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Pediatric Patients' Radiation Dose Assessment During Routine Chest X-ray Procedure in Some Selected Centres in Kebbi State

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Abstract:
Pediatric X-ray examination is a problematic procedure from the point of view of the amount of radiation delivered. The children have a higher potential of developing cancer when compared with adults receiving same amount of radiation. The longer life span in children gives room for any toxic effects of radiation dose to appear. The present study aimed at assessing the entrance skin dose (ESD) of children undergoing routine chest x-ray at Koko general hospital and Federal Medical Centre Birnin Kebbi. A total of 75 patients were enrolled in this study. ESD was assessed for posterio-anterior (PA) chest projections. In each projection, the patient's data (such as Sex & Age) and exposure factors were collected prospectively on a data collection form designed. An indirect method was employed to determine ESD for each patient. The mean ESD results obtained at the age of 0-10 years in this research were found to be 1.41mGy & 0.42 mGy, and 1.78 mGy & 0.63mGy at the age of 10-16 years for Koko and FMC respectively. Similarly, reference dose levels obtained were found to be 1.60 & 0.48 for 0-10 years and 1.68 & 0.75 for 10-16 years respectively for Koko and FMC. The mean ESD Value of Koko is greatly high compared to FMC results. The results presented in this research were remarkably higher than those reported in the literature except for a few studies that recorded higher value than the result reported in this study with factor of 4.09 mGy & 5.24 mGy for 10-16 years and 1.99mGy & 2.98 mGy for 0-10 years. The Diagnostic Reference Levels were below the value reported in the literature for both age groups. Koko Centre recorded the highest value of DRLs and ESD, this may likely occur as a result of variations of exposure factors.

Keywords: Entrance Skin dose, Pediatric patient, Exposure parameters and Chest X-ray

INTRODUCTION

An x-ray procedure has to do with the use of ionizing radiation. Exposure to this radiation was believed to cause radiation induced-problems such as cancer in most cases affecting fast growing tissues and radiosensitive organs as shown in pediatric patients. Therefore, in medical imaging of children care must be taken adequately (Asogwa *et al*, 2021). The pediatric radiological procedure needs urgent attentions because small children are much more sensitive to ionizing radiation than adolescents. The report issued by United Nation Scientific Committee on Effects of Atomic Radiation [UNSCEAR] indicated that pediatric exposure to ionizing radiation at 0-5 years are two to three times when compared with adult patients. There are a lot of evidences and examples that pediatric patients are more easily to be affected by ionizing radiation than the adult patients. Due to the result of life-span of children, these make additional problems on radiologist and radiographers to obtain excellent radiographs with minimum radiation dose all the time. The late effects of radiation are also greater in children probabilistically. The major factor in which child

exposure to radiation depend is age at which it happened. Therefore, it is significant that radiation dose delivered during pediatric X-ray to be minimized. About 10% of X-ray procedures were constituted by babies and children. The conventional chests X-ray are common and are among first x-ray procedures performed by clinicians. It is about 40% of all images performed by the radiologist and radiographer accounted for the chest X-ray examinations (Asogwa *et al*, 2021).

The term ESD refers to the amount of radiation received /absorbed by the skin where the x-ray beam incident on the patient. These amounts of radiation absorbed by the skin have long before now utilized to report patient doses and extensively investigated for children everywhere in the universe.

In Nigeria, there are limited studies pertaining pediatric patients. Entrance surface Dose (ESD) is a measure of the radiation dose absorbed by the skin where the X-ray beam enters the patient, it has been used to report patient doses, and this has been studied for pediatric patients all over the world. The aim of the study was to determine ESD for children who referred to the FMC and KOKO general hospital (Eljak *et al*, 2015). To the best of the researcher knowledge, no investigational study was done in Kebbi State regarding Pediatric patient radiation dose (Eljak *et al*, 2015). The appearances of risk of biological effect are greatly higher in pediatric patients because of their newly growing tissue cells. Recently, many efforts were put in place in order to decrease the danger of radiation from all sources of diagnostic x-ray imaging modalities of children (Alatts and Abukhiar, 2014). One of the major efforts is the introduction of diagnostic reference levels [DRLs] and regular dose assessment. These levels must not be exceeded for standard examinations when good and normal practices applied (Alatts and Abukhiar, 2014).

