CORRELATION OF ENTRANCE SKIN DOSE WITH BODY MASS INDEX (BMI) FOR PATIENTS EXAMINED BY DIAGNOSTIC X-RAY

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Abstract: **Radiation cannot be perceived by our normal senses, such as sight, feeling and smell.Medical X-rays Exposures in several countries are the most important synthetic source of exposure to ionizing radiation. However, the information of diagnostic X-rays medical exposure is integrated into international legislative repertories.Data on the assessment of patient's entrance skin dose (ESD) and the health risk from conventional radiography in daily routine of diagnostic medical examinations is lacking in the city of Gombe.In this study, Entrance Skin dose (ESD) were estimated for patients undergoing common diagnostic X-ray examinations in one of the radiographic center in Gombe town. The ESD has been estimated using calculation techniques.The mean ESD for examinations of the chest (PA, LAT), abdomen (AP), pelvis (AP), lumber spine (AP, LAT) and skull (PA, LAT) were 0.36, 0.18, 0.95, 0.36, 0.58, 1.32, 0.52 and 0.31 mGy respectively. The determine coefficient (R^2) was ranging between 0.94-0.97 and the correlation (R) was ranging between 0.97-0.99. The ESDs reported in this study are lower than comparable reference dose values published in the literature.**

Keywords: **Entrance skin dose (ESD); Radiation; X-ray; Diagnostic X-rays; Lumbar spine.**

1. INTRODUCTION

Patient exposures arising from radiological procedures form the largest part of the population exposure from artificial sources of radiation [1]. There are many uses of radiation in medicine. The most well-known is using X-ray to see whether bones are broken. X-ray imagine is one of the most basic and routine forms of imaging within modern medicine. Using electromagnetic radiation, scientists and doctors have the ability to visualize internal situations. X-ray imaging takes advantage of the fact that dense structures (i.e. bone) absorb more X-rays than the softer tissues that surround it [1]. There are additional areas in medicine using radiation or radioactive material. These are for treatment of disease or cancer and are commonly called therapy. A subspecialty in nuclear medicine is nuclear medicine therapy. A common example of nuclear medicine therapy is the use of radioactive iodine to treat thyroid problems including thyroid cancer [2].

The recommendation from International Commission for Radiological Protection (ICRP) says that medical activities involving ionizing radiation should fulfill the principles of justification and optimization [3]. Regular periodic monitoring of the performance of radiological equipment and assessment of techniques employed in their use is one of the basic requirement of the optimization process [3]. The monitoring serves to focus and maintain standards, image quality and very importantly patient dose. The values of measured quantities above which corrective action needs to be taken was seeks to be establish. Protection of the patient from radiation is very important, which lead to several regulation bodies to carry out studies that lead to the establishment of regulation and standards to guide its practice [3].

Patient doses in radiography primarily depend on the entrance skin dose and the sensitivity of the organs and tissues that are irradiated during the radiographic examination [4]. Entrance skin dose is the absorbed dose to the entrance skin of the patient at the central point of the irradiated area [4and 5]. In assessing the dose received by patient in a radiographic exposure, entrance skin dose is an important parameter. The diagnostic X-ray examinations received by patient have enormous benefit but the ionizing nature of the X-rays indicate that the use of it is not entirely without risk. All exposure received by patient during X-ray examination need to be optimized and justified for this reason. In term of the benefit of the exposure and its risk, among the basic requirements for such is the knowledge of patient dose.

Most countries have legislation controlling the use of ionizing radiation and although legal systems differ, the dose levels recommended by the ICRP, together with its general philosophy and recommendations, are common factors [6]. Nigeria Basic Ionizing Radiation Regulation (NBIRR) is a regulation body for radiation which was introduced in Nigeria under Nigeria Nuclear Regulation Authority (NNRA) which make it mandatory to Radiologist, Radiographers and medical physicist to undergo two weeks radiation protection training in order to handle or work with X-ray to ensured workers safety and the safety of patient [7]. Diagnostic reference levels is important to be used in each hospital so that the radiation dose received by patient will be manage and to commensurate with the clinical purpose.

