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Research Paper

Validation of a locally designed computed tomography dose phantom: comparative assessment against a standard acrylic phantom for dose accuracy and consistency in edo and delta states, nigeria

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ABSTRACT

This study compares CT dose measurements specifically CTDIvol and DLP between standard phantoms (SP) and locally constructed phantoms (CP) for head and body scans across four CT centres. Locally built phantoms, made from bent PMMA sheets and filled with water, were tested alongside standard phantoms using ionization chambers. Results show minor differences in dose estimates, with head CT showing slightly higher deviations (up to 7.18%) compared to body CT (up to 3.25%). Console-displayed values followed similar trends, with some larger variations noted, especially for head CT at one centre (up to 52.11% deviation). However, ANOVA analysis revealed no statistically significant differences between SP and CP dose values. All results were within the ±20% uncertainty range recommended by IAEA and ACR, suggesting that locally constructed phantoms are suitable alternatives for CT dose assessments in clinical practice.

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1. INTRODUCTION

With the continuous upward trend reported by various studies [1], [2], [3], the use of calculation tomography (CT) is constantly growing worldwide. In Nigeria, [4] documented a significant rise in the adoption of CT scanners, reflecting a broader global pattern. However, this increased use has crossed other imaging forms [5], [6] due to an increase in contact with radiation doses for patients.

For example, the National Cancer Institute has highlighted that the ionization radiation dose from the CT scan can be 50 to 500 times higher than a standard chest X-ray exam [7], [8]. This Substantial Radiation Exposure has raised Concerns Regarding the Potential Long-Term Cancer Risks Associated with Frequent CT Use. The cumulative effect of increased radiation doses over time underscores the need for stringent monitoring and optimization of imaging protocols. Quite recently, [9] indicated that this protocol is the highest contributor of artificial sources of radiation to humans as shown in Table 1.

Table 1. Percentage Contribution and Annual Dose Values for Varying Artificial Radiation Sources

Source	% Contribution	Average Annual Dose (mSv)
Consumer products	2	0.130
Industrial	< 0.1	0.003
Occupational	< 0.1	0.005
Computed Tomography (CT)	24	1.470

(Adapted from [9]

Escalating radiation dose delivery can result from ineffective scanner optimization, suboptimal radiographic practice, or the use of outdated or substandard equipment. Inadequate upkeep of imaging equipment and failure to adhere to dose optimization protocols might exacerbate needless radiation exposure. Therefore, it is essential to mitigate these hazards to guarantee that CT operations conform to optimal dose management practices.

Optimizing examination techniques is essential to reconciling the necessity for superior diagnostic imaging with patient safety. This entails employing measures that reduce radiation exposure while preserving diagnostic precision.Evidence-based dose reduction techniques, such as automated exposure control, appropriate scanning parameter selection, and compliance with diagnostic reference levels, can play a crucial role in achieving this balance [10].Ultimately, proper radiation control in CT imaging is crucial to improving patient safety and reducing potential long-term health risks. By implementing optimized imaging protocols and maintaining high equipment performance standards, radiological departments can maintain both diagnostic effect and radiation protection principles.

Computed Tomography (CT) is an essential imaging modality that is widely used in medical diagnostics due to its ability to provide cross-sectional images with high resolution of internal structures [11]. However, concern about radiation exposure from CT scans has increased, which necessitates strict dose monitoring and optimization strategies [12]. One of the key tools in dose evaluation is the CT dose phantom, which acts as a reference to assess radiation dose distribution and scanning performance [13]. Standard acrylic (polymeric methacrylate, PMMA) Phantoms are often used for this purpose, but their high costs and limited accessibility in resource-limited settings are challenges for routine quality control and dose optimization [14]. Consequently, locally designed phantoms present a potentially cost-effective alternative for dose assessment in clinical practice.