In Nigeria as in other African countries, there are scarce of data available on pediatric chest x-ray procedures. The results of ESD for chest obtained in the present work are determined for the first time. The comparison of entrance skin dose with other studies and reference dose levels should assist in optimizing pediatric radiological procedures. The results displayed will serves as base line data required for obtaining national reference levels in Nigeria (Osman *et al.,* 2013). The aims of this research work were to estimate amount of dose received by infants and children in conventional chest radiological procedures in General hospital Koko and Federal Medical Centre Birnin Kebbi, Kebbi State, Nigeria. The motivational factor driven the research is the concerns due to the burden associated with the radiological procedures of small children, especially in a region of country that has increasing X-ray procedures such as Kebbi State (Osman et al., 2013).

MATERIAL AND METHODS

The x-ray machines models used in this research work include: mobile x-ray machine with model number of MOBIX1000S made in Korea installed at Koko general hospital and have total filtration of 3.3 mmAl, while that of Federal Medical Centre is mobile X-ray machine with model number of Model: 2185226 made in India and have total filtration of 1.63 mmAl.

Selection and Description of Participants

The study was conducted prospectively in the period of November 2021 to March 2022. The children were investigated at the X-ray units, Radiology department of Federal Medical Centre Birnin Kebbi and KOKO General Hospital. Before the conduct of this research, an Ethical approval was obtained from the research ethical committee of the two centres. Informed consents were also obtained from the patients (who can verbally communicate) and the parents (whose child cannot communicate verbally) (Samaila, 2022).

Assessment of Entrance Skin Dose [ESD]

Patient information including age and gender was considered. The type of radiological examination and applied projection as well as the exposure details such as tube voltage (KV), tube current (MAS), focal to skin distance (FSD) were evaluated (Eljak *et al*, 2015). Data were collected on patient doses during the period of three months of 2021-2022. The ESD was calculated according to the following equation which was applied

$$\mathrm{ESD} = \mathrm{c}\left(\frac{\mathrm{kVp}}{\mathrm{FSD}}\right)^{2}\left(\frac{\mathrm{mAs}}{\mathrm{mmAl}}\right)$$

The ESD was calculated according to the above equation which was applied by (Tung and Tsai; 1999). Where: ESD stands for Entrance skin dose, c = constant = 0.2775, kVp = Applied Tube potential, mAs = Tube current multiplied by exposure time, FSD = Focus to skin distance, Al = Aluminum Filtration considered to be 3.3 mmAl (Samaila and Rilwanu, 2023)

Statistical Analyses

The ESD was calculated using equation one above. Both the ESD results and exposure parameters were statistically analyzed using an excel spreadsheets where estimation of mean, minimum [Min], maximum [Max], Standard Deviation [STDEV), Ratio of max/min and Third quartile performed.

RESULT AND DISCUSSION

The recorded exposure parameters as well as the assessed Entrance Skin Dose, statistical parameters and estimated values of Diagnostic Reference Levels are summarized in table1, while the comparison of ESD and DRLs are also summarized in table 2 and table 3 respectively for Koko and FMC. The summarized results were presented in figures as indicated below.

Table 1: ESD, DRL and Statistical parameters for the two centres

Centre	Age Group	Exposure Factors	Min	Max	Mean	Stdev	Max/Min	3th Quartile [75th percentile]
KOKO	0-10	FFD [cm]	100.00	100.00	100.00	0.00	1.00	1.60
		FSD [cm]	69.00	90.00	76.67	7.14	1.30	
		kV [kv]	70.00	70.00	70.00	0.00	1.00	
		mAs [mAs]	18.00	20.00	19.67	0.79	1.11	
		ESD [mGy	1.02	1.73	1.41	0.24	1.70	
	10-16	FFD [cm]	100.00	100.00	100.00	0.00	1.00	1.68
		FSD [cm]	68.00	88.00	88.00	5.97	1.29	
		kV [kv]	70.00	70.00	70.00	0.00	1.00	
		mAs [mAs]	20.00	20.00	20.00	0.00	1.00	
		ESD [mGy	1.06	1.78	1.78	0.22	1.67	
FMC	0-10	FFD [cm]	100.00	180.00	123.93	26.82	1.80	0.48
		FSD [cm]	80.00	165.00	108.86	26.47	2.06	
		kV [kv]	58.00	76.00	66.14	6.04	1.31	
		mAs [mAs]	3.20	16.00	12.55	4.45	5.00	
		ESD [mGy	0.10	0.81	0.42	0.21	8.14	
	10-16	FFD [cm]	110.00	178.00	146.50	30.76	1.62	0.75
		FSD [cm]	90.00	156.00	125.33	26.07	1.73	
		kV [kv]	60.00	95.00	77.67	12.11	1.58	
		mAs [mAs]	12.00	25.00	19.00	5.29	2.08	