Entrance skin dose can be determine by different method. The common method for calculating ESD are either by direct measurement using thermoluminescent dosimeters (TLD) stacked on the patient's skin orindirectly via mathematical model calculations based on the X-ray machine output. Phantom and data from the patients' exploration can also be used to calculate ESD [8 and 9].

Using TLD to measure the ESD for patients are generally time consuming and it required some special equipment to be used which may not be available at the most radiographic centers. Also, to measure the ESD using ionizing chambers require some factors conversion to convert the reading of the ionization chamber (IC)to absorbed dose which is complicated method [10]. Due to unavailability and accessibility of TLD or IC instrument, in this study ESDs was calculated using mathematical techniques. The aim of this research was to correlate ESD with BMI for patients exposed to diagnostic X–ray at radiographic centers in Gombe city. In order to achieve this objective,Chuan and Tsai formula was employed to estimate the ESD for many patients exposed to diagnostic X-ray. International ESD values reported in the literature were compared with the values obtain in this research.

2. MATERIALS AND METHODS

The total number of 200 patients were used in this research, in which the X-ray diagnostic equipment was used to expose patents. The data of the patients such as Age and Gender was recorded at the beginning and then the technician will centered the patient to be ready for radiographic. The parameters such as peak tube voltage (kVp), exposure current and time product (mAs) and focus to skin distance (FSD) were recorded at the time of the examination. For each patient undergoing the particular diagnostic procedure, the information taken was recorded.Chuan and Tsai formula [11] is applied to calculate the ESD for patients coming to the X-ray radiographic center in this work. This formula is given as follows:

$$ESD\ (mGy) = c\left(\frac{kVp}{FSD}\right)^2\left(\frac{mAs}{mm\ Al}\right) \quad (1)$$

Where kVp represents X-ray peak tube voltage and mAs represents the exposure value which means that tube's current times exposure time. While FSD (Focus to Skin Distance) represents the measured distance between X-ray tube and patient part being exposed to X-rays, mm. Al gives minimum inherent filtration Aluminum equivalent and c is constant which equals to 0.2775.
The BMI is then calculated by dividing the subject's weight by the square of his/her height.

$$BMI = \frac{weight\ (kg)}{(height)^2\ (m^2)} \quad (2)$$

The obtained data was analyzed using Excel.

3.RESULTS AND DISCUSSION

3.1 RESULTS

Table1: patients' information and exposure parameters for five x-ray examinations. (Ranges in parenthesis).

	Radiograph	Projection	Age	Weight (kg)	Mean KVP	Mean mAs	Mean ESD (mGy)	Height (m)	BMI (kg/m²)
1-10	Chest	LAT	7 (2-9)	20 (15-25)	63	12	0.016	1.21	13.66
	Pelvis	AP	10 (3-10)	29 (18-30)	50	10	0.079	1.37	15.45
	Skull	LAT	8 (5-8)	25 (16-33)	50	10	0.125	1.27	15.50
	Abdomen	AP	9 (3-8)	23 (14-28)	48	14	0.035	1.37	13.20
	LSJ	LAT	8 2-9)	22 (17-30)	30	10	0.034	1.26	13.86
11-20	Chest	LAT	15 (12-19)	33 (28-40)	63	12	0.086	1.36	17.84
	Pelvis	AP	18 (11-19)	39 (30-35)	54	17	0.125	1.41	19.62
	Skull	LAT	20	30	52	20	0.198	1.38	15.75
	Abdomen	AP	15 (11-18)	36 (30-39)	67	23	0.429	1.37	19.18
	LSJ	AP	18	38	55	15	0.138	1.39	19.67
21-30	Chest	LAT	27 (23-30)	48 (50-65)	77	34	0.214	1.50	21.33
	Pelvis	AP	28 (25-30)	47 (40-58)	62	19	0.262	1.51	20.61
	Skull	PA	26 (22-30)	45 (45-51)	61	22	0.311	1.42	22.32
	Abdomen	AP	27 (25-28)	52 (46-61)	73	24	0.443	1.55	21.64
	LSJ	AP	25 (21-28)	54 (50-58)	71	21	0.332	1.58	21.63
31-40	Chest	PA	34 (31-39)	58 (52-76)	76	32	0.275	1.62	22.10
	Pelvis	AP	34 (32-39)	61 (44-71)	75	21	0.417	1.69	21.36
	Skull	LAT	37 (31-40)	65 (50-69)	63	31	0.331	1.69	22.16
	Abdomen	AP	37 (33-40)	69 (59-70)	75	28	0.512	1.74	22.79
	LSJ	AP	37 (32-40)	66 (50-80)	77	31	0.718	1.72	22.31
41-50	Chest	LAT	46 (41-49)	61 (61-78)	80	32	0.294	1.65	22.41
	Pelvis	AP	48 (43-51)	65 (66-72)	74	25	0.481	1.70	22.49
	Skull	PA	47 (44-50)	69 (62-70)	69	32	0.413	1.72	23.32
	Abdomen	AP	45 (42-48)	66 (59-68)	73	41	0.842	1.69	23.11
	LSJ	AP	49 (48-50)	65 (62-67)	84	40	0.752	1.66	23.59
51-60	Chest	LAT	55 (52-58)	69 (80-81)	91	40	0.301	1.71	23.60

