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Original Research Article

Establishing Paediatric Head Computed Tomography Diagnostic Reference Levels for Lusaka Province

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Abstract: ***Introduction***: Paediatric Computed Tomography (CT) scans are essential diagnostic tools, but they raise important concerns due to children's increased vulnerability to radiation risks compared to adults. In Zambia, the lack of locally established paediatric Diagnostic Reference Levels (DRLs) hampers efforts to standardise protocols and optimise radiation doses. This study introduces the first local DRLs and estimates the effective doses for paediatric head CT scans in Lusaka Province. ***Methods***: A retrospective, cross-sectional study was conducted at three public hospitals in Lusaka, involving data from 337 paediatric patients aged 0-18 years who underwent head CT scans between 2019 and 2023. Effective Doses (ED) were calculated using age-specific conversion factors based on age-based DRLs, according to the ICRP protocol. Results: The established local DRLs showed an age-related increase, indicating the need for higher radiation parameters in older children. Median (IQR) DLP values ranged from 551.5 mGy·cm (IQR 456.10-653.80) for the <1-year age group to 793.4 mGy·cm (IQR 701.00-1210.00) for the 10-15-year age group. The overall median effective dose was 4.66 mSv (IQR 2.605-7.375 mSv). Significant differences in DLP values between centres were observed ($p<0.0001$). Patient age showed a moderate positive correlation with both $CTDI_{vol}$ ($r=0.375$, $p<0.0001$) and DLP ($r=0.476$, $p<0.0001$). Compared to international benchmarks, the DRLs displayed notable differences. ***Conclusion***: This study has established local Diagnostic Reference Levels (DRLs) for paediatric head CT scans in Lusaka, Zambia. Variations in CT doses were observed across hospitals. It is advised that CT imaging protocols for paediatric patients be optimised. Collaboration between radiographers, radiologists, and medical physicists, along with comprehensive training for CT radiographers, is also recommended.

Keywords: Computed Tomography, Local Diagnostic Reference Levels, Radiation Dose, Effective Dose, Paediatric Head CT, Zambia.

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INTRODUCTION

The invention of CT marks a significant milestone in the history of diagnostic medicine. Since its emergence in the early 1970s, this technology has fundamentally transformed clinical practice by enabling detailed cross-sectional imaging of the human body, thus overcoming the limitations of conventional radiography (Schulz, Stein and Pelc, 2021). CT is a widely used diagnostic tool globally, valued for its ability to produce high-resolution, non-superimposed images that are essential for detecting a broad range of conditions, from subtle pathologies to severe traumatic injuries (Gricienė and Šiukšterytė, 2021). The introduction of multidetector CT (MDCT) in the 1990s further enhanced this capacity, offering unprecedented speed and spatial resolution (Kohl, 2005). These advancements have made CT an essential modality for assessing critically ill, uncooperative, or very young patients, often eliminating the need for sedation or general anaesthesia in emergencies. Common and critical applications in CT head imaging in paediatrics include investigating traumatic brain injuries (such as skull fractures, haemorrhages, and contusions), congenital anomalies, hydrocephalus, and brain tumours (Goldstein, Dawadi and Viljoen, 2022).

However, the widespread use of CT, especially in children, has raised increasing concerns about the associated ionising radiation exposure. Studies consistently show that children are biologically more vulnerable to radiation-related health risks than adults (Brenner *et al.*, 2001; Brenner and Hall, 2012; Pearce *et al.*, 2012; Sheppard *et al.*, 2018). An extensive epidemiological study involving over 680,000 paediatric patients estimated a 24% higher risk of cancer linked to childhood and adolescent CT scans (Wagner *et al.*, 2018). Furthermore, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has concluded that, for an equivalent dose, the lifetime cancer risk for a person exposed as a child may be two to three times higher than for an adult (UNSCEAR, 2014).

This global issue is especially significant in Zambia, where children under 18 years constitute about 53.4% of the population (UNICEF, 2023). This demographic means that any health risks primarily affecting children have significant public health consequences for the country. Therefore, implementing robust radiation safety practices, including strict dose optimisation, is a vital public health priority for the Zambian healthcare system. To manage radiation doses effectively, international organisations such as the International Commission on Radiological Protection (ICRP) strongly endorse the principles of justification and optimisation, with Diagnostic Reference Levels (DRLs) playing a crucial role (Wagner *et al.*, 2018; Tan *et al.*, 2021). DRLs are tools that indicate typical dose levels for a procedure on a standard group of patients. They are usually based on national or regional surveys, often set at the 75^{th} percentile of the dose distribution and serve as benchmarks to identify and scrutinise imaging practices that result in unusually high or low doses (Abdulkadir *et al.*, 2021). The purpose of DRLs is to increase awareness of radiation exposure and to encourage dose reduction in line with the As Low As Reasonably Achievable (ALARA) principle (Vañó *et al.*, 2017).