		ESD [mGy	0.34	0.81	0.63	0.17	2.38	

Table 2: Comparison of Mean Entrance Skin Dose to Pediatric Patients Undergoing Chest X-ray procedure and other studies

Centre	Age Group (years)	This study [mGy]	Osman *et al.*, 2013	Mesfin *et al.*, 2017	Asogwa *et al.*, 2021	Egbe *et al.*,2008	Nahangi & Chaparian, 2015	Eljak *et al.*, 2015
KOKO	0-10	1.41	0.30	3.40	0.55	0.11	0.170	0.34
	10-16	1.78	0.30	5.87	1.30	0.10	0.213	0.39
FMC	0-10	0.42	0.30	3.40	0.55	0.11	0.17	0.34
	10-16	0.63	0.30	5.87	1.30	0.10	0.21	0.39

Table 3: Comparison of Diagnostic Reference Levels with other studies

Centre	Age Group	This study [3rdQuartile]	Mesfin *et al.*, 2017
KOKO	0-10 years	1.60	2.55
	10-16 years	1.68	4.40
FMC	0-10 years	0.48	2.55
	10-16 years	0.75	4.40

The results of ESD and DRLs tabulated in table 1-3 above were also presented in figures as shown below for easy comparative analysis.

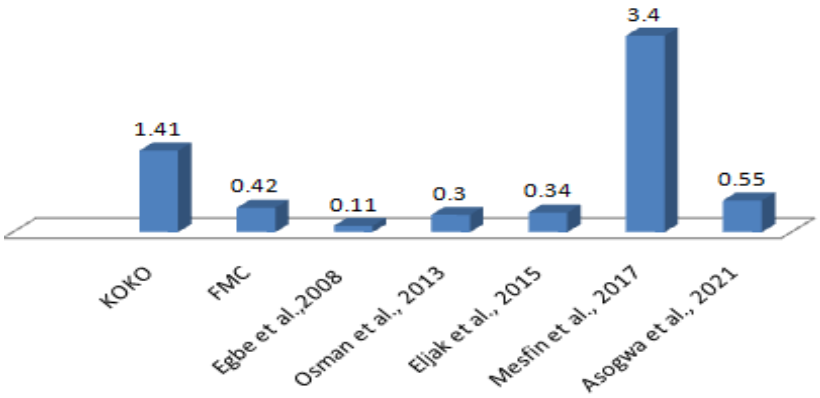

Figure 1: ESD [mGy] of age group from 0-10 years

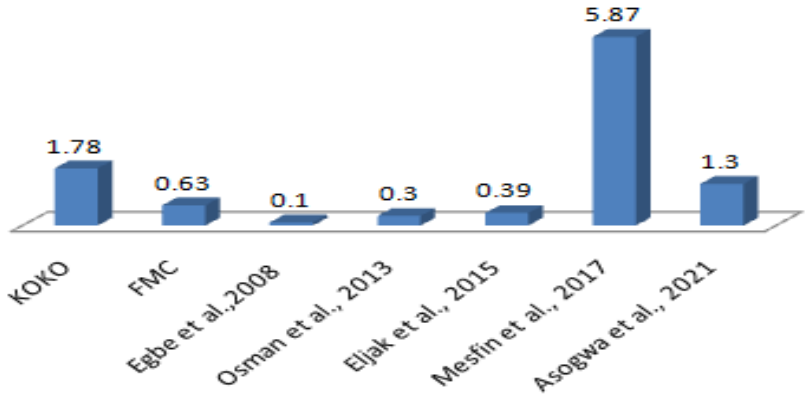

Figure 2: ESD [mGy] of age group from 10-16 years

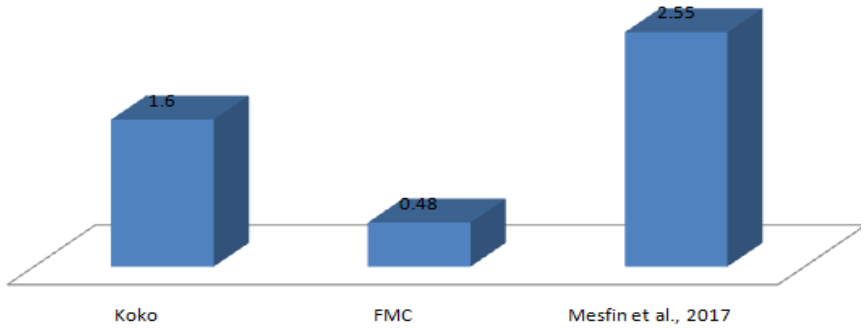

Figure 3: Diagnostic Reference Levels [75th percentile] of 0-10 years

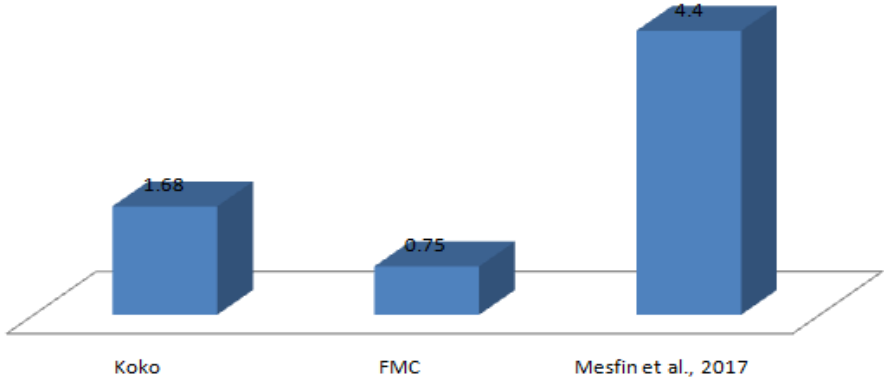

Figure 4: Diagnostic Reference Levels [75th percentile] of 10-16 years

DISCUSSION

The techniques of pediatric x-ray procedures differ greatly due to the extensive variation in pediatric patient size. Henceforth, different exposure factors selection may be compulsory to obtain good results for the same anatomical parts according to the children age. Table 1 indicate the results of the statistical analysis of exposure parameters [such as kV, mAs, FFD, FSD], entrance skin dose and diagnostic reference levels for each age groups. The highest ESD and DRLs was found in age group of 10-16 years of Koko general hospital. Similarly, FMC recorded lower value of ESD and DRLs in age group of 0-10 years compared to Koko. The ESD value obtained in Koko at the age of 0-10 & 10-16 years in this research was well compared with the values reported in other studies and found to be greater than the values of (Osman *et al.*,2013; Egbe *et al.*, 2008; Nahangi & Chaparian, 2015 and Eljak *et al.*, 2015), but below the result of (Mesfin *et al.*, 2017) while in FMC, ESD results obtained are remarkably higher than the results obtained by (Osman *et al.*, 2013; Asogwa *et al.*, 2021; Egbe *et al.*, 2008; Nahangi & Chaparian, 2015 and Eljak *et al.*, 2015), but below the result of (Mesfin *et al.*, 2017 and Asogwa *et al.*, 2021) as shown in table 2 and represented in Fig. 1 and fig. 2 respectively.