	Pelvis	AP	56 (55-60)	67 (52-80)	77	28	0.492	1.69	23.46
	Skull	PA	55 (51-59)	61 (42-79)	66	17	0.478	1.61	23.53
	Abdomen	AP	57 (56-58)	71 (73-80)	81	63	1.488	1.72	24.00
	LSJ	LAT	57 (55-60)	67 (62-76)	81	38	0.772	1.68	23.74
61-70	Chest	PA	61 (62-68)	70 (65-80)	60	50	0.388	1.71	23.94
	Pelvis	AP	60	71	72	21	0.508	1.69	24.86
	Skull	LAT	64 (62-66)	70 (68-74)	68	24	0.572	1.68	24.80
	Abdomen	AP	62	71	85	65	1.672	1.69	24.86
	LSJ	AP	63 (60-68)	68 (60-85)	82	39	0.980	1.68	24.09
71-80	Chest	PA	71	71	82	30	0.425	1.71	24.28
	Pelvis	AP	76	72	75	20	0.523	1.69	25.21
	Skull	PA	74 (72-75)	74 (73-85)	69	31	0.869	1.72	25.01
	Abdomen	AP	75	78	90	70	2.153	1.70	26.99
	LSJ	LAT	74 (73-75)	85 (60-81)	78	29	3.168	1.69	29.76

Table 2: Mean Entrance Skin Dose and age.

Examination	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	MEAN
Chest PA				0.275			0.388	0.425	0.36
Chest LAT	0.016	0.086	0.214		0.294	0.301			0.18
Abdomen AP	0.035	0.429	0.443	0.512	0.842	1.488	1.672	2.153	0.95
Pelvis AP	0.079	0.125	0.262	0.417	0.481	0.492	0.508	0.523	0.36
Lumber AP		0.138	0.332	0.718	0.752		0.980		0.58
Lumber LAT	0.034					0.772		3.168	1.32
Skull PA			0.311		0.413	0.478		0.869	0.52
Skull LAT	0.125	0.198		0.331			0.572		0.31

Table 3: comparison of measured mean ESD (mGy) values with other studies for common radiography.

Examination	This study	KEFFI[12]	IAEA[13]	IRAN[14]	UK[15]	KASHAN(IRAN)[16]
Chest PA	0.36	0.37	0.33	0.41	0.15	0.37
Chest LAT	0.18	0.42	* *	2.70	0.50	0.99
Abdomen	0.95	* *	3.64	4.06	4.00	2.01
Pelvis	0.36	* *	3.68	3.18	4.00	1.76
Lumber AP	0.58	* *	4.07	3.43	5.70	2.18
Lumber LAT	1.32	* *	8.53	8.41	10.00	5.36
Skull PA	0.52	* *	2.41	2.83	1.8	1.39
Skull LAT	0.31	* *	* *	1.93	1.1	1.01