An audit of CT services in Zambia, which found that only five (5) out of twenty-two (22) facilities had diagnostic reference levels (DRLs) in place, highlights the significant obstacle that the absence of locally established DRLs presents to consistent dose optimisation (Kafwimbi, Bwanga and Sichone, 2021). Furthermore, a preliminary study aimed at proposing adult national DRLs (NDRLs) for standard CT examinations in Zambia found that DRLs for the brain and chest were higher than those from other countries, confirming the need to optimise CT scan parameters and protocols (Kafwimbi *et al.*, 2025). This study was initiated to fill this critical gap by establishing the first local DRLs for paediatric head CT scans in Lusaka Province. It aimed to describe the demographic and technical details of these scans, establish age-specific DRLs based on key dose metrics ($CTDI_{vol}$ and DLP), and estimate the effective doses received by patients. The findings provide a vital baseline for improving radiation safety, standardising protocols, and safeguarding paediatric patients in Zambia.

METHODS

Study Design

This research employed a quantitative, cross-sectional design. The data was obtained from archived data on CT machines in Lusaka province.

Study Sites and Equipment

The study was conducted at three (3) major public tertiary hospitals in Lusaka Province. These institutions were selected based on their high patient throughput, data management practices, and the presence of modern or recently installed CT scanners.

Study Population and Sample Size

The study population consisted of CT scan files of all paediatric patients aged 0-18 years who underwent a head CT scan at the selected sites between 2019 and 2023 from the selected hospitals. A census approach was used to collect all available records that met the inclusion criteria. A total of 337 patient records were included. Inclusion criteria required that the records contained: complete patient demographics (age and sex); a head region scan; and a complete CT dose report with values for $CTDI_{vol}$ and DLP. This study's dataset exceeded the ICRP-recommended minimum of 20 scan sets per age group, thereby ensuring adequate rigour (Vañó *et al.*, 2017).

Data Collection Process

Following ethical approval from the University of Zambia Biomedical Research Ethics Committee (UNZABREC: protocol no. 4211-2023), as well as approval from the Zambia National Health Research Authority (NHRA) and the respective hospitals, data were carefully collected from CT scanner consoles and digital patient records.

A standardised data collection sheet was used to record essential information from each of the 337 paediatric head CT examinations included in the study. The data collection process followed a strict plan to ensure accuracy and consistency. A thorough review of image quality was carried out as part of the inclusion criteria to ensure that all included images were of diagnostic quality and free from motion artefacts. It covered the entire head from the vertex to the base of the skull, in accordance with established standards such as EUR 16262 (Jurik *et al.*, 1998). There are several approaches that are used to establish DRLs, Dosemetric quantities such as $CTDI_{vol}$ and DLP and patient parameters such as size, age and weight, (Kafwimbi *et al.*, 2023). Information gathered for each scan included:
Patient Demographics: Age and sex were recorded from the patient records.

i. Technical Parameters: Detailed technical settings were retrieved from the CT scanner consoles, including kilovoltage peak (kVp), effective current (mAs), number of scan phases, slice thickness, scan type (with or without contrast media), scan mode (axial, helical, or combined), number of scan series, and the phantom size used.

ii. CT Dose Metrics: Key radiation dose indicators, specifically the Volumetric Computed Tomography Dose Index ($CTDI_{vol}$) and the Dose Length Product (DLP), were directly obtained from the CT dose reports. All $CTDI_{vol}$ values were confirmed to be based on the 16-cm phantom, which is the standard for head scans.

Scans with missing dose reports or those that did not meet the inclusion criteria were excluded from the final analysis, reducing the initial data set from 621 scans to 337. The collected data were then stored on password-protected computers to maintain confidentiality and comply with the Zambian Data Protection Act (2021). The effective dose was estimated using simplified conversion factors, which provide a general rather than precise measure of individual patient risk. Despite these limitations, the research provides robust data that is valuable for initiating improvements in radiation protection nationwide.