A diagnostic reference level [third quartile] is an indicator of whether radiation dose delivered to patients is higher or lower than the recommended value in a medical imaging such x-ray procedures. The DRLs obtained in this research was well- compared with other studies and found to be higher than the results obtained by (Mesfin *et al.*, 2017) with factor of 0.95 & 2.07 and 2.72 & 3.65 for age group of 0-10 years and 10-16 years respectively as indicated in table 3 and well presented in fig.3 and fig.4.

The research revealed that there's an urgent need for standardization of pediatric radiological procedures in Kebbi State and Nigeria at large. This can be achievable when concerted effort was

put in place at ensuring comprehensive quality control and quality assurance program, including training of all personnel involved in pediatric X-ray examinations and calibration of X-ray in all radiology departments

CONCLUSION

Pediatric patient's radiation doses [ESD] and 75^{th} percentile (third quartile) was assessed and are well-compared with the other studies. The radiation dose delivered was remarkably high compared to the recommendations of Europeans commission. The study revealed that the exposure parameters such as kV, mAs, FFD and FSD played a major role in dose increase. It is indicated that further reduction in pediatric radiation dose is achievable by sticking to the radiation protection optimization and justification guidelines. Considering the results in this study can significantly reduce the patient's radiation doses in pediatric x-ray examination. The results presented serves as baseline data for deriving regional and national reference dose levels for pediatric radiological examination in the study area. This research work is expected to provide awareness to medical professional about the radiation doses in pediatric x-ray procedures. Therefore, Protocol optimization and justification is currently needed for pediatric patients in the studied facilities.

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ETHICAL APPROVAL

Prior to the conduct of this research written approval has been collected from the Ethical Research Committee of FMC and Ministry of health Birnin Kebbi. The patient's consent was also obtained verbally for those capable of communications and those who cannot communicate their guardians/parents give verbal approval.

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