Note: ** indicates data not available

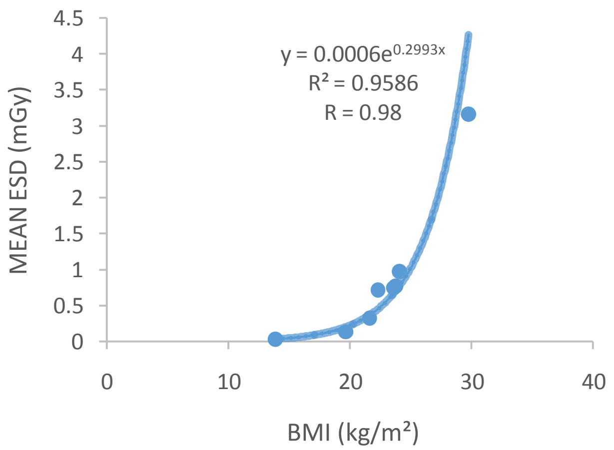

Fig 1: mean ESD (mGy) against BMI (kg/m²) for LSJ (AP, LAT).

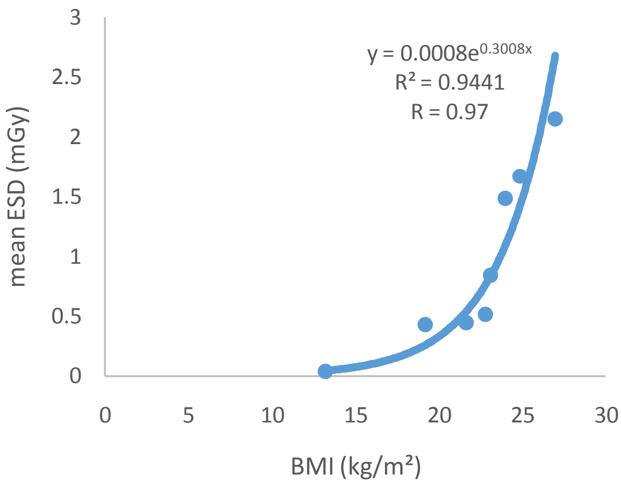

Fig 2: mean ESD (mGy) against BMI (kg/m²) for Abdomen (AP).

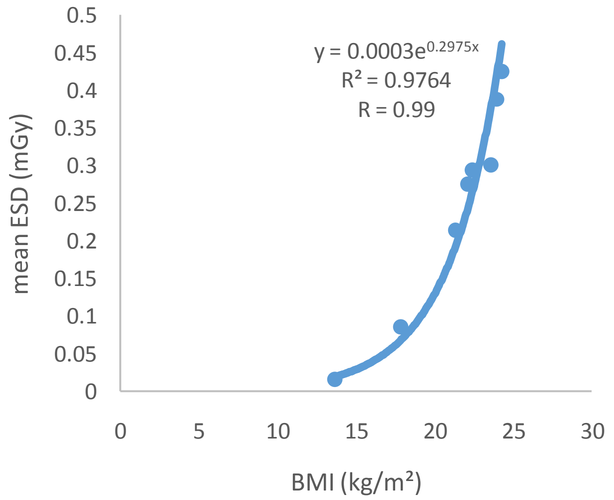

Fig 3: mean ESD against BMI for chest (PA, LAT).

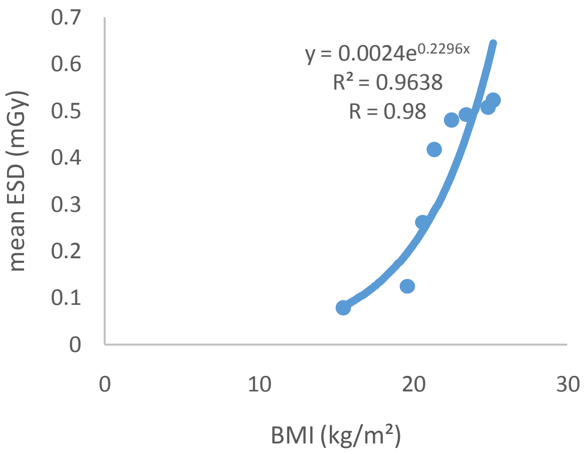

Fig 4: mean ESD (mGy) against BMI (kg/m²) for pelvis (AP).

