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Chest X-Ray ESD and ESAK Assessment in A Few Diagnostic Radiological Facilities in Delta State

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Abstract: Background: The utilization of X-rays in medical procedures has sparked apprehension regarding their potential adverse consequences, despite their undeniable advantages in the realms of diagnosis and therapy. The present study aimed to evaluate the levels of Entrance Skin Dose (ESD) and Entrance Skin Air Kerma (ESAK) associated with chest X-ray examinations conducted in diagnostic radiological facilities located within Delta State. The present study employed a standardized approach to describe the materials and methods used in the research. The dose assessment was performed on a sample of 700 patients who were 18 years of age or older. These patients were selected from 10 operational facilities located throughout the State. The findings of the study are as follows: The effective dose (ESD), ascertained through the utilization of patient anatomical data and exposure parameters, fell within the recommended reference dose limits of 1 mGy (National Nuclear Regulatory Agency) and 0.4 mGy (International Atomic Energy Agency) for the majority of healthcare facilities. Nevertheless, certain centers demonstrated elevated dose levels, which can be attributed to factors such as increased exposure rates, aging x-ray tubes, and inadequate technician competency. The effective dose values (ESD) exhibited a range of 0.018 to 1.671 mGy for males and 0.084 to 1.542 mGy for females. The range of Entrance Skin Air Kerma (ESAK) values for males was found to be between 0.019 and 0.085 mGy, while for females it ranged from 0.016 to 0.098 mGy. These values were observed to be within the recommended dose limits. In conclusion, this study emphasizes the significance of surveillance of radiation exposure and the implementation of quality assurance protocols in order to safeguard patient well-being and mitigate potential hazards linked to chest X-ray procedures conducted in diagnostic radiological establishments.

Keywords: Entrance Skin Dose (ESD), Entrance Skin Air Kerma (ESAK), X-Ray, Ionizing Radiation, Diagnostic, Effective Dose.

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1. INTRODUCTION

The term "Entrance Skin Dose (ESD)" is commonly employed in the domain of radiology and radiation protection, specifically within the realm of medical imaging. The term "skin entrance dose" pertains to the quantity of radiation absorbed by the patient's skin at the point where the X-ray or other radiation beam enters the body during a medical imaging procedure. The effective dose (ESD) is a crucial parameter in evaluating the potential hazard of radiation exposure to the patient's skin and underlying tissues. ESD measurements are employed by healthcare practitioners to ensure the maintenance of radiation doses at levels that are reasonably achievable, while simultaneously obtaining diagnostically valuable images.
Entrance Skin Air Kerma (ESAK) is a technical term that pertains to the field of radiation and its application in medical imaging. Similar to the concept of ESD, this parameter quantifies the quantity of radiation energy that is absorbed by a specific mass of air at the initial point of entry of the X-ray or radiation beam. The parameter in question pertains to the magnitude of the radiation beam at the point of entry into the skin. The utilization of Effective Dose (ESAK) values is a common practice in the assessment and regulation of radiation exposure in medical imaging procedures. This approach aids in the optimization of the imaging process by mitigating potential health hazards for both patients and staff.
Both the concepts of ESD (Entrance skin dose) and ESAK (Entrance surface air kerma) play a crucial role in the field of radiation protection, as they are instrumental in ensuring that medical imaging procedures are carried out with utmost safety and minimal radiation exposure in mind. X-ray imaging is widely recognized as a well-established modality for medical diagnosis. Extensive research has consistently demonstrated the undeniable advantages that diagnostic patients derive from these examinations. However, it is important to acknowledge that the ionizing nature of X-rays does entail certain inherent health risks that cannot be entirely eliminated. The potential adverse effects of utilizing X-ray technology in medical examinations have raised significant apprehension among individuals, despite the undeniable advantages it offers in terms of diagnosis and treatment [1]. Based on the findings of the International Commission on Radiation Units and Measurements [2], it has been determined that chest radiography constitutes approximately 25% of the total X-ray examinations conducted.
X-ray radiation brandishes a weighty radiation load upon patients and healthcare workers [3][1] and [4]. As ionizing radiation traverses the internal organs of a living organism, a portion of its energy permeates the cellular structure of the tissue. It's crucial to bear in mind that such actions have the capacity to provoke harm to the DNA, the genetic material, and other indispensable components dwelling within these cells. Typically, the body's innate defense mechanism expertly mends damaged DNA or eradicates afflicted cells. However, at heightened dosage levels, an eminent measure of cellular devastation may ensue, manifesting as noticeable harm like skin erythema, organ impairment, and potentially lethal outcomes [5].

