ISSN 2350-1030

International Journal of Recent Research in Physics and Chemical Sciences (IJRRPCS)
Vol. 10, Issue 2, pp: (6-12), Month: October 2023 – March 2024, Available at: www.paperpublications.org

EVALUATION OF SAFE PAEDIATRIC CT SCAN RANGES FOR CHEST SCAN IN SELECTED MEDICAL FACILITIES IN RIVERS STATE, NIGERIA

*Christian M. Eke[1], Briggs-Kamara M. A.[2], Israel Cookey[3], Amakiri, A. R. C.[4]

[1,2] Department of Physics, Faculty of Science, Rivers State University, Nkpolu-Oroworukwo; P.M.B 5080, Port Harcourt, Rivers State, Nigeria

DOI: https://doi.org/10.5281/zenodo.10046049

Published Date: 27-October-2023

Abstract: **This paper is concerned with radiation-induced malignancy and the risk of severe chest injury in children using a computed tomography (CT) scan to detect chest pathologies. We have carried out a computed tomography of the chest, their impact on clinical management and the performance of the CXR from six selected smedical facilities in Rivers State, Nigeria. This retrospective study examined children (less than 18 years) who underwent CCT for a sample size of 100 using the z-scores for unlimited population, determined at random from National Population Commission data on Rivers State paediatric residents. A maximum of 1 millisievert (mSv) per scan and cumulative dose not exceeding 5 mSv per year is a reasonably achievable radiation dose stipulated by U.S. Department of Health and Human Services. The study's findings suggest that using a scaling factor of 0.623 and a conversion factor of 0.017 to convert the CTDIw value to the effective dose, a pediatric patient will be exposed to a total dose of 2mGy for a CT scan length of 200mm. The Kruskal-Wallis statistical rank test and the Kolmogorov-Smirnov test of normality were used to calculate the results on head scans at the 75th percentile. Four groups of results were created: Group 1 (ages 0 - 5), Group 2 (ages 0 - 10), Group 3 (ages 10 - 15), and Group 4 (ages 15 - 18). This study determined that** $\mathrm{CTDI_{vol}\ (mGy)\ and\ DLP\ (mGy.cm)}$ **of 42.93 (mGy)- 59.33 (mGy) and 15.33 (mGy.cm) - 61.02 (mGy.cm) is acceptable. Hence, this work advocates the use of a CT scanner with higher slices (64slices and above) in order to advance research on the reference dose for all pediatric CT chest scans.**

Keywords: **Tomography, Dose Index, Diagnostic, Paediatrics, Chest Scan, Radiation.**

1. INTRODUCTION

Over the past 20 years, computed tomography (CT) has gained popularity as a diagnostic tool. The need for increased institutional consistency is highlighted by the fact that radiation doses from frequently performed diagnostic CT exams are higher and more variable than typically indicated (Smith-Bindman et al., 2009). Despite the potential risks associated with CT procedures, installation and usage of medical imaging technology are expanding in Nigeria (Ekpo et al., 2019). The monitoring and reporting of computed tomography dose, however, hasn't received much attention (Thomas et al., 2018). A dose optimization intervention is also necessary because paediatric head CT doses in Nigeria are higher than those reported internationally. For the diagnosis of trauma, renal calculi, appendicitis, pediatric cancer, and heart problems, computed tomography is frequently used (Ekpo et al., 2019). Children are more vulnerable than adults to getting cancer from being exposed to ionizing radiation. Children need special care because of their developing life expectancy following exposure, in the wake of nuclear accidents, and when radiation is used for diagnosis or therapy (Donnelly et al., 2001). A still-evolving area of radiology is computed tomography (CT), a specialized modality in medical radiography. Computed tomography is the practice of using radiation to create images of the bones, blood vessels, tissues, and organs of the body. A CT scan provides doctors with a much clearer picture of what is happening inside the body than traditional X-rays do.