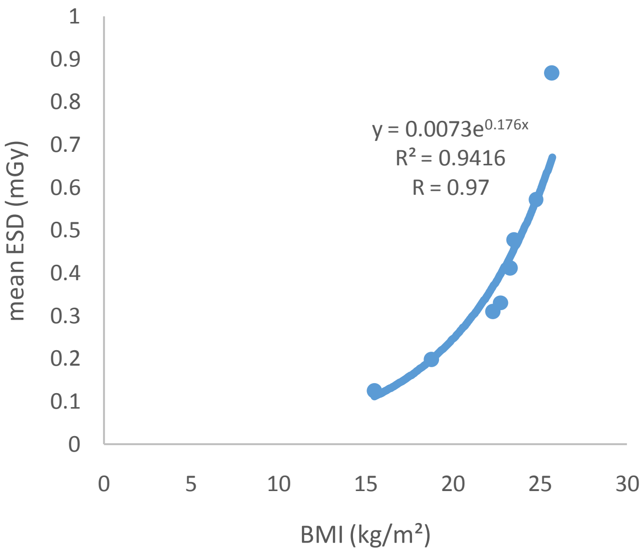

Fig 5: mean ESD (mGy) against BMI kg/m²) for skull (PA, LAT).

3.2 DISCUSSION

In this survey, biographical data such as patient age, weight, height and machine parameters were recorded. This is shown in Table 1, with range in bracket. Table 2 is mean ESD and age with shows that as ESD increased, age also increased. Table 3 compares the mean values of measured ESD (mGy) for each of examination in this study with corresponding values reported in the other studies: [12, 13, 14.15 and 16]. There is wide variation in mean ESD (mGy) used, which shows that there is no standard of procedure.

Comparing the exposure parameters values, measured mean ESD applied in this study with the guide levels of [12, 13, and 16] references for chest PA projection reveals that ESD is similar. Also lumber Lat projection reveals that ESD is similar to [16]. However for chest Lat, Abdomen, Pelvis, Lumber AP, Lumber Lat, Skull PA and Skull Lat projections, the ESD values were lower than the values found by the [13, 14 and 16].

As shown in figure 1 there is exponential correlation between mean ESD (mGy) and BMI (kg/m²) for patients undergoing lumber spine (LSJ AP,LAT) x-ray examination with determination coefficient (R^2) of 0.9586 and correlation (R) of 0.98. Also figure 2 shows that there is exponential correlation between mean ESD (mGy) and BMI (kg/m²) for patients undergoing Abdomen (AP) x-ray examination with determination coefficient (R^2) of 0.9441 and correlation (R) of 0.97. Figure 3 shows the exponential correlation between mean ESD (mGy) and BMI (kg/m²) of patients undergoing chest (PA, LAT) x-ray with determination coefficient (R^2) of 0.9764 and correlation (R) of 0.99. Figure 4 also shows exponential correlation between mean ESD (mGy) and BMI (kg) for patients undergoing pelvis (AP) x-ray with determine coefficient (R^2) of 0.9638 and correlation (R) 0f 0.98. While figure 5 shows exponential correlation between mean ESD (mGy) and BMI (kg) for patients undergoing skull (PA, LAT) x-ray with determine coefficient (R^2) of 0.9416 and correlation (R) of 0.97.

4.CONCLUSION

An estimation of entrance surface dose during diagnostic X-ray examination of patients has been carried out. The patient's individual ESD values were observed to be consistent with the range of values of the existing knowledge. The ESD values of the present study were compared with the reference levels of the existing knowledge and the values obtained on the present study are mostly comparable. The ESD in all the examinations were below the reference. This implies that the radiation risk to an average patient in the hospitals included in this work is low and the risk to workers in the hospitals is generally low. Also, in all the examinations it shows that there is a good correlation between the entrance skin doses with body mass index during diagnostic X-ray examination. This shows that patients with higher body mass index will received more dose than the patients with lower body mass index. The difference between this study and other study carried out was the machine used, the age of the patients and the place the study carried out.

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