The establishment of the International Commission on Radiological Protection (ICRP) in 1928 was impelled by the recognition of the plausible deleterious ramifications entwined with radiation exposure. The International Commission on Radiological Protection (ICRP) dutifully oversees and dispenses guidance on all aspects concerning safeguarding against ionizing radiation. It issues recommendations on fundamental principles and, when deemed appropriate,

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establishes radiation dose limits. The International Commission on Radiological Protection (ICRP) solely provides recommendations, leaving the responsibility of implementing these recommendations to individual governments based on their respective national circumstances. In the year 2007, a definition was provided which established the overarching principle of radiological protection. This principle states that any medical examination involving the utilization of ionizing radiation necessitates the referring healthcare provider, in collaboration with the radiologist, to provide a justification for the procedure.

The utilization of the radiological examination in question, when deemed necessary, will yield a greater benefit to the patient compared to any potential harm.

The specific radiological examination serves a designated purpose when deemed necessary for a particular disease and age cohort. Typically, this examination aims to enhance the accuracy of diagnosis or treatment or to furnish essential information pertaining to the individuals under examination. It is necessary for the individual patient to undergo the examination.

as stated by [7], the principal objective of optimizing radiological protection during an examination is to modify imaging parameters and protective measures in order to obtain the necessary image while minimizing radiation dose and maximizing net benefit. This entails consistently adhering to the ALARA (as low as reasonably achievable) principle for all examinations and procedures. The year 2001 witnessed the birth of the Nigerian Nuclear Regulatory Authority (NNRA) through the enactment of the Nuclear Safety and Radiation Protection Act 1995. This esteemed organization was bestowed with the primary duty of safeguarding the well-being and fortification of radioactive sources. Consequently, any and all employment of ionizing radiation in the realm of medicine and myriad other human activities within Nigeria is subject to meticulous oversight by the Nigeria Nuclear Regulatory Authority (NNRA).

Embedded within the fabric of Nigeria, the Nigerian Nuclear Regulatory Authority (NNRA) stands mighty and resolute, entrusted with the arduous mission of ensuring absolute compliance with stringent regulations in the employment and utilization of ionizing radiations. These regulations, carefully crafted and enforced, serve as an unwavering shield, shielding practitioners and the general public from the pernicious repercussions of ionizing radiation. Numerous countries, recognizing the gravity of the situation, have enacted legislation to vigilantly regulate the utilization of ionizing radiation. The majority of nations have enacted legislation to regulate the utilization of ionizing radiation. While there may be variations in legal systems, it is noteworthy that the International Commission on Radiological Protection (ICRP) plays a significant role in establishing recommended dose levels and promoting a general philosophy and set of recommendations that are widely recognized [8]. The Nigeria Basic Ionizing Radiation Regulation (NBIRR) is a regulatory entity established within the Nigeria Nuclear Regulation Authority (NNRA) to oversee radiation-related matters in Nigeria. As per the NBIRR guidelines, it is obligatory for Radiologists, Radiographers, and medical physicists to complete a two-week radiation protection training program. This training is designed to ensure the safety of both healthcare workers and patients when handling or working with X-ray equipment [9]. As per the International Atomic Energy Agency (IAEA) [10] and [11], the attainment of procedural optimization in x-ray examinations within diagnostic radiologic facilities necessitates the establishment of a quality control (QC) program by each