Importantly, despite the increased use of CT in pediatric situations, children's needs are sometimes disregarded when developing examination protocols for adult patients. The dose generated as a result is two to six times higher than what is required to generate images with a satisfactory level of quality (Donnelly et al., 2001). Ionizing radiation risks and potential side effects from the intravenous contrast agent, or dye, that may be used to improve visibility, are two potential drawbacks of CT scans. The risk of developing cancer over the course of one's lifetime may be marginally increased by ionizing radiation exposure (US FDA, 2022). Ionizing radiation exposure poses a particular risk to children because young people are more likely than adults to develop cancer per unit of radiation exposure, and because cancer develops more slowly in children. However, when compared to the advantages of an accurate diagnosis or intervention, the risk connected with a medically necessary imaging examination is relatively low in both children and adults. It is crucial to use the proper exposure factors when performing CT scans on children because using exposure settings intended for adults could result in a higher radiation dose than necessary to produce a useful image for a child. The US Food and Drug Administration (FDA) advises you to discuss the advantages and risks of the procedure as well as any prior X-ray procedures you or your child may have undergone with your doctor if they recommend a CT scan for you or your child (US FDA, 2022). It should always be carried out if a CT scan or other examination with minimal radiation exposure is deemed medically necessary. The Computed Tomography Dose Index (CTDI) and Dose Length Product (DLP) for head and chest scan were created as a result for pediatric CT scanning (Ekpo et al., 2019). According to Idowu and Okedere (2020), the majority of Nigerians are covered by the nation's public healthcare system, which is inadequate due to a lack of funding, personnel, and resources. Private healthcare facilities, which provide 70% of the nation's health services, are essential in bridging this gap. Other significant hindrances to radiology practice in Nigeria include a lack of dependable electricity and issues with equipment accessibility and upkeep. The purpose of this study is to establish the diagnostic reference ranges for paediatric chest computed tomography (CT) in Port Harcourt, Rivers State, Nigeria. According to the literature that is currently available, paediatric CT scan research has not been conducted in Port Harcourt. Calculating the computed tomography dose index (CTDI) and dose length product (DLP) for pediatrics are the study's specific objectives.

2. MATERIALS AND METHODS

Study Area

The study's study area was a few particular hospitals with functional CT equipements in Port Harcourt, Rivers State, Nigeria. The Port Harcourt metropolis is located between Latitude 405'11" and 5015'45" North of the equator and Longitude 6022'25" and 805'12" East of the Greenwich meridian. Therefore, Orange Diagnostics Limited, Port Harcourt, Rivers State (Centre 3) is located at 32 Orieku Street, off Ogbunabali Road, Nkpogu, Port Harcourt, Rivers State, University of Port HarcourtTeaching Hospital (UPTH) (Centre 2) is located along East-West Road, Port Harcourt, Rivers State, and Rivers State University Teaching Hospital (RSUTH) (Centre 1) is located at 84 Forces Ave, Old GRA, Port Harcourt, Omaduma Street, off Elegbam Road, in Port Harcourt, Rivers State is where you can find Image Diagnostics. The study centers were Georges Diagnostics Centre, Port Harcourt, Rivers State (Centre 6) located at Ezimgbu Road, Rumuola, Port Harcourt, Rivers State and Intercontinental Diagnostics Port Harcourt (Centre 5) located at No 5 Ezimbgu link road / Mummy B Road, GRA Phase 4, Port Harcourt, Rivers State.

Equipment Used

The primary tools used in this study were six Multi-Slice CT scanners that had the following characteristics and were supplied by the research facilities: Center 1, 2, 5, and 6: Brivo model, 64 slices, 70 aperture, and 30 degree tilt, made by GE. Bright speed, GE, manufacturer 4, 50% aperture, 30° tilt, and 4 slices are all found in the third center. Center 4: 64 slices, a 70-degree aperture, and a 30-degree tilt for the Somatom model, manufactured by Siemens. The paediatrics (0–18) age group is the study's intended audience.

Sample Size

The sample size was derived using the z-scores unlimited population sample size determination.

$$n' = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2} \qquad (1)$$

Where:

z is the z score = 1.16

ε is the margin of error 95%

$\hat{p}$ is the population proportion (0.25)

Thus:

$$n' = \frac{(1.16)^2 \times 0.25(1-0.25)}{(0.05)^2}$$

$$\frac{1.3456 \times 0.1875}{0.0025} = \frac{0.2523}{0.0025}$$

$$= 100.92 \cong 100$$

Therefore, the sample size for the study is 100 paediatrics for head CT Scan.