Data Analysis

Frequencies, medians, and associated interquartile ranges were used to describe the descriptive data. To assess differences in technical parameters and dose metrics across the three hospitals, the Kruskal-Wallis test was used, followed by Dunn's multiple-comparison test (P < 0.05). Finally, age-based Diagnostic Reference Levels (DRLs) were established by calculating the median and interquartile range of $CTDI_{vol}$ and DLP values for five age groups, and the effective dose (ED) for patients was estimated using the formula $E = \kappa \times DLP$.

RESULTS

Patient Demographics

A total of **337** paediatric head CT (PHCT) scans were analysed from three public hospitals in Lusaka Province. The largest patient groups were in the 1-5 years (n=98) and 5-10 years (n=97) age brackets as shown in Table 1 below.

Table 1: shows the characteristics of CT images

Hospital	Machine	Age Group and Number of Examinations				
		<1 years	>/=1<5 years	>/=5<10 years	>/=10<15 years	>/=15<18 years
1	1	8	46	50	28	24
2	1	4	1	0	6	2
	2	2	6	4	6	1
3	1	14	45	42	23	25
		28	98	96	63	52

Technical Parameters

There was a significant association between $CTDI_{vol}$ and the number of detector rows. Increasing the number of detector rows reduced $CTDI_{vol}$. There was also a significant association between $CTDI_{vol}$ and DLP: an increase in DLP was associated with an increase in $CTDI_{vol}$, as shown in Table 2 below.

Table 2: Distribution of Equipment Details and Spearman's rank correlation (*CT dose indices, Technical parameters, and patient age)*

Hospital	Brand of Machine		Model		No. Detector Rows		Year of Installation	
1	Philips		Ingenuity Core 128		128		2020	
2	Siemens		SOMATOM Definition AS		24		2019	
	Siemens		Sensation Open		64		2008	
3	Neusoft		NeuViz 128		128		2020	
Spearman's rank correlation								
	Dose Indices		**Technical Parameters**				**Patient Parameters**	
	$CTDI_{vol}$		**kV**		**No. of Detector Rows**		**Patient Age**	
$CTDI_{vol}$	**r**	***p-value***	**R**	***p-value***	**r**	***p-value***	**r**	***p-value***
	1.000		.617**	<0.0001	-.291**	<0.0001	.375**	<0.0001
DLP	.726**	<0.0001	.570**	<0.0001	-.246**	<0.0001	.476**	<0.0001
	r	***p-value***	**R**	***p-value***	**r**	***p-value***	**r**	***p-value***

Note: *$CTDI_{voL}$ = Volumetric Computed Tomography Dose Index; DLP = Dose Length Product; kV = kilovoltage; **p < 0.0001.*

Age-Based DRLs and Inter-Hospital Comparisons

The highest median DRL values were observed in the **10-15 years** age group. Table 3 below illustrates the DRLs.

Table 3: The Proposed Age-based Paediatric Head CT DRL values for Lusaka Province

AGE-BASED PAEDIATRIC HEAD CT DIAGNOSTIC REFERENCE LEVEL VALUES							
Age Group (years)	**DLP (mGy.cm) Per Examination**				**$CTDI_{vol}$ (mGy) Per Examination**		
	N	**Percentile 25**	**Median**	**Percentile 75**	**Percentile 25**	**Median**	**Percentile 75**
<1y	28	458.70	551.50	645.10	23.60	29.07	34.91
>/=1<5y	98	530.00	620.30	730.00	25.60	32.50	37.50
>/=5<10y	96	607.65	672.30	752.50	27.60	32.50	37.50
>/=10<15y	63	701.00	793.40	1210.00	32.50	37.50	48.80
>/=15<18y	52	706.60	786.30	1147.00	32.50	37.50	48.80

Note: N: Number of patients, $CTDI_{vol}$: Volumetric CT dose index (mGy), DLP: dose length product (mGy.cm)

There were significant variations in DLP values among the three hospitals. The highest values were observed at hospital 2, as shown in Figure 1 below.