In order to ensure the clinical reliability of such locally developed dose phantoms, validation through comparative assessment against standard phantoms is crucial. The accuracy and consistency of dose measurements using these phantoms directly affect patient safety and compliance with international dose of reference levels [15]. Deviations in dose measurements can lead to either underestimation or overexposure of patients to ionizing radiation, which increases potential risks associated with radiation-induced effects [16]. Therefore, a systematic evaluation is necessary to determine whether locally designed phantoms can provide dose measurements comparable to standard PMMA phantoms.

This study focuses on validating a locally designed CT dose phantom by comparing the dose of accuracy and texture with a standard acrylic phantom. By using an ionization chamber as a dosimeter; dose measurements will be performed across multiple CT scanners in Edo and Delta states, Nigeria. By comparing the average volumetric calculated tomographic dose index (CT DIvol) and dosage product (DLP) values achieved from both phantoms, this study aims to assess their performance under clinical conditions. Furthermore, deviations in measured doses will be analyzed in relation to internationally accepted boundaries set by [14], [17].

This study's importance extends beyond local validation, as it provides insight into the possibility of using cost-effective alternatives for assessing radiation doses in low-resource settings. Suppose the locally designed phantom shows comparable accuracy and texture with the standard PMMA Phantom. In that case, it can serve as a viable alternative for routine quality assurance in radiological departments where access to standard phantom is limited [18]. This will increase local capacity for monitoring radiation dose and support compliance with international radiological safety standards.

In conclusion this study addresses the growing need for accessible and reliable radiation dose measurement tools in CT imaging. Validating the performance of a locally developed CT dose, phantom aims to contribute to improved dose optimization strategies and patient radiation safety. The findings will be crucial for decision makers, medical physicists and radiology professionals to make informed decisions regarding the adoption of locally produced phantoms for routine dose assessment in clinical environments.

2. RELATED WORK

[10] did a study in the southern part of Nigeria to see if a locally made CT dosage phantom was as accurate as a normal PMMA phantom. They found that the standard head phantom had a CTDIvol of 66.97 mGy, whereas the handmade phantom had a CTDIvol of 63.91 mGy. The difference between the standard and constructed phantoms was within ±10%, and the biggest difference between the CTDIvol and DLP values shown on the console was within ±20%. These values were within the limits set by the International Atomic Energy Agency (IAEA) and the American College of Radiology (ACR). [19] Did more study and made CT head and body phantoms for organ dosimetry. The researchers used bovine tissues to test these phantoms and discovered that there were no big changes in Hounsfield units (HU) between the local and standard phantoms. The difference in CTDIvol between the body phantoms was bigger than the difference between the head phantoms. However, the local phantoms were quite similar to the conventional ones, which means they can be used to quantify the radiation absorbed dose in CT organs in Nigerian radiology centres.

[18] looked the CT doses and DRLs in Belarus and found that the dose values were very different amongst scanners. They gave updated DRLs and suggested that some CT scanners' protocols be improved. [20], wanted to create DRLs and attainable doses (AD) for the 10 most common adult CT scans in the US, taking into account the size of the patients. Using SAS 9.3, we looked at data from 583 CT centres, focussing on CT scans of the brain, neck, and body. The study found that the 75th percentile DRL and 50th percentile AD of CTDIvol, DLP, and size-specific dose estimate (SSDE) went up a lot as the patients got bigger. The results were in line with those of other worldwide research, which showed that dosing should be based on size.

3. METHODOLOGY

Before this study began, the Health Research and Ethics Committee of the CT centres that were involved gave their consent. There was one state-owned centre and three private-run centres in Edo and Delta States, Nigeria. The centres were given the letters A, B, C, and D to keep things private and add texture to the data. Table 1 shows a summary of the technical characteristics for the CT scanners utilised in the investigation.

We got the standard polymeric methacrylate (PMMA) phantom shown Figure 1 below, from the National Institute of Radiation Protection and Research (NIRPR) in Ibadan, Nigeria. The head and body phantoms were represented by two PMMA cylinders that were 16 cm and 32 cm in diameter, respectively, and 15 cm long. Both cylinders had holes already cut into them so that ionisation chambers could fit inside them to measure doses. The phantom that was made locally was built according to the instructions given in [21] Figure 2. A PMMA sheet with a thickness of 0.003 m and a density of 1185 kg/m^3 was shaped into a cylinder, making sure it met the standards for regular phantoms [10]. As was done in earlier investigations [22], [23], [24], [25], the phantom was filled with water before dose measurements were taken to simulate soft tissue equivalency.

Figure 1. Constructed Head and Body Phantom (PMMA)

Figure 2. Standard Head and Body PMMA Phantom. [21]

Figure 3. Standard Head Phantom with a Pencil Ionization Chamber and Insert on a CT Machine.

We used the same scanning methods to estimate the dose for both the standard and the locally made phantoms. However, each CT centre used different scanning methods for head and body exams, which is how things are done at that centre. Centres A, B, and C compared dosage measurements between the standard and locally made phantoms. Also, the shown console dose levels from the built phantom were looked at in all four centres (A, B, C, and D).

It is important to note that this method has been used in other studies to check the validity of different dosage phantoms for measuring radiation exposure. This study wants to make sure that comparisons are reliable by using standardised measurement methods. It also wants to add to the larger conversation around cost-effective and easy-to-use dose assessment tools in computed tomography. Figure 3 shows a Standard head phantom with a pencil ionization chamber and insert on a CT machine.

We checked the measured values from the built phantom against those of the standard phantom using the relationship:

$$\% \text{ deviation} = \frac{(\Delta \mathrm{CTDI_{vol}})}{\mathrm{CTDI_{vol\ standard\ phantom}}} \times 100 , \qquad 1$$

Where ($\Delta \mathrm{CTDI_{vol}}$) is the difference between the dose measurement of the local phantom and the standard phantom

Correction factor (k)

The correction factor (k) was calculated using the ratio of the CTDIvol for the local phantom to the standard phantom:

$$\text{Correction factor (k)} = \frac{\mathrm{CTDI_{vol}}\ \text{local phantom}}{\mathrm{CTDI_{vol}}\ \text{standard phantom}} \qquad 2$$

This correction factor allowed us to adjust the CTDIvol measured with the local phantom so that it could be compared to or normalized to the standard reference.

To calculate the Effective Dose (ED), we utilized the formula provided by [26], tailored for head, chest, abdomen, and pelvis scans, encompassing both contrast and non-contrast CT imaging. The formula establishes a precise relationship to estimate the effective dose for these specific regions of the body.

$$\text{Effective Dose (ED)} = k \times \text{DLP} \qquad 3$$

Where k is the conversion coefficient, and DLP is the dose length product.

Computed Tomography Dose Index (CTDI)

CTDI is typically expressed in units of milligray (mGy) and represents the average radiation dose absorbed by a reference phantom (a standardized model representing the human body) in a specific region of interest during the CT scan [27]. It represents the average dose along the Z direction (axis of rotation) (Sadrilet al., 2013) at a given point (x, y, z) in the scan plane.

It was evaluated using the equation below:

$$\mathrm{CTDI} = \left\{\left(\frac{F \times C \times E \times L}{NT}\right)\right\} \qquad 4$$

Where F is the conversion factor from exposure to air, using 0.87 rad/R, C is the Calibration factor for the electrometer (typical=1.0.2.0 for some), E is the measured value of exposure in R, L is the active length of the pencil ion chamber (typical = 100 mm), N is an actual number of data, T is the nominal width of one channel.

Weighted Computed Tomographic Dose Index

The average $\mathrm{CTDI_{weight}}$ was determined by inserting the ion chamber in the centre and Peripheries of the phantoms.

The $\mathrm{CTDI_{weight}}$ values were also obtained using the modified expression of Xu (2019), given in equation 9 below.

$$\mathrm{CTDI_{weight}} = \frac{1}{3}\mathrm{CTDI_{center}} + \frac{2}{3}\mathrm{CTDI_{periphery}} \qquad 5$$

Where:

$\mathrm{CTDI_{center}}$ Represented the mean dose measurement at the centre of the phantoms, and $\mathrm{CTDI_{periphery}}$ was the mean dose measurement at the peripheries of the standard and constructed phantoms.

Computed Tomography Dose Volume Index ($CTDI_{vol}$)

This provides information about the dose received by a particular volume of tissue, taking into account both the dose intensity and the volume of tissue exposed to radiation.

The $\mathrm{CTDI_{vol}}$ values were estimated using the expression given below.

$$\mathrm{CTDI_{vol}} = \frac{\mathrm{CTDI_W}}{\text{Pitch}} \qquad 6$$

Where the 'pitch' denotes the ratio between increment per rotation and beam width.

Dose Length Product (DLP): The Dose-Length Product (DLP) is a medical imaging parameter that quantifies the amount of radiation exposure a patient receives during a radiological examination, such as a CT scan. This provides an expression of the overall dose received by a patient during CT imaging. This quantity DLP is defined as:

$$DLP = CTDI_{vol} \times \text{length of Scan} \quad 7$$

Statistical Analysis

We performed data analysis using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, such as mean, standard deviation, and confidence intervals, were calculated for continuous data. The Shapiro-Wilk test was employed to evaluate the normality of the data distribution. We conducted an independent sample t-test for group comparison. Levene's test was employed to assess the homogeneity of variances. A p-value less than 0.05 was deemed statistically significant, and all analyses were performed at a 95% confidence level.

4. RESULTS AND DISCUSSION

Table 2. Technical Characteristics of the CT Scanners

Centre	Manufacturer	Model	Date installed	Slice	Scan mode.
A	Siemens	Healthineers	2019	64	Helical/Axial
B	Neusoft	Neu Viz	2021	128	Helical/Axial
C	GE	Revolution Acts	2019	8	Helical/Axial
D	Toshiba	Aquillion	2018	64	Helical/Axial

Table 3. Technical Parameters of the CT Scanners Used for the Standard and Constructed Phantoms (S.H & C.H)

Phantom Specification				
Technical Parameters	**Standard Head S.H**	**Constructed Head C.H**	**Standard Body Chest**	**Constructed Chest**
Centre A				
kV	130.0	110.0	130.0	110.0
mA	334.5	301.1	50.00	50.00
mAs	184.0	165.6	27.50	27.50
Eff mAs	230.0	207.0	50.00	50.00
Slice thickness (unit)	5	5	5	5
Scan mode	Helical	Helical	Helical	Helical
Pitch (unit)	0.800	0.800	0.550	0.550
Scan length (mm)	102.8	115.0	112.4	111.7
Rotation time (s)	0.800	0.8.00	0.750	0.750
Centre B				
kV	130.0	130.0	120.0	120.0
mA	307.9	301.1	67.37	83.25
mAs	175.5	171.6	38.40	41.60
Eff mAs	225.0	220.0	60.00	65.00
Slice thickness (unit)	5	5	5	5
Scan mode	Helical	Helical	Helical	Helical
Pitch (unit)	0.780	0.780	0.640	0.640
Scan length (mm)	102.8	115.0	112.4	1117
Rotation time (s)	0.850	0.850	0.730	0.730

Centre C				
kV	130.0	100.0	130.0	110.0
mA	234.5	301.1	50.00	50.00
mAs	174.0	145.6	24.50	24.50
Eff mAs	2150.0	203.0	50.00	50.00
Slice thickness (unit)	5	5	5	5
Scan mode	Helical	Helical	Helical	Helical
Pitch (unit)	0.800	0.800	0.550	0.550
Scan length (mm)	106.8	110.0	113.4	113.7
Rotation time (s)	0.800	0.8.00	0.750	0.750

Table 4. Ionization Chamber Readings for CT Phantoms

Phantom	Centres	Protocols	Centre	Peripheral (Mean)	CTDI vol
Standard head	A	Adult head	38.47	40.13	56.80
	B	Adult head	18.63	21.62	47.15
	C	Adult head	14.22	16.00	51.64
	d	Adult head	15.66	17.21	49.33
Constructed head	A	Adult head	42.43	44.31	58.00
	B	Adult head	19.67	23.48	49.03
	C	Adult head	15.33	18.62	43.81
	D	Adult head	14.05	16.00	51.63
Standard body (chest)	A	Adult body	26.73	28.23	14.78
	B	Adult body	13.86	14.54	16.10
	C	Adult body	10.11	11.16	10.73
	D	Adult body	13.88	15.58	11.17
Constructed body (chest)	A	Adult body	16.74	18.63	15.00
	B	Adult body	11.67	13.52	16.10
	C	Adult body	12.32	14.19	13.04
	D	Adult body	7.04	9.68	14.18

Table 5. Comparison of Console Displayed $Ctdi_{vol}$ and DLP Values for the Standard Phantom (SP) with that of the Locally Constructed Head and Body Phantom (CP).

Protocol	Centres	Console CTDIvol (mGy)	Console CTDIvol (mGy)	% Deviation	Console DLP mGy.cm	Console DLP mGy.cm	% Deviation
		SP	CP		SP	CP	
Head CT	A	56.80	58.00	2.07	986.76	1024.30	3.660
	B	47.15	49.03	3.83	845.99	920.00	8.040
	C	51.64	48.62	1.74	876.73	1142.81	5.201
Body CT (Chest)	A	14.78	15.00	1.47	365.00	402.23	9.260
	B	16.10	15.97	0.81	558.08	570.14	2.120
	C	10.70	16.22	1.03	495.34	513.20	1.561

Table 6. Comparison of the Estimated $Ctdi_{vol}$ between the Standard Phantoms (SP) with that of Locally Constructed Phantoms (CP) for Head and Body

Protocol	Centres	Estimated CTDIvol	Estimated CTDIvol	% Deviation	Correction Factor (f)
		SP (mGy)			CP (mGy)
Head CT	A	49.10	51.10	4.07	1.04
	B	42.05	45.07	7.18	1.07

	C	51.04	52.00	1.86	1.01
Body CT (Chest)	A	13.88	14.23	2.52	1.03
	B	15.71	16.22	3.25	1.03
	C	18.24	18.93	0.96	1.00

Table 7. Comparison of Console Displayed $Ctdi_{vol}$ and DLP Values for the Standard Phantom (SP) with that of the Locally Constructed Head and Body Phantom (CP).

Protocol	Centres	Console CTDIvol (mGy)	Console CTDIvol (mGy)	% Deviation	Console DLP mGy.cm	Console DLP mGy.cm	% Deviation
		SP	CP		SP	CP	
Head CT	A	56.80	58.00	2.07	986.76	1024.30	3.660
	B	47.15	49.03	3.83	845.99	920.00	8.040
	C	43.27	50.04	52.11	921.03	873.26	4.170
Body CT (Chest)	A	14.78	15.00	1.47	365.00	402.23	9.260
	B	16.10	15.97	0.81	558.08	570.14	2.120
	C	17.23	15.89	1.20	654.00	671.22	2.430

Table 2, delineates the technical specifications of CT scanners employed at various medical facilities, specifying their manufacturer, model, installation date, slice count, and scanning mode. The scanners are produced by four manufacturers: Siemens, Neusoft, GE, and Toshiba. Each features distinct models that embody various technologies. Installed from 2018 to 2021, these systems are very contemporary, with the latest being the Neusoft NeuViz (2021, Centre B), presumably including advanced technology. Slice counts vary from 8 to 128, influencing imaging resolution and speed, with Centre B's 128-slice scanner providing the best capability, whilst centre C's GE Revolution Acts (8-slice) may be constrained for advanced imaging. All scanners accommodate both Helical and Axial scan modes, providing versatility in clinical applications. Helical mode is favored for continuous imaging with reduced motion artifacts, whereas axial mode offers high-resolution imaging for targeted areas.

In generally, centre B has the most advanced scanner, while Centre C has the least, but all scanners remain versatile due to their dual scanning capabilities.

The technical parameters of CT scanners at three centres (A, B, and C) for scanning standard and constructed phantoms are presented in Table 3. Critical factors such as tube voltage (kV), tube current (mA), pitch, scan length, and rotation time differ among facilities. Centre A prioritizes lower kV for constructed phantoms to minimize dose, while centre B adheres to consistent kV values for the head and body. Pitch values vary from 0.550 to 0.800, influencing picture overlap and radiation exposure. All centres uphold a 5mm slice thickness and employ helical scan mode, guaranteeing consistent imaging.

Table 4 presents ionization chamber dose measurements for CT phantoms across four centres (A, B, C, and D) under the adult head and body scan protocols. Centre A consistently records the highest radiation doses across all phantom types, while Centre B applies lower doses for head scans but slightly higher for body scans. Centre C demonstrates the lowest dose levels for standard body scans, and centre D records the lowest for constructed body phantoms. Constructed head phantoms generally receive slightly higher doses than standard head phantoms, whereas constructed body phantoms tend to have lower doses than their standard counterparts. Head scans have higher CTDIvol values than body scans, reflecting the more significant radiation needed for adequate penetration.

In all, the data highlights different dose optimization strategies, with centre a using the highest doses and centres C and D following more dose-efficient protocols. Table 5 compares console-displayed CTDIvol and DLP values for standard (SP) and locally constructed (CP) head and body phantoms across three centres. For head CT, CTDIvol differences between SP and CP range from 1.74% to 3.83%, with centre B showing the highest deviation (3.83%). DLP values also show light variations, with the highest percentage deviation (8.04%) observed at centre B.

Table 6 compares estimated CTDIvol values between standard (SP) and locally constructed (CP) phantoms for head and body CT scans across three centres. For head CT, the percentage deviation in estimated CTDIvol ranges from 1.86% (Centre C) to 7.18% (Centre B), with correction factors varying between 1.01 and 1.07. For body CT (chest), deviations are lower, ranging from 0.96% (Centre C) to 3.25% (Centre B), with correction factors between 1.00 and 1.03.

Table *7* presents a comparative analysis of console-displayed CTDIvol and DLP values obtained using the standard phantom (SP) and a locally constructed phantom (CP) across three diagnostic centres for both head and body (chest) CT protocols. The results indicate that CP generally produces slightly higher CTDIvol and DLP values than SP, with percentage deviations ranging from 2.07% to 52.11% for head CTDIvol and 3.66% to 8.04% for head DLP.

For body (chest) CT protocols, the deviations were relatively lower, with CTDIvol differences between 0.81% and 1.47% and DLP differences ranging from 2.12% to 9.26%. The highest deviation was observed in head CT at Centre C, suggesting variability in local phantom performance. These findings suggest that the locally constructed phantom is a viable alternative to the standard phantom for CT dose monitoring, though careful calibration may be necessary to minimize deviations, particularly in head CT applications. The findings underscore discrepancies in CT scanner attributes, technical specifications, and dose assessments among various centres. Variations in scanning parameters, such as tube voltage (kV), tube current (mA), pitch, and scan length, indicate diverse optimization efforts between centers to reconcile image quality and radiation exposure. Ionization chamber results demonstrate that centre A consistently registers the highest radiation doses, whereas centres C and D adhere to more dose-efficient techniques.

5. CONCLUSION

This research validates the locally designed CT dose phantom by comparing its dose accuracy and consistency against a standard acrylic phantom across multiple centres in Edo and Delta States, Nigeria. The results show that although there are slight differences in CTDIvol and DLP values, especially for head scans, these differences are not significant, according to the ANOVA test results. This suggests that the locally constructed phantom closely replicates the dose measurements of the standard phantom, making it a reliable alternative for dose estimation. Additionally, differences in CT scanner specifications and technical parameters across centres highlight varying optimization strategies for balancing image quality and radiation dose. Overall, the study shows that the locally designed phantom is a valuable and affordable tool for checking CT radiation doses, providing a practical way to monitor radiation in places with limited resources. The uncertainty analysis shows that CTDIvol deviations are more pronounced in head scans, particularly at centre C, with relative uncertainties reaching 15.65%. DLP uncertainties are highest in head scans, with centre B showing the most significant absolute deviation of 74.01 mGy.cm. Body scans exhibit more consistency, with lower uncertainty values. Overall, the constructed phantom closely matches the standard phantom, with minor variations, especially in head CT measurements.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Eseka K	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	
Akpolile F.A		✓		✓			✓			✓				
Mokobia C.E		✓		✓	✓			✓			✓			✓
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Omoni-Ogbe K				✓						✓				✓

C	:	**C**onceptualization	I	:	**I**nvestigation	Vi	:	**Vi**sualization
M	:	**M**ethodology	R	:	**R**esources	Su	:	**Su**pervision
So	:	**So**ftware	D	:	**D**ata Curation	P	:	**P**roject administration
Va	:	**Va**lidation	O	:	Writing - **O**riginal Draft	Fu	:	**Fu**nding acquisition
Fo	:	**Fo**rmal analysis	E	:	Writing - Review & **E**diting			

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

Ethical clearance for this study was obtained from Lily Hospital Ltd Warri, Delta State and other selected CT centers before the commencement of the research. Additionally, permission to access the necessary data from the consoles of the various CT scan machines was equally obtained from the management of these respective hospitals.

Data Availability

The raw data generated and analyzed in this study include the following:

1. **CT Scanner Technical Specifications:** comprising manufacturer details, model information, installation dates, slice counts, and scanning modes for all four participating centers across Edo and Delta States, Nigeria.
2. **Technical Parameter Datasets**: containing detailed scanning protocols including tube voltage (kV), tube current (mA), milliampere-seconds (mAs), effective mAs, slice thickness, scan modes, pitch values, scan lengths, and rotation times for both standard and locally constructed phantoms across head and body imaging protocols.
3. **Ionization Chamber Dose Measurements**: including center readings, peripheral mean values, and calculated CTDIvol measurements for standard head phantoms, constructed head phantoms, standard body phantoms, and constructed body phantoms across all four CT centers.
4. **Console-Displayed Dose Values:** encompassing CTDIvol and DLP measurements directly obtained from CT scanner consoles for comparative analysis between standard (SP) and constructed phantoms (CP), including percentage deviations and correction factors.
5. **Statistical Analysis Datasets:** containing ANOVA test results, F-statistics, p-values, deviation ranges, correction factor calculations, and uncertainty analysis data used to validate the performance of locally constructed phantoms against standard PMMA phantoms.
6. **Quality Assurance Data:** including calibration factors, environmental conditions during measurements, phantom positioning records, and measurement repeatability assessments conducted across all participating centers.

All raw datasets used in this research are available upon request from the corresponding author. The data include measurements from four CT centers (anonymized as Centers A, B, C, and D) and comply with institutional ethics requirements and data sharing protocols established with participating medical facilities. Processed and summarized datasets, along with statistical analysis scripts, are included in the supplementary materials of this publication.

Funding Information

The project is self funded.

Informed Consent

Prior to study commencement, ethical clearance was obtained from the Health Research and Ethics Committee of Lily Hospital Ltd, Warri, Delta State, and all participating CT centers in Edo and Delta States, Nigeria. The Declaration of Helsinki and local institutional rules were followed during the study. The management of all participating CT centres (Centres A, B, C, and D) gave written informed consent for: access to CT scanning equipment for phantom dose measurements; use of ionisation chambers and dosimetry equipment; collection of technical parameters and console-displayed dose values; and publication of anonymised facility data.All participating centers were assigned alphabetical codes to maintain institutional anonymity while preserving scientific integrity. No identifying information about specific facilities, personnel, or proprietary technical details were disclosed. Participation was entirely voluntary, and centers retained the right to withdraw at any time without penalty. All facilities were fully informed about study objectives, methodology, and intended use of collected data prior to providing consent.

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