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such facility in the country. This program should encompass routine QC testing of ionizing radiation-emitting equipment, staff training, and evaluation of patient doses.
Moreover, according to [5], the primary concern in the field of radiation protection in X-ray diagnostic radiology often revolves around the issue of excessive radiation exposure to patients. The reason behind this phenomenon lies in the absorption of high doses by human cells, which leads to the initial manifestation of a biological effect or disorder characterized by a decrease in the count of white blood cells. This reduction becomes apparent within a few hours following exposure. Moreover, research has demonstrated that during cellular division, chromosomes exhibit a heightened susceptibility to ionizing radiation, resulting in potentially significant alterations to the gene arrangement within the chromosomes. Extra doses of ionizing radiation have the potential to increase the average gene mutation rate, resulting in the occurrence of abnormalities in subsequent generations [5]. This underscores the increasing importance of assessing the radiation dose level for an additional region of the human body, in addition to the target organ or volume, during X-ray examinations.
Furthermore, it is important to emphasize that when implementing radiation dose limits in real-world scenarios, it is crucial to take into account both the stochastic and non-stochastic dose limits. As a result, these limits may serve as the primary reference for determining the maximum allowable dose. It is important to emphasize that the utilization of diagnostic reference level (DRL) is commonly employed in the optimization of radiation dosage administered to patients. In this context, it has been concluded that certain radiological examinations can have a detrimental impact on cell proliferation, as indicated by reference [12]. Based on this comprehension, it is appropriate to assert that there exists a necessity to consistently conduct technical periodic evaluations of dosage in order to enhance radiation protection for patients. The main objective of conducting patient dose measurement is to determine the standard dose administered to an average patient through the utilization of x-ray equipment and examination techniques in a specific radiology room, specifically for the particular type of radiograph or examination being investigated [13].

The issue of patient radiation in chest X-ray examinations has not received the anticipated level of attention throughout the State. Hence, the objective of this study is to assess the radiation doses received by male and female patients undergoing chest X-ray examinations at specific diagnostic radiologic facilities in various locations within Delta State. The evaluation of the patients' Entrance Surface Dose (ESD) and Entrance Surface Air Kerma dose (ESAK) was conducted, and the obtained results were subsequently compared with the research outcomes of other scholars worldwide. It is advisable to utilize the estimation of Entrance Skin Air Kerma (ESAK) for the purpose of evaluating radiation dose and facilitating the comparison of patient dose levels with diagnostic reference levels in the field of general radiology [14]. The dosimetry quantities that are frequently employed in diagnostic radiology to assess the typical dose administered to an average adult patient are the patient Entrance Surface (Skin) Dose (ESD), which accounts for backscatter in simple x-ray projections, the Entrance Surface Air Kerma, and the Dose Area Product (DAP) for more intricate examinations [15][16] and [17]. The findings of this study will serve as a valuable benchmark for comparing measurements at various x-ray facilities within the State and globally. Additionally, it will offer an opportunity to explore the potential for further minimizing patient radiation exposure. The assessment of

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radiographic techniques and dose for individual radiographs was conducted with meticulous attention. The obtained results were then compared with other relevant studies conducted in Africa, Europe, and Asia. Additionally, the quality criteria for diagnostic radiographic images proposed by the European Commission and the recently published UK reference dose level were taken into consideration for comparison purposes [18].