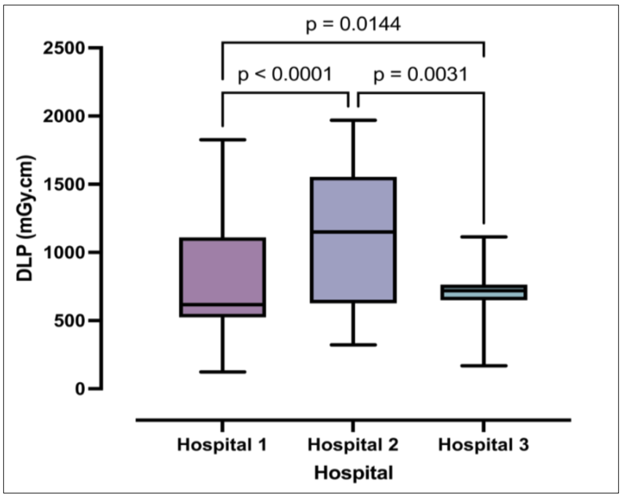

Figure 1: Differences in Dose length Product (DLP) values across three selected public hospitals

There were significant variations in $CTDI_{vol}$ values between hospital 1 and 2, and hospital 2 and 3. The highest $CTDI_{vol}$ values were observed in hospital 2 as shown in figure 2 below.

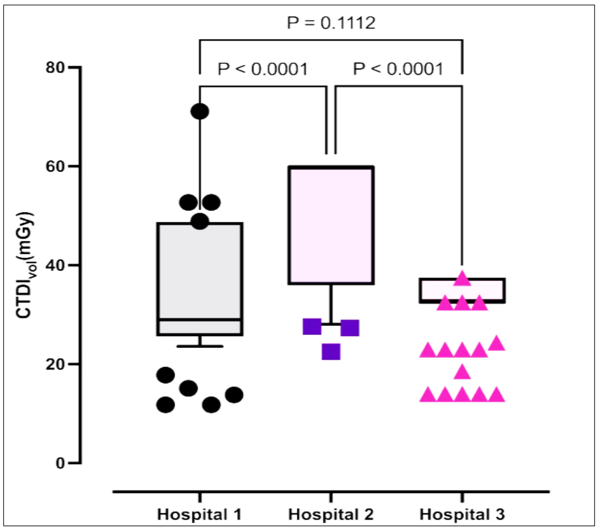

Figure 2: Comparison on $CTDI_{vol}$ values for the selected public hospital

Estimated Effective Doses

The median IQR for effective dose was 4.66 (2.60-7.375) mSv as shown in figure 3 below. There was a significant difference in effective dose between hospitals 1 and 3 as shown in figure 4. There was a significant difference in effective dose values in all the age groups except between the age groups 5-10 years and 10-18 years as shown in figure 5 below.