Theory of Kolmogorov Smirnov Test of Normality

This theory bears the names of Kolmogorov (1933) and Smirnov (1948) who were pioneers. The random variable's distribution is known as the Kolmogorov distribution. The Kolmogorov-Smirnov test (K-S test or KS test) is a nonparametric assessment of the equality of continuous (or discontinuous) one-dimensional probability distributions. It can be used to compare one sample with a reference probability distribution or two samples with one another (two-sample K-S test). Essentially, the test provides an answer to the question, "How likely is it that we would see two sets of samples similar to these if they were taken from the same (but unidentified) probability distribution?" and "How likely is it that if these samples were taken from that probability distribution"

For this study where several sample are involved, results were deduced from the two-sample Kolmogorov –Smirnov Test Eq. (2):

$$D_{n,m} = \underbrace{Sup}_{x} \left| F_{1,n}(x) - F_{2,m}(x) \right| \qquad (2)$$

Where:

$F_{1,n}$ and $F_{2,m}$ = the empirical distribution functions of the first and the second sample respectively

Sup = the supreme function

Therefore, for several samples as is the case here we have (Eq. 3):

$$D_{n,m} > c(\alpha)\sqrt{\frac{n+m}{n \cdot m}} \qquad (3)$$

Where:

n and m are the sizes of the first and the second samples respectively. Eq. (2.11) becomes Eq. (4).

$$c(\alpha) = \sqrt{-\ln\left(\frac{\alpha}{2}\right)\cdot\frac{1}{2}} \qquad (4)$$

So that Eq. (4) becomes:

$$D_{n,m} > \sqrt{-\ln\left(\frac{\alpha}{2}\right)\cdot\frac{1+\frac{m}{n}}{2m}} \qquad (5)$$

Sampling Technique

Children who had undergone a referred CT examination within two months of the data collection and had a birth certificate that had been legally certified were eligible for inclusion. They might have also been getting CT scans at the facility while the study was going on. Subjects lacking a legitimate birth certificate were not included. The ages of the patients were ascertained from their birth certificates. Body mass index (BMI), stature (height), and BMI are the three fundamental anthropometric measurements. The steps for taking the measurement are demonstrated in the following instructions for measuring height. The person must stand straight and touch an upright surface with their heels, buttocks, and back. The heels should be paired and flat on the ground. It is determined using meters. Measurements of height and weight were taken using scales calibrated to the nearest meter (m) and kilogram (kg), respectively.

Computed Tomography Dose Index: Is derived using (Dowsett *et al.*, 2006):

we can calculate the CTDI value using the following formula:

CTDI = CTDIw x DLP x Kf (1)

Where Kf is the conversion factor, DLP is the dose-length product, and CTDIw is the weighted CTDI. The weighted CTDI (CTDIw) calculation comes next. The following formula is used to determine this value:

CTDIw = CTDI100 x k (2)

Where k is a scaling factor and CTDI100 is the CTDI value at 100 mm. The patient's size and the area being scanned determine the scaling factor. to figure out the DLP, or dose-length product. It is calculated using the following formula to determine the total amount of radiation exposure during a scan:

DLP = CTDI x scan length (3)

We used a scan length of 200 mm, which is appropriate for pediatric chest scans. This gives us a DLP value of:

DLP = 0.017 x 0.623 x 200 = 2.1182 mGy.cm. (4)

The CTDIw value is changed into the effective dose using a conversion factor of 0.017 and a scaling factor of 0.623.

This indicates that a total dose of 2mGy will be administered to the patient.

The 75th percentile of the results was calculated.

The statistical analysis was done with the aid of Microsoft Excel. The dose and scan parameters (and DLP) were expressed as mean, range, and third quartile. The Kruskal-Wallis H Kolmogorov-Smirnov Tests were also performed in the study using SPSS v.22, with a 0.001 level of significance, to determine variance. The results for the four groups are related and are displayed in tables and charts. The results obtained was compared to both national and international best practices to arrive at acceptable CT ranges for Paediatrics in Port Harcourt, which is generalized for Nigeria.

