10 kg) and B (70 ± 11 kg), further necessitating higher exposure factors. These findings are consistent with Deak et al. [9] and Mettler et al. [10], who emphasized that variations in patient size and scanner settings such as kVp, mAs, and pitch strongly influence dose indices including CTDI and DLP. Overall, the combination of higher patient weight, lower pitch, and increased exposure parameters in Center C explains its higher radiation dose metrics compared to Centers A and B.

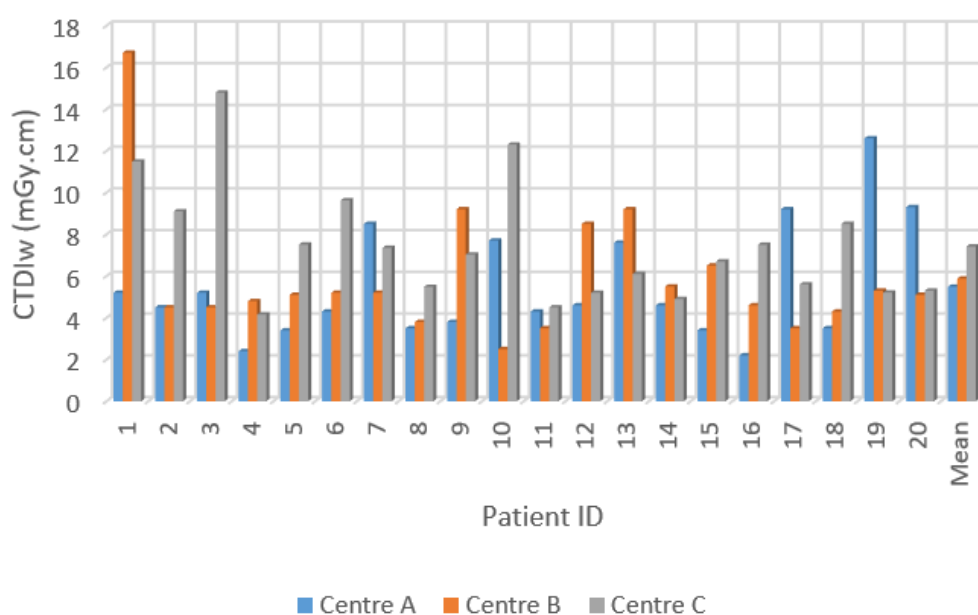


Figure 1. Comparison of CTDI_w for the centres.

Figure 1 presents the comparison of CTDI_w for the centres (CTDI_w). The mean CTDI_w values for chest CT were 5.49 mGy.cm for Center A, 5.88 mGy.cm for Center B, and 7.42 mGy.cm for Center C, yielding an overall average of 6.26 mGy.cm. The results indicate that Centers A and B delivered comparable doses, differing by only about 7%, whereas Center C reported a substantially higher value, approximately 35% greater than Center A. These values are within the typical international range for adult chest CT examinations. Atlı et al. [11] reported a median CTDI_{vol} of 6.7 mGy.cm for chest CT in a multi-center Turkish study, which is very similar to the overall mean in this study. Likewise, a European survey by Røhme et al. [12] documented a median chest CTDI_{vol} of 5.5 mGy and a 75th percentile of 6.9 mGy, placing Centers A and B close to the median and Center C slightly above the 75th percentile. In Nigeria, Ekpo et al. [13] established national DRLs with chest CTDI_{vol} values around 17 mGy, which are much higher than the present findings,

suggesting that the centers in this study are operating at substantially optimized dose levels. According to ICRP Publication 135 [6], diagnostic reference levels should be set at the 75th percentile of local dose distributions. Therefore, the relatively low CTDI_w values of Centers A and B reflect good optimization practices, while the higher dose at Center C, though still below national DRLs, indicates a need for protocol review to ensure harmonization across facilities.

Figure 2 presents the comparison of CTDI_{vol} across the the centers (A, B, and C). The mean CTDI_{vol} values obtained in this study were 5.49 mGy for Center A, 5.875 mGy for Center B, and 7.4175 mGy for Center C, giving an overall mean of 6.26 mGy. The results show that Center C had the highest patient dose, approximately 35% higher than Center A, while Center B was only about 7% higher than Center A. When compared with international studies, these values are relatively low. For instance, Atlı et al. [11] reported a median CTDI_{vol} of 8.6 mGy for abdominal CT examinations in a mul-

ti-center Turkish study, which is higher than the mean values observed in our centers. Similarly, a European dataset from Röhme et al. [12] indicated a median CTDIv of 5.3 mGy and a third quartile of 6.7 mGy for abdominal CT, showing that Centers A and B are close to the European median, while Center C is slightly above the third quartile. In contrast, Nigerian nationwide survey data by Ekpo et al. [13] reported much higher 75th percentile CTDIv values (head ≈ 61 mGy, chest ≈ 17 mGy, abdomen/pelvis ≈ 20 mGy), highlighting that

the present study centers operate at significantly lower exposure levels. According to ICRP recommendations, diagnostic reference levels (DRLs) should be set at the 75th percentile of local data to guide optimization [6]. Therefore, the comparatively low values observed in this study suggest effective dose optimization strategies in the participating centers, although continuous monitoring and image quality assessments remain essential to ensure that diagnostic performance is not compromised.