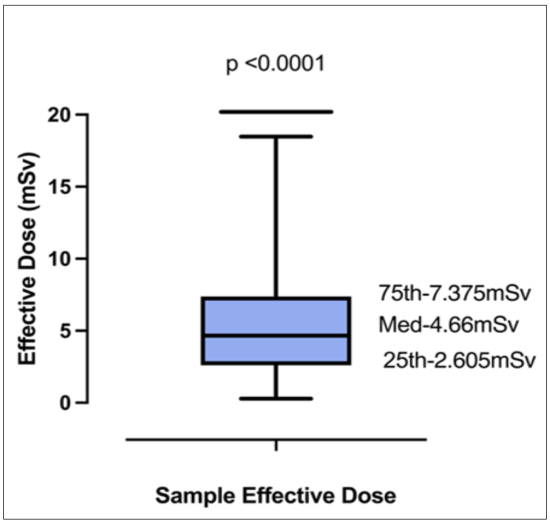

Figure 3: Distribution of Effective Dose

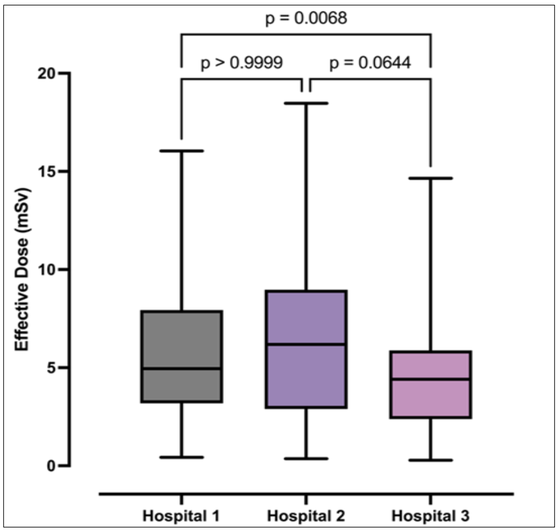

Figure 4: Per Hospital- Distribution of Effective dose

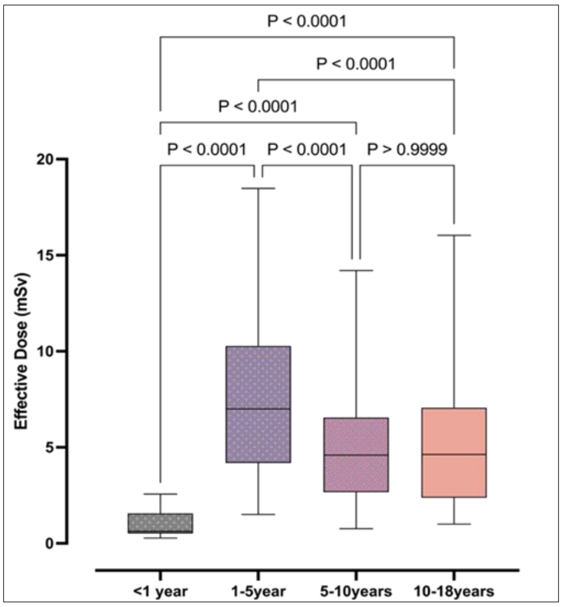

Figure 5: Distribution of Effective Dose and Age group 2

For contrast-enhanced CT (CECT) scans, the median effective dose was higher than for non-contrast scans. Interestingly, for CECT scans, females received a lower median (IQR) effective dose of 6.08 mSv (IQR 4.86-8.75) than males, 7.52 mSv (IQR 5.12-10.06), as shown in Table 4.

Table 4: Distribution of Type of Scan $CTDI_{vol}$, Dose Length Product and Effective Dose by Sex

Sex	Type of Scan	$CTDI_{vol}$ (mGy) median (IQR)	Total DLP (mGy·cm) Median (IQR)	Effective Dose (mSv)Median (IQR)
Male	Non-Contrast Enhanced CT scan (NCCT)	32.5 (27.6-37.5)	735.2 (602.1-1447.40)	3.59 (2.26-5.85)
	Contrast Enhanced CT scan (CECT)	37.50 (31.5-37.50)	1552.55 (1394.9-1963.8)	7.52 (5.12-10.06)
Female	Non-Contrast Enhanced CT scan	32.50 (27.60-37.50)	724.55 (627.80-1281.50)	3.78 (2.37-5.71)
	Contrast Enhanced CT scan	37.50 (31.55-48.80)	1559.80 (1177.10-2282.60)	6.08 (4.86-8.75)

DISCUSSION

This study has established paediatric diagnostic reference levels from three hospitals in Lusaka. A total of 337 paediatric head CT scans were collected from which dose indices and patent parameters were obtained to establish the DRLs. The DRLs were set according to age groups ranging from <1year, >/=1<5, >/=5<10, >/=10<15, and, >/=15<18.

Our analysis of 337 paediatric head CT scans from three public hospitals in Lusaka gave us a detailed look at real-world imaging practices. A significant hurdle we faced was incomplete patient data at one of the hospitals, a common issue in this type of research. This problem is not unique to Zambia, but is also observed in Japan, as noted by Takei *et al*., (2016), and in Palestine, according to Atiya (2024). This highlights a clear, global need for better, automated data management to support dose monitoring (Ekpo, Adejoh and Erim, 2019). We also saw how a hospital's equipment age—from a 2008 scanner to newer 2020 models—affected practice and dose, a finding common in multi-centre studies (Van der Merwe and Mahomed, 2020; Eddy *et al.*, 2021). Newer machines often come with built-in dose-saving features, such as iterative reconstruction and automatic exposure control (AEC), which can significantly reduce radiation exposure (Benmessaoud *et al.*, 2020).

The median (IQR) age of the children in our study was 7 years old (IQR 3-12), a distribution that aligns with other international and regional studies (Kanal *et al*., 2022; Abdulkadir *et al*., 2021). This age profile is likely driven by the high rates of head trauma and neurological conditions common in young children and adolescents. The wide age range in our sample confirms why it is so important to have age-specific DRLs, a principle the International Commission on Radiological Protection (ICRP) stands behind and that other African studies have also supported (Suliman *et al*., 2015). We also found a slight male majority (53.71%), a typical demographic in paediatric CT scans due to the higher frequency of traumatic injuries in boys (Kanal *et al*., 2022; Goldstein *et al*., 2022). While a patient's sex does not directly influence DRLs, this data helps us better understand the patient population being scanned.