Microsoft Excel was used to complete the statistical analysis. The third quartile, mean, and range were used to express the dose and scan parameters (, and DLP). In order to determine variance, the Kruskal-Wallis H Kolmogorov-Smirnov Tests were also carried out in the study using SPSS v.22, with a 0.001 level of significance. Tables and charts showing the results for the four groups are related. The outcomes were compared to both domestic and foreign best practices in order to establish acceptable CT ranges for pediatrics in Port Harcourt that are applicable to all of Nigeria.

ISSN 2350-1030

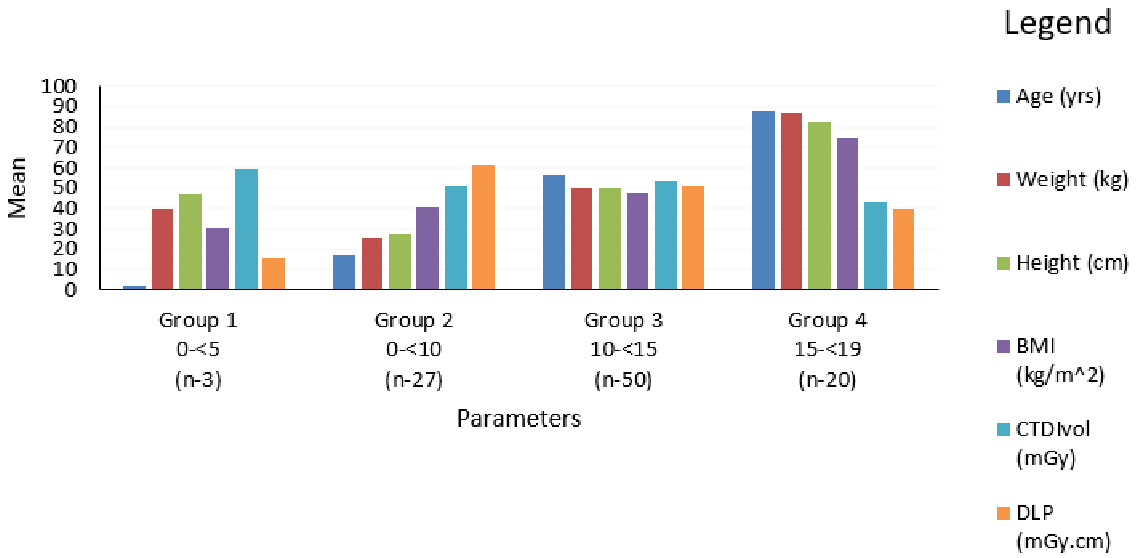
International Journal of Recent Research in Physics and Chemical Sciences (IJRRPCS)
Vol. 10, Issue 2, pp: (6-12), Month: October 2023 – March 2024, Available at: www.paperpublications.org

3. RESULTS

Table 1 below lists the conclusions from the analysis of) and DLP of head scan for pediatrics in Port Harcourt:

Table 2: Statistical Estimation of the Total Sample Size of Chest Scans

			Percentiles						Mean Rank			
									Group 1 0-<5	Group 2 0-<10	Group 3 10-<15	Group 4 15-<19
Parameters	**N**	**Mean**	**Range Min-Max**	**25th**	**50th (Median)**	**75th**	**Kruskal-Wallis H Df=3**	**Asymp. Sig**	**(n-3)**	**(n-27)**	**(n-50)**	**(n-20)**
Age (years) (0- <17)	100	10.91±3.47	1.00-16.00	8.0000	12.0000	14.0000	81.491	.000	2.00	17.00	56.37	88.33
Weight (kg)	100	40.30±10.97	9.30-60.50	32.5000	40.5000	46.5000	53.069	.000	39.67	25.54	49.92	87.28
Height (cm)	100	1.40±.19	.38-1.62	1.3000	1.4200	1.5600	43.173	.000	47.33	26.89	50.49	82.88
Body Mass (kg/m^2)	100	19.93±2.66	15.70-25.90	17.7900	19.6000	20.9500	18.995	.000	30.33	40.54	47.48	74.53
$CTDI_{vol}$ (mGy)	100	14.28±20.70	6.30-210.21	10.0100	10.5000	12.1000	2.008	.571	59.33	50.63	52.93	42.93
DLP $(mGy.cm)$	100	217.99±4.83	200.10-240.10	216.2375	218.1000	218.2075	10.699	.013	15.33	61.02	51.17	39.90