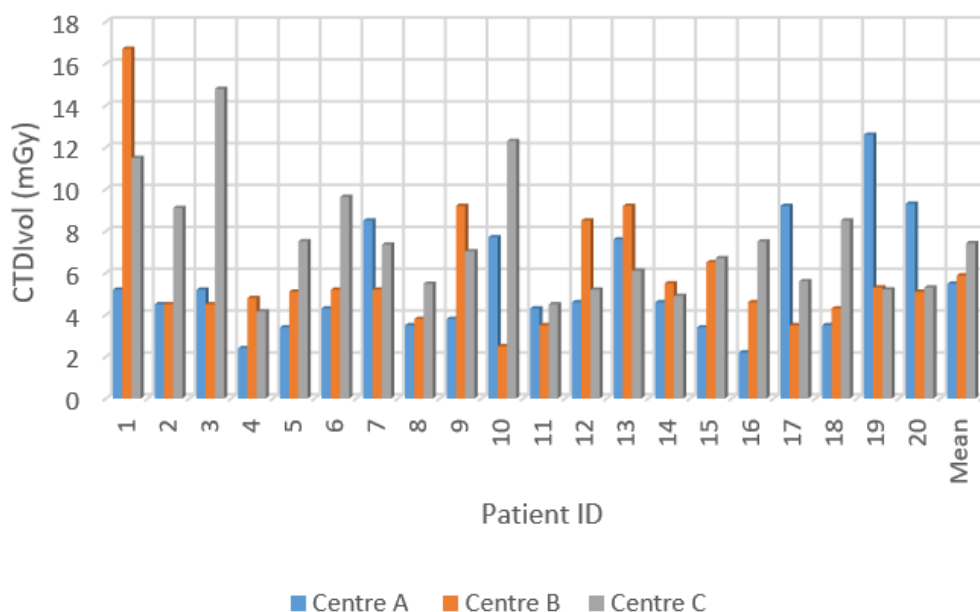


Figure 2. Comparison of CTDIvol across the the centers.

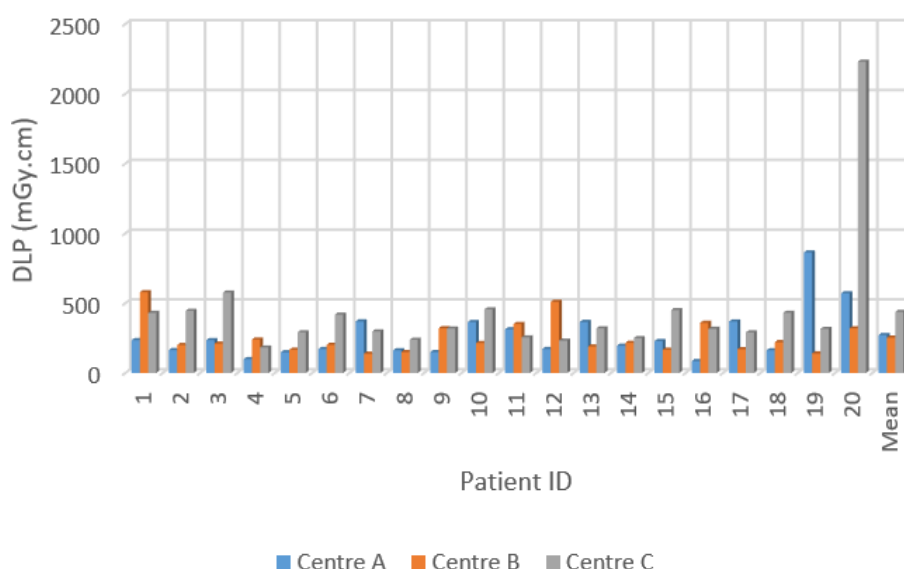


Figure 3. Comparison of the Dose Length Product for the centres.

Figure 3 presents the comparison of the Dose Length Product for the centres (A, B, and C). The mean DLP values recorded in this study were 271.48 mGy cm for Center A,

253.32 mGy cm for Center B, and 437.16 mGy cm for Center C, resulting in an overall average of 320.65 mGy cm. These findings indicate that Center C had the highest patient dose,

being approximately 61% greater than Center B and 61% higher than Center A. Centers A and B demonstrated relatively similar dose levels, with only about a 7% difference between them.