Our examination of technical parameters revealed significant inconsistencies in practice. The median (IQR) effective current (mAs) was 240 mAs (IQR 240 -349), but the actual range was vast (132–378 mAs), with notable differences between hospitals ($p < 0.05$). This underscores the urgent need for standardised dose optimisation protocols. This issue is not unique to us; studies in Japan and Cameroon report similar findings, highlighting the pressing need for standardisation and training to ensure radiographers consistently adhere to the ALARA (As Low as Reasonably Achievable) principle.

Our analysis also showed that 120 kVp was the most common tube voltage used (66.2% of scans). Even for very young children, this was higher than the 100 kvp exposure parameters used in a study in Lithuania (Gricienė and Šiukšterytė, 2021). This widespread practice of using adult-level settings on children is a global issue, observed in studies from Japan, the US, and across Africa. However, it also presents a significant opportunity for substantial dose reduction simply by implementing age- and size-appropriate kVp protocols, such as using 80 or 100 kVp for smaller patients.

Our study successfully established Zambia's first local Diagnostic Reference Levels (DRLs) for paediatric head CT, using the median of the Dose Length Product (DLP) and Volumetric Computed Tomography Dose Index ($CTDI_{vol}$) for different age groups. The trend observed was as expected: median DRL values for both $CTDI_{vol}$ and DLP generally increased with patient age. This finding aligns with international guidelines and the fundamental principle that larger patients require more radiation to obtain a quality image (Vañó, *et al.*, 2017; European Commission, 2018; Gricienė and Šiukšterytė, 2021; Bouchareb *et al.*, 2025). This is also consistent with other African studies (Suliman *et al.*, 2015; Benmessaoud *et al.*, 2020).

When comparing our results to international benchmarks, the DLP DRLs from our study are noticeably higher than many international recommendations, a significant concern given the heightened radiosensitivity of children. Table 5, our DLP DRL for infants (<1 year) was 551.5 mGy·cm, which is substantially higher than the median benchmarks from Lithuania (144.3 mGy·cm), Morocco (379.8 mGy·cm), Malaysia (250.1 mGy·cm), and France (270 mGy·cm) (Takei *et al.*, 2016; Benmessaoud *et al.*, 2020; Célier *et al.*, 2020; Griciené and Šiukšterytė, 2021). This suggests that the total scan length or irradiated area might be excessive in some cases, a problem also noted in other African studies (Ekpo, Adejoh and Erim, 2019). This echoes findings from an audit of CT services in Zambia, which revealed challenges related to poor maintenance and a lack of service contracts, particularly in public hospitals (Kafwimbi, Bwanga and Sichone, 2021). The audit also highlighted an unequal distribution of scanners, with most located in Lusaka province hospitals (Kafwimbi, Bwanga and Sichone, 2021).

For the $CTDI_{vol}$ DRLs, as shown in Table 5, our values show a mixed comparison. Our median DRL of 29.07 mGy for the <1year age group is higher than those from Morocco (22.72 mGy), Malaysia (22.64 mGy), and France (17 mGy) but lower than Japan (30.7 mGy). For the 1-5 and 5-10 year age groups, our $CTDI_{vol}$ DRLs of 32.5 mGy are higher than those from Morocco (24.97 mGy and 26.16 mGy), Malaysia (29.39 mGy and 31.63 mGy), and France (19 mGy and 24 mGy) (Benmessaoud *et al.*, 2020; Célier *et al.*, 2020; Muhammad *et al.*, 2020). These comparisons indicate that the radiation doses in Zambia, as measured by $CTDI_{vol}$, are higher for all age groups compared to several international medians, highlighting a clear area for dose optimisation.

The comparison of our study's DLP and CTDIvol DRLs with European benchmarks provides valuable insights into current practices. As shown in Table 5, the DLP DRLs from our research are consistently and significantly higher than the corresponding European DRLs across all paediatric age groups. For instance, our DLP DRL for the 0-<3 months age group is 499.2 mGy·cm, compared to the European DRL of 300 mGy·cm (European Commission, 2018). This notable difference indicates that the total radiation energy delivered to patients, as measured by DLP, is considerably higher in our setting.