4. DISCUSSION

Table 1 shows that the mean doses for males and females used to calculate the paediatric reference dose were divided into four groups. The acceptable doses for Group 1 (ages 0-5) were 52.25 mGy and 50.67 mGy.cm, for Group 2 they were 45.84 mGy and 48.39 mGy.cm, for Group 3 they were 54.08 mGy and 54.81 mGy.cm, and for Group 4 (ages 15–18) they were 49.71 mGy and 44.95 (mGy.cm). The values in our findings were appropriate for pediatric use (Griciene and Siuksteryte, 2021). We calculated the median DLP values for routine chest CT as follows: 116.1 mGy/cm for children aged 0 to 3 months; 163.4 mGy/cm for children aged 3 to 1 year; 231.9 mGy/cm for children aged 1-6 years; and 284.2 mGy/cm for children aged 6 years and older. We recommended that these values be reduced by 50%. Furthermore, Group 1 experienced the least increase in age and weight, while Group 4 experienced the greatest increase, as shown in Figure 1. Further research revealed that patients' height increased from Groups 1 through 3, but decreased in Group 4. We also observed that BMI decreased from mid-Group 2 to Group 4, but gradually increased from Group 1 to Group 4. More significantly, the data shows that there was an increase from Group 2's middle until the beginning of Group 4, when it then took a decrease. Also supporting these findings are (Griciene, Bareike, and Krynke, 2018). Notably, Group 1 experienced a decline. This is significant because it demonstrates that dosage needs to decrease for very young babies and only increase with age, even though as they age further, dosage requirements decrease. However, as seen in the chest Scans, there was a decline in all Groups. **Determined Computed Tomography Dose Index and Dose Length Product**

This study determined that for chest we determined 42.93 (mGy)- 59.33 (mGy) and 15.33 (mGy.cm) - 61.02 (mGy.cm) which is acceptable Table 1. This results is in line with the findings of American College of Radiology Dose Index Registry (Kanal *et al.*, 2021) as the results meet up with dictates of ALARA – As Low As Reasonably Achievable, and safety for practice of the Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations, (Kanal *et al.*, 2021). As similar result for chest scan by the American College of Radiology Dose Index Registry were $\mathrm{CTDI_{vol}(mGy)}$ (1.8-14) mGy for chest respectively.

Determined Computed Tomography Dose Index and Dose Length Product

This study found that for the chest, we came up with acceptable values of 42.93 (mGy)- 59.33 (mGy) and 15.33 (mGy.cm)- 61.02 (mGy.cm) (Table 1). This result is consistent with the findings of the American College of Radiology Dose Index Registry (Kanal et al., 2021), and it complies with the requirements of the Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations for practice safety (Kanal et al., 2021). The American College of Radiology Dose Index Registry found a similar result for a chest scan: (1.8-14) for chest, respectively.According to the Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations, ALARA stands for As Low As Reasonably Achievable and Safety for Practice (Kanal et al., 2021). The American College of Radiology Dose Index Registry found that the chest scan results ranged from (19 to 55) and (267 to 910).

5. CONCLUSION

The goal of the study was to identify appropriate paediatric CT scan chest ranges for use in a few chosen medical facilities in Rivers State, Nigeria. Based on a retrospective analysis of dosages for paediatrics ranging from ages 0 to 18 years for both males and females used in the study, the Diagnostic Reference Ranges for Paediatric Computed Tomography (CT) in Port Harcourt, Rivers State, Nigeria were established. However, taking into account their weight and height, their dosages can be adjusted to fall within the established dose range developed in this study. The 75th percentile of these values for routine chest scans is comparable to those reported internationally in literature, despite the fact that CTDIvol and DLP dose values for chest are significantly higher. Technical factors may result in high doses, so selecting the appropriate parameter and maximizing dose variation are advised. Additionally, even as they work to enhance their performance, this dosage is appropriate for all radiographic CT chest scanning on pediatrics, including soft tissue monitoring, chest injuries, and bone fractures.