2. MATERIALS AND METHODS

This study selected a total of ten (10) operational diagnostic radiologic facilities located throughout the State. The dose assessment was performed on a sample of 700 patients who were 18 years of age or older. The selection of facilities for the study was based on the availability of reliable and comprehensive data. The selected facilities consist of five (5) hospitals owned by the State government, one (1) facility owned by the federal government, and four (4) private hospitals. To address ethical concerns, the facilities under investigation were assigned codes ranging from F1 to F10. The diagnostic radiologic centres were subsequently allocated as follows: F1-F5 to state government hospitals, F6 to federal government hospitals, and F7-F10 to private hospitals. The demographic information of the patient, including age, gender, height, and weight, was derived from the patient's anatomical data. The anatomical data of the patient were reviewed retrospectively for the period spanning from October 2022 to March 2023. The review encompassed an examination of the characteristics of the different x-ray machines utilised, including their peak tube voltage (kVp), exposure current and time product (mAs), and focus to skin distance (FSD) employed during each diagnostic examination and procedure.

2.1 Evaluation of Entrance Surface (skin) Dose (ESD).

The ESD is defined as the absorbed dose measured in air on the x-ray beam axis at the point where the x-ray beam enters the patient. The ESD for each patient was evaluated using the equation below [19]:

$$\mathrm{ESD} = \frac{\mathrm{O}}{\mathrm{P}}\left(\frac{\mathrm{KV}}{\mathrm{SD}}\right)^2 \mathrm{mAs}\left(\frac{100}{\mathrm{FSD}}\right)^2 \mathrm{BSF} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathrm{i}$$

Where O/P is the output of the x-ray machine in mGy/(mAs) at 80 kV at a distance of 100 cm and normalized to 20 mAs, kV is the tube potential, mAs is the product of the tube current and the exposure time, FSD is the focus -to skin distance (cm), and BSF is the backscatter factor [20]. In this study, the BSF value used is within the range of 1.31 to 1.37 and this is in accordance with the European commission guidelines [21] and [10].

For us to determine the output value in the above equation, we adopted the model as proposed by [22] and [20]. They showed that the output of the x-ray machine depends on the voltage output and the mAs values. This is as shown in the equation below:

$$\frac{\mathrm{O}}{\mathrm{P}}(\mathrm{mAs}, \mathrm{KV}) \ = \propto (\mathrm{KV})^{\beta} \ \mathrm{x} \ \mathrm{mAs} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathrm{ii}$$

$$\mathrm{In}\ \frac{\mathrm{O}}{\mathrm{P}}(\mathrm{KV}) \ = \eta + \beta\ \mathrm{In}\ (\mathrm{KV}) \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathrm{iii}$$

$$\text{Where } \eta = \mathrm{In}\ \alpha$$

Using the values from measurement, the parameters η and β are estimated by employing the use of the Ordinary Least Square method, using R software [20].

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Also, the body mass index (BMI) of each patient investigated was evaluated using the formula provided by [9]. The formula is given below:

Body Mass Index (BMI) $= \frac{W(Kg)}{H^2(m^2)}$................................iv

Where W is the patient weight in kg and H the height in meters

2.2 Entrance Surface Air Kerma (ESAK)

The Entrance Surface Air Kerma is the Air Kerma on the central x-ray beam axis at the point where the x-ray beam enters the patient or phantom with contribution of backscattered radiation [23] and [1]. The International Atomic Energy Agency (IAEA) recommends the use of equation (v) below in patient dose assessment owing to the fact that studies have proven that incident air kerma is much easier to evaluate accurately and this could ease the practical problem associated with achieving electronic equilibrium in the field [24] & [1]

To measure the entrance surface (skin) air kerma (ESAK) from measured x-ray exposure technique factors (kVp, mAs and FFD) using the semi empirical formula as recommended by IAEA protocol and code of practice[10]. [1] gave the formula for evaluating ESAK as:

$$ESAK = Y(d) \times mAs \times \frac{d}{(FFD-t_p)^2} \times BSF \quad \text{........…....... v}$$

Where Y(d) is the x -ray tube output at a distance of 100 mAs, FFD is the focus -film- distance, t_p is the patient thickness and BSF is given as the backscatter factor which depends on tube potential, device filtration and the size of radiation field [23], [10] and [1]. To evaluate the patient thickness t_p, we employed the patient thickness formula as given by [25]. The formula is given as:

$$t_p = \sqrt[2]{\frac{W}{\pi h}} \quad \text{...................................... vi}$$

where W is patient weight in kg, h is the height in meters and π is a constant with the value of 3.142.