Similarly, the $CTDI_{vol}$ DRLs from our study display a mixed but concerning pattern. As detailed in Table 5, our $CTDI_{vol}$ DRLs exceed the European DRLs for the youngest age groups (0-<3 months and 3 months-<1 year). The median values of 27.6 mGy and 32.5 mGy are higher than the European DRLs of 24 mGy and 28 mGy, respectively. This finding is significant because these young children are the most radiosensitive. Conversely, our DRLs for older children (1-<6 years and >6 years) are lower than the European DRLs (32.5 mGy vs 40 mGy and 37.5 mGy vs 50 mGy, respectively) (European Commission, 2018). This mixed comparison highlights the critical need for locally relevant DRLs. The consistently higher DLP and $CTDI_{vol}$ for infants suggest that practices for this most vulnerable group require urgent attention to optimise dose. The higher DLP values may indicate that scan lengths are longer than necessary. While the lower DRLs for older children are encouraging, the overall findings emphasise a lack of consistent, age-appropriate protocols, presenting a clear opportunity for improvement through targeted training and policy implementation.

Our analysis of estimated effective radiation doses (ED) across the whole sample revealed a median (IQR) of 4.66 mSv (IQR 2.61-7.38). This enormous spread tells us that some children are getting much higher doses than others for the same exam. This variability is a strong signal that we need to standardise practices and lower the upper end of these exposures, following recommendations from international bodies like the ICRP. We found significant differences in median ED across the three hospitals. Hospital 2 had the highest median (IQR) ED 6.185 mSv (IQR 2.898-8.970), which tracks with its higher $CTDI_{vol}$ and DLP values. This suggests that their practices may be leading to higher overall patient doses. The difference between hospitals highlights the need for each facility to conduct its own internal audits and review protocols.

As expected, contrast-enhanced CT (CECT) scans led to higher median effective doses than non-contrast scans. Interestingly, for CECT, females received a lower median (IQR) effective dose of 6.08 mSv (IQR 4.86-8.75) than males 7.52 mSv (IQR 5.12-10.06). This goes against some existing literature that shows either no gender difference or higher doses for females (Charuakkra, *et al*., 2023; Yadav and Dhakal, 2024). This difference could be due to our calculation method for medians versus other studies using means, or it could be specific to the patient demographics and protocols at our sites. It is a finding that points to the need for standardised reporting to make comparisons easier (Pearce *et al.*, 2012).

The effective doses also varied by age group, with the highest median ED observed in the scans of the 1–5 years age group 6.995 mSv (IQR 4.180-10.27). This non-linear pattern differs from some international studies where older children receive the highest doses (Thomas and Wang, 2008). However, it aligns with other African studies showing that younger children tend to receive more radiation (Suliman *et al*., 2015; Benmessaoud *et al*., 2020). These discrepancies are likely due to differences in protocols and methods for estimating doses. Our findings emphasise the importance of personalised dose optimisation strategies for children, considering their age, size, and clinical needs, to ensure they receive the lowest possible dose while still obtaining high-quality images.

A strong, correlation between effective dose and total DLP was observed. This supports the core relationship between these two metrics, a connection acknowledged in DRL guidelines worldwide (Vañó, *et al.*, 2017; Kadavigere, Sukumar and Pendem, 2021). This robust correlation confirms that, by optimising protocols to lower DLP, we can directly reduce the effective dose a child receives. This consistent result across various countries, from Belgium (Buls *et al.*, 2009) to Morocco (Benmessaoud *et al.*, 2020) and Palestine (Atiya, 2024), validates DLP as a dependable measure for dose management and underscores its importance in enhancing safety in Zambia.

CONCLUSION

This study has established and proposed local Diagnostic Reference Levels (DRLs) for paediatric head CT scans in Lusaka, Zambia. The variations in CT doses observed across hospitals confirm the need to optimise imaging protocols and doses for paediatric CT examinations. To achieve this, collaboration between radiographers, radiologists and medical physicists, coupled with extensive training for CT radiographers, is recommended.

Ethical Issues

Following ethical approval from the University of Zambia Biomedical Research Ethics Committee (UNZABREC: protocol no. 4211-2023), as well as approval from the Zambia National Health Research Authority (NHRA) and the respective hospitals, data were carefully collected from CT scanner consoles and digital patient records.

Limitations of the Study

Our study offers essential baseline data but has limitations. Its retrospective nature and reliance on sometimes incomplete hospital records introduced biases. The findings of this study may not be generalised to the rest of the country, as data were collected only from Lusaka province.

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