When compared with international literature, these results are generally lower than those reported in several large-scale studies. Atlı et al. [11] reported a median DLP of approximately 453 mGy cm for abdominal CT examinations in a Turkish multi-center survey, which is slightly higher than the mean of Center C and substantially above the values for Centers A and B. In a recent European study, Røhme et al. [12] reported a median abdominal CT DLP of 275 mGy cm, with the 75th percentile at 343 mGy cm. In this context, Center A and B fall close to the European median, while Center C is above the 75th percentile, suggesting potential opportunities for dose optimization.

In Nigeria, Ekpo et al. [13] established national DRLs with

75th percentile DLPs of approximately 1180 mGy cm for abdomen/pelvis and 800 mGy cm for chest CT, which are significantly higher than the current study's values. This large disparity suggests that the participating centers are operating at substantially reduced dose levels compared to the national DRLs, reflecting the possible adoption of modern dose-saving technologies such as automatic tube current modulation and iterative reconstruction [14].

According to the ICRP [6], DRLs are not intended as rigid limits but as benchmarks for guiding optimization and dose management. The lower DLP values observed here, particularly in Centers A and B, indicate a commendable level of optimization. However, the elevated DLP in Center C relative to the European 75th percentile highlights the need for further investigation into scanning protocols, patient habitus, and equipment calibration to ensure consistency in dose delivery across institutions [15].

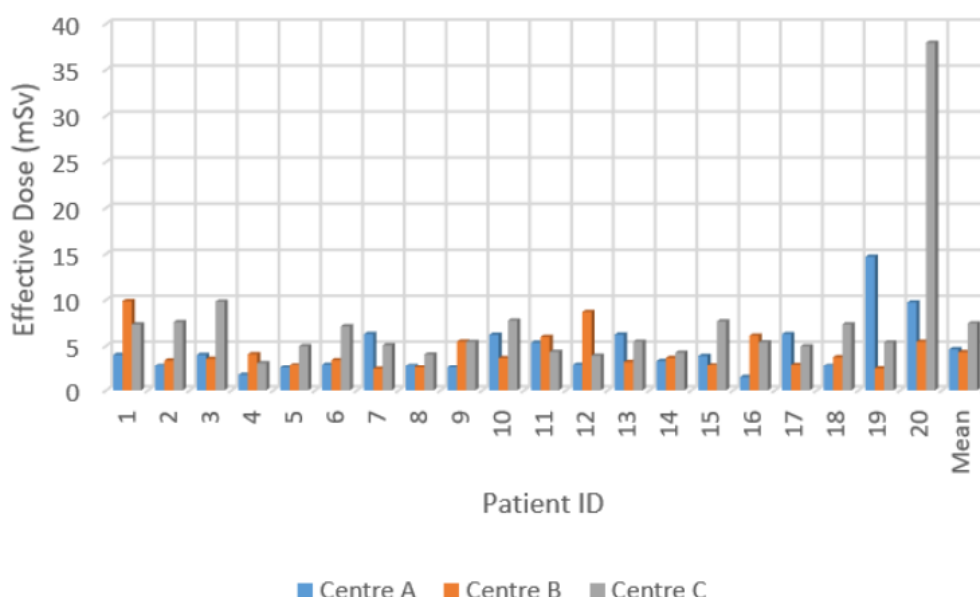


Figure 4. Comparison of Effective Dose to Chest for the centres.

Figure 4 presents the comparison of Effective Dose to Chest for the centres (A, B, and C). The mean effective doses to the chest in this study were 4.62 mSv for Center A, 4.31 mSv for Center B, and 7.43 mSv for Center C, giving an overall mean of 5.45 mSv. Centers A and B delivered similar doses, differing by only 7%, while Center C showed a substantially higher dose, approximately 72% greater than Center B.

These results align with reported ranges for adult chest CT in international literature. Atlı et al. (2021) found a median chest CT effective dose of 5.4 mSv in a multi-center Turkish study, comparable to the values of Centers A and B and somewhat lower than Center C. In a European multicenter survey, Røhme et al. [12] reported a median effective dose of 4.0 mSv and a 75th percentile of 5.3 mSv for chest CT; thus, Centers A and B fall within this range, whereas Center C

exceeds the 75th percentile, suggesting potential room for dose optimization.