ACKNOWLEDGEMENT

The study centers, including Orange Diagnostics Limited, Port Harcourt, Rivers State (Centre 3), Image Diagnostics, Port Harcourt, Rivers State (Centre 4), Intercontinental Diagnostics, Port Harcourt (Centre 5), and Georges Diagnostics Centre, Port Harcourt, Rivers State (Centre 6) are all acknowledged by the authors for their cooperation and understanding in carrying out the study.

REFERENCES

[1] American College of Radiology (2023). Regulatory issues. American College of Radiology. https://www.acr.org/Advocacy-and-Economics/Regulatory-Issues.

[2] Dowsett, D.J., Kenny, P.A., and Johnston, R. E. (2006). *The Physics of Diagnostic Imaging (2nd ed.)*. CRC Press, London.

[3] Donnelly, L.F., Emery, K.H., Brody, A.S., Laor, T., Gylys-Mori,n V.M., Anton, C.G., Thomas, S.R., and Frush, D.P. (2001). Minimizing radiation dose for paediatric body applications of single-detector helical CT: strategies at a large children's hospital. *American Journal of Roentgenology. 176*: 303–306

[4] Ekpo, E. U., Adejoh, T., and Erim, A. E. (2019). Dose benchmarks for paediatric head computed tomography examination in Nigeria. *Radiation Protection Dosimetry. 185(4):* 464–471.

[5] [FGN] Federal Government of Nigeria (2006). *Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations.* Laws of the Federation of Nigeria, Abuja.

[6] Idowu, B., and Okedere, T.A. (2020). Diagnostic radiology in Nigeria: A Country Report. *Journal of Global Radiology. 6*. DOI:10.7191/jgr.2020.1072.

[7] Kanal, K.M., Butler, P.F., Chatfield, M.B., Wells, J., Samei, E., Simanowith, E., Golden, D., Gress, D.A., Burleson, J., Sensakovic, W.F., Strauss, K.J., & Frush, D. (2021). U.S. diagnostic reference levels and achievable doses for 10 paediatric CT examinations. *Radiology. 302(1):* 164-174.

[8] Kolmogorov, A. (1933). Sulla determinazione empirica di una legge di distribuzione. *Journal of the Italian Institute of Actuaries. 4:* 83–91.

[9] Kruskal, W.H., and Wallis, W.A. (1952). Use of ranks in one criterion variance analysis. *Journal of the American Statistical Association. 47:* 583-621.

[10] Smith-Bindman, R., Lipson, J., Marcus, R., Kim, K. P., Mahesh, M., Gould, R., Berrington de González, A., and Miglioretti, D. L. (2009). Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Archives of Internal Medicine. 169(22):* 2078–2086.

[11] Thomas, A., Onwujekwe, E.C., Abba, M., Ali, A.M., Imo, A.S., Nzotta, C.C., and Chiegwu, H.C. (2018). Computed tomography scanner census and adult head dose in Nigeria. *The Egyptian Journal of Radiology and Nuclear Medicine. 49:* 66–70.

[12] U.S Centre for Disease Control and Prevention (2023). *ALARA – As Low As Reasonably Achievable.* U.S. Department of Health and Human Services. USA.

[13] United States Food and Drug Administration (FDA) (2022). Computed-tomography (CT). United States Food and Drug Administration. www.fda.gov.

[14] Gricienė B, Šiukšterytė M. (2021), Local Diagnostic Reference Levels for Paediatric Head CT Procedures. Acta Med Litu.;28(2):253-261.

[15] Griciene B, Bareike, M and Krynke, L (2018), Assesment of exposure and setting of local diagonostic reference levels for CT procedures. Physica Medica Vol. 52 Page 31-32

[16] Suleman Modu Ngaram, Ibrahim Baba Mohammed, (2019), "Study of Radiation Doses in Adult and Paediatric Patients Undergoing Computed Tomography Examination in Nigeria", Advances in Computed Tomography, Vol.8 No.3,

[17] Smirnov, N. (1948). Table for estimating the goodness of fit of empirical distributions. *Annals of Mathematical Statistics*, *19* (2), 279–281.

[18] Kolmogorov, A. (1933). Sulla determinazione empirica di una legge di distribuzione. *G. Ist. Ital. Attuari. 4*, 83–91.