For the purpose of evaluating the radiation output Y (d) for the various x -ray machines used, [26] gave the following formula for radiation output Y (d) for different phases of x -ray machines.

Single phase (SP): $Y(d) = 0.5 \times 6.53 \times 10^{-4}$ mR ………………....vii
Three phase (TP): $Y(d) = 0.5 \times 6.53 \times 10^{-4}$ mR ……………...…viii
High frequency generator (HFG): $Y(d) = 1.0 \times 6.53 \times 10^{-4}$ mR ……………...…ix

The radiation output Y(d) generated from equations vii-ix is then converted to mGy/mAs by multiplying it by a factor of 0.00877/mAs [27].

3. RESULTS

Table 1.0. Characteristics of the x-ray machines from various diagnostic radiologic centers.

Facility room	Machine type	Production year	Machine power rating	Automatic Exposure Control Operation.

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F1	TP	2010	85	AEC and Manual
F2	TP	2004	120	AEC and Manual
F3	SP	1990	110	AEC and Manual
F4	TP	2006	90	AEC and Manual
F5	SP	2003	75	AEC and Manual
F6	HFG	1990	95	AEC and Manual
F7	SP	1998	70	AEC and Manual
F8	TP	2005	90	AEC and Manual
F9	HFG	2000	124	AEC and Manual
F10	TP	2001	80	AEC and Manual

Table 2.0 Gender distribution and mean values of patient parameters

Mean (range) patient parameters							
Facility code	**Gender**	**Figure**	**Age**	**Weight (kg)**	**Height (cm)**	**BMI(kg/m^2)**	**tp (kg/m)**
F1	M	45	48(30-45)	71(65-88)	1.7(1.5-1.8)	24.57(23.12-25.10)	7.292
	F	30	32(25-45)	55(51-73)	1.5(1.5-1.7)	24.44(24.00-24.81)	6.832
F2	M	40	47(20-37)	66(65-91)	1.6(1.4-1.8)	25.78(25.01-26.00)	7.247
	F	45	38(23-46)	60(49-69)	1.6(1.5-1.7)	23.44(23.12-23.89)	6.738
F3	M	20	55(30-65)	78(70-97)	1.7(1.5-1.8)	26.99(26.22-27.00)	7.643
	F	40	48(32-55)	73(68-86)	1.6(1.4-1.8)	28.52(28.11-28.88)	7.621
F4	M	28	33(21-40)	56(55-69)	1.5(1.5-1.7)	24.89(24.00-25.13)	7.125
	F	22	41(25-37)	67(61-80)	1.5(1.5-1.8)	29.78(29.45-30.00)	7.541
F5	M	47	30(25-71)	54(52-68)	1.6(1.4-1.7)	21.09(21.01-22.00)	6.555
	F	43	42(30-65)	67(61-83)	1.6(1.5-1.8)	26.17 (26.15.26.25)	6.734
F6	M	33	54(28-70)	65(61-86)	1.7(1.5-1.9)	22.49(22.33-22.60)	6.977
	F	53	35(26-50)	58(51-79)	1.5(1.4-1.6)	25.78(25.27-26.12)	7.016
F7	M	21	31(23-45)	55(49-70)	1.5(1.5-1.7)	24.44(24.40-24.59)	6.832
	F	37	43(27-55)	67(64-81)	1.6(1.5-1.8)	26.17(26.02-26.31)	7.301

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F8	M	43	39(21-60)	59(55-68)	1.5(1.4-1.7)	26.22(25.98-26.54)	7.076
	F	21	33(32-65)	69(61-77)	1.6(1.5-1.8)	26.95(26.82-27.00)	7.410
F9	M	20	41(30-70)	68(66-81)	1.5(1.5-1.8)	30.22(30.09-30.31)	7.597
	F	32	35(30-58)	62(58-65)	1.5(1.4-1.6)	27.56(27.45-28.00)	7.254
F10	M	39	33(23-42)	58(55-65)	1.5(1.4-1.8)	25.78(25.51-25.97)	7.016
	F	41	37(21-55)	60(56-68)	1.6(1.5-1.8	23.44(23.28-24.03)	6.909

Table 3.0 Exposure factor (mean value) for various x-ray machines

Facility code	**Gender**	**kVp**	**mAs**	**FSD (cm)**	**FFD (cm)**	**FFD-tp (cm)**
F1	M	70(70-75)	41(38-50)	55(53-55)	130(128-150	122.708
	F	32(25-35)	43(40-45)	100(98-105)	150(148-157)	143.168
F2	M	85(80-90)	45(41-40)	100(100 100)	140(140-150)	132.753
	F	70(67-72)	58(55-65)	45(41-48)	170(165-175)	163.262
F3	M	75(70-80)	55(50-56)	52(50-55)	181(180-192)	173.357
	F	60(60-90)	40(40-45)	45(45-47)	100(100-135)	92.379
F4	M	70(67-73)	48(45-50)	100(95-100)	115(110-120)	107.875
	F	80(78-82)	37(34-37)	100(98-100)	93(90-100)	85.459
F5	M	38(35-45)	25(24-28)	60(58-65)	117(115-125)	110.445
	F	75(70-75)	45(45-50)	45(45-50)	121(120-130)	114.266
F6	M	80(75-82)	65(63-67)	45(42-46)	150(145-160)	143.023
	F	65(60-66)	42(40-48)	53(50-55)	160(160-170)	152.984
F7	M	74(70-80)	68(65-72)	54(51-59)	130(129-140)	123.168
	F	72(70-75)	15(10-20)	100(95-100)	175(172-180)	167.699
F8	M	75(70-85)	41(40-45)	100(99-115)	120(115-125)	112.924
	F	82(80-85)	34(31-36)	100(100 110)	110(100-110)	102.590
F9	M	94(90-98)	15(12-18)	85(85-90)	150(150-162)	142.403
	F	70(68-73)	79(77-82)	100(100 112)	134(130-140)	126.746
F10	M	75(72-75)	45(44-46)	100(95-110)	125(120-130)	117.984
	F	67(65-75)	77(75-84)	45(42-46)	154(150-160)	147.091

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Table 4. Entrance Skin Dose (ESD) and Entrance Skin Air Kerma (ESAK) values from mean exposure parameters and patients' parameters using equations above.

Facility code	Gender	Y(d) *10^{-3} mGy/mAs	BSF (IAEA 2007)	ESD (mGy)	ESAK (mGy)
F1	M	0.00526	1.36	0.018 (0.015-0.019)	0.072 (0.070-0.074)
	F	0.00526	1.35	0.084 (0.082-0.085)	0.069 (0.067-0.070)
F2	M	0.00526	1.36	0.216 (0.215-0.217)	0.081 (0.080-0.083)
	F	0.00526	1.36	0.298 (0.297-0.310)	0.062 (0.061-0.063)
F3	M	0.00285	1.31	0.313 (0.312-0.315)	0.085 (0.084-0.087)
	F	0.00285	1.35	0.481 (0.480-0.484)	0.016 (0.015-0.017)
F4	M	0.00526	1.33	0.511 (0.509-0.512)	0.034 (0.033-0.036)
	F	0.00526	1.35	1.221(1.218-1.223)	0.088 (0.086-0.089)
F5	M	0.00285	1.31	0.487 (0.486-0.490)	0.023 (0.021-0.025)
	F	0.00285	1.35	1.168 (1.165-1.169)	0.074 (0.072-0.077)
F6	M	0.00593	1.37	0.357 (0.354-0.357)	0.019 (0.018-0.019)
	F	0.00593	1.35	0.697(0.696-0.698)	0.086 (0.085-0.088)
F7	M	0.00285	1.36	0.441(0.440-0.443)	0.059 (0.057-0.061)
	F	0.00285	1.36	1.231 (1.230-1.234)	0.071 (0.069-0.073)
F8	M	0.00526	1.35	0.989 (0.987-0.989)	0.076 (0.074-0.078)
	F	0.00526	1.35	1.542 (1.541-1.543)	0.082 (0.080-0.083)
F9	M	0.00593	1.32	1.671(1.670-1.674)	0.024 (0.022-0.126)
	F	0.00593	1.35	1.348 (1.346-1.350)	0.098 (0.096-0.099)
F10	M	0.00526	1.35	1.109 (1,107-1.110)	0.069 (0.066-0.072)
	F	0.00526	1.33	0.580 (0.580-0.583)	0.043 (0.041-0.045)

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Table 5. Comparison of ESD value present investigation with previous literatures.

Examination type	**Present investigation**	**[28]**	**[19]**	**[29]**	**[14]**	**[30]**
Chest x-ray	(0.018-1.671)	(0.18-1.05)	(0.02–0.31)	0.32-0.52	0.4	0.3

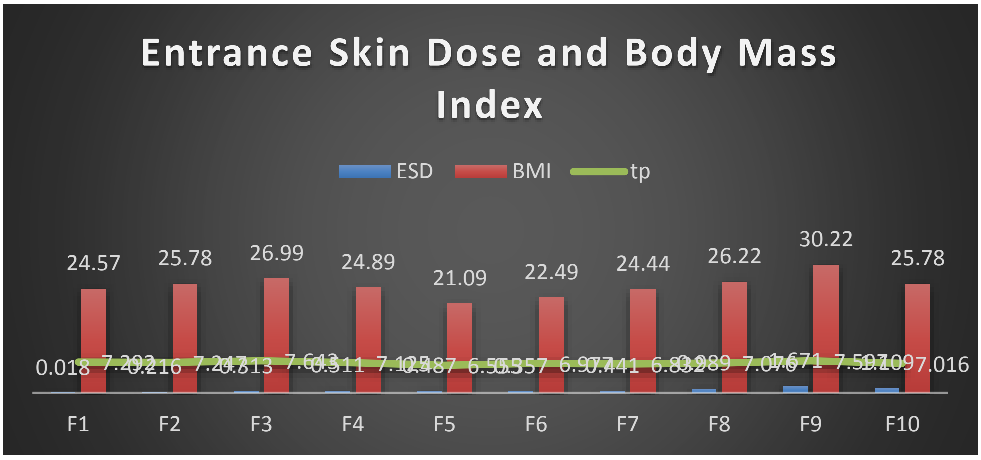

Fig 1. Entrance Skin Dose, Patients' Body Mass Index and Body thickness value for male patients

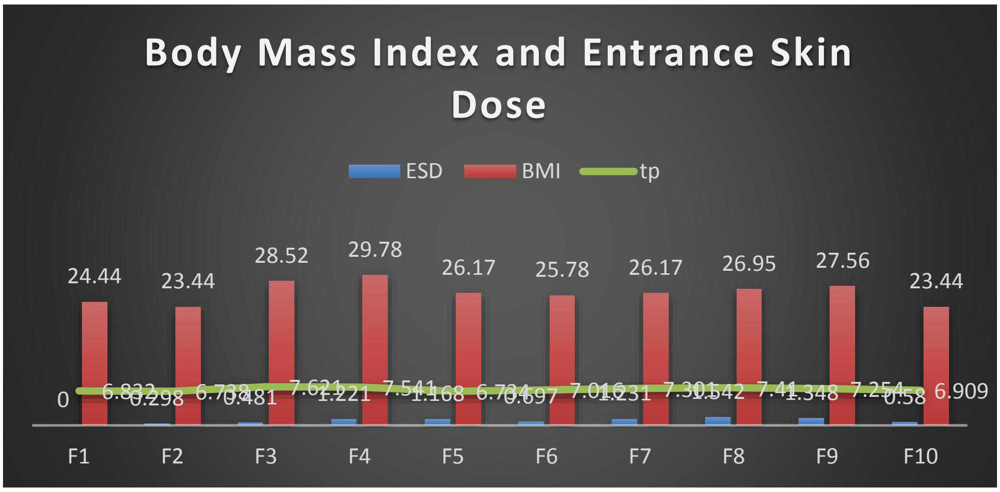

Fig 2. Entrance Skin Dose, Patient' Body Mass Index, and Body thickness value for female Patient

4. RESULTS

This study analyzed data from ten x-ray machines in ten radiological diagnostic centers in Delta State over six months. The data included the machine's make, production year, power rating, and automatic exposure control operation. The study also included anatomical data for patients, exposure parameters, machine output, backscatter factor, effective dose, and corresponding entrance surface air kerma values. The study compared the average ESD values obtained in the

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study with previous literature and established international reference dose levels. The study also showed a graphical correlation between entrance skin dose level, body mass index, and body thickness values for male and female patients. The findings are documented in tables and figures.

5. DISCUSSION

A study was conducted on 700 individuals, with 336 male and 364 female, who underwent chest X-ray examinations and associated medical procedures. The study evaluated entrance skin dose and entrance skin air kerma dose. The average age of the patients varied between 32 and 55 years, with an average weight of 54 to 78 kg. The study found that some patients had an elevated BMI, suggesting they may be overweight and require increased radiation dosages. The average body thickness ranged from 6.56 kg/m to 7.60 kg/m.
The maximum tube potential voltage was 94 kVp for male patients in a private healthcare facility, while a state government-owned facility with code F1 achieved the lowest voltage of 32 kV for female patients. Most diagnostic centers use shallow tube potentials, but some require higher voltages. The study also found that the Entrance Skin Dose (ESD) values for patients fell within the recommended reference dose limit of 1 mGy per year for joint x-ray examinations and procedures. However, approximately 35% of the diagnostic centers reported exceeding the reference dose limit of 0.4 mGy, due to factors such as high loading of exposure rate, aging of x-ray tubes, and inadequate competency of technicians.
The effective dose (ESD) values varied between 0.018 and 1.671 mGy for male patients and between 0.084 and 1.542 mGy for female patients. The highest and lowest ESD values were observed in facilities F1, a state government facility, and F9, a private facility center. The study also found that the ESAK values for male and female patients were below the recommended levels established by prominent radiation protection agencies.

6. CONCLUSION

The study evaluates Entrance Skin Dose (ESD) and Entrance Skin Air Kerma (ESAK) in chest X-ray examinations at diagnostic radiological facilities in Delta State. Most facilities follow the recommended dosage limits, but some have elevated levels, potentially posing a radiation hazard for patients undergoing multiple examinations within a year. The study also found a correlation between ESD and body mass index (BMI), suggesting that individuals with higher BMI receive increased ESD dosages. The measured ESAK dose values were within the International Atomic Energy Agency's reference dose limit of 0.4 mGy. The study also found that individuals with greater body thickness require higher radiation dosage, affecting the use of higher kilovoltage peak settings during imaging procedures. The study emphasizes the need for consistent assessment of radiation doses by local and international radiation protection agencies to maintain quality control, maintain high image quality, and minimize radiation exposure in X-ray procedures. The study provides valuable insights into radiation doses in chest X-ray examinations in Delta State, emphasizing the importance of