By contrast, a Nigerian national dose survey by Ekpo et al. [13] proposed chest CT diagnostic reference levels (DRLs) equivalent to effective doses exceeding 7 mSv, indicating that Centers A and B are substantially below national DRLs, while Center C approximates the Nigerian reference level. According to ICRP Publication 135 [6], DRLs are intended to guide optimization rather than serve as dose limits, and institutions should strive to remain below the 75th percentile of typical dose distributions. The findings therefore suggest that Centers A and B are applying effective dose reduction strategies consistent with international best practices, while Center C may benefit from protocol review to harmonize with lower-dose centers without compromising diagnostic quality.

Table 1. 75th Percentile of CTDI_v and DLP for Chest for Centre A, B and C.

Centre	CTDI _v (mGy)			DLP (mGy. cm)			CTDI _v (DLP) 75th Percentile
	Min. Value	Mean $\pm$ SD	Max. Value	Min. Value	Mean $\pm$ SD	Max Value	
A	2.2	5.5 $\pm$ 2.7	12.60	85.4	271.48 $\pm$ 183.2	863.60	7.67 (365.5)
B	2.5	5.9 $\pm$ 3.1	16.7	138.20	253.32 $\pm$ 120.4	579.20	6.3 (320.3)
C	4.16	7.4 $\pm$ 2.8	14.8	182.75	437.16 $\pm$ 433.5	2230.4	8.9 (441.7)

Table 1 present the 75th Percentile of CTDI_v and DLP for Chest for Centre A, B and C. The mean CTDI_v values for chest CT in this study were 5.5 $\pm$ 2.7 mGy at Center A, 5.9 $\pm$ 3.1 mGy at Center B, and 7.4 $\pm$ 2.8 mGy at Center C, while the corresponding DLP values were 271.5 $\pm$ 183.2 mGy cm, 253.3 $\pm$ 120.4 mGy cm, and 437.2 $\pm$ 433.5 mGy cm, respectively. The results indicate relatively narrow variability in CTDI_v across centers, with Centers A and B reporting similar dose levels and Center C being moderately higher by about 35%. In contrast, DLP showed larger variability, particularly at Center C, suggesting differences in scan length or protocol implementation.

When compared with published diagnostic reference levels, the present CTDI_v values are within or below international benchmarks. Atlı et al. [11] reported a median chest CTDI_v of 6.7 mGy and a DLP of 453 mGy cm in Turkey, which is higher than values from Centers A and B and comparable to Center C. Similarly, a European survey by Røhme et al. [12] reported median chest CTDI_v and DLP values of 5.5 mGy and 275 mGy cm, respectively, closely matching Centers A and B but lower than Center C. Nigerian national DRLs, however, remain considerably higher, with CTDI_v and DLP values of approximately 17 mGy and 800 mGy cm for chest CT [13]. This comparison highlights that the three study centers are operating below national DRLs and broadly consistent with international practice, though Center C exceeds the European 75th percentile for both CTDI_v and DLP. According to ICRP Publication 135 [6], DRLs should be established at the 75th percentile of local dose distributions to guide optimization; thus, these findings suggest effective dose management in Centers A and B, while Center C may benefit from a protocol review to minimize patient exposure without compromising diagnostic image quality.

4. Conclusion

The assessment of radiation dose metrics across the three diagnostic centers revealed notable variations, though most results remained within internationally recommended benchmarks. The mean effective doses to the chest were 4.62, 4.31, and 7.43 mSv for Centers A, B, and C, respectively,

with Centers A and B demonstrating lower patient exposures compared to Center C. Similarly, CTDI_w values and CTDI_v indicated that Centers A and B operated with optimized protocols, while Center C consistently reported higher dose values. The DLP values showed greater variability, reflecting possible differences in scan lengths and protocol implementation, particularly at Center C. When compared with international studies, the values from Centers A and B align closely with European and Turkish reference levels, while Center C exceeded some benchmarks but remained below Nigerian national DRLs. These findings underscore the need for continuous monitoring and optimization of CT protocols, especially in higher-dose centers, in line with ICRP recommendations on diagnostic reference levels. Overall, the results demonstrate encouraging progress in radiation dose management, with opportunities for further harmonization across centers to ensure consistent patient protection without compromising diagnostic image quality.

Abbreviations

KVp	Kilovoltage Peak
mAs	Tube Currenttime Product
Ma	Tube Time Product
CT	Computed Tomography
DRLs	Diagnostic Reference Levels
CTDI _v	Represents the Volume Computed Tomography Dose Index
CTDI _w	Weighted Computed Tomography Dose Index
DLP	Dose Length Product
DRLs	Diagnostic Reference Levels
ED	Effective Dose
NNRA	Nigerian Nuclear Regulatory Authority

Author Contributions

Ilupeju Yemisi: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology

Idris Mustapha Mohammed: Project administration, Supervision, Validation

Odeleye Olagoke Samson: Visualization, Writing – orig-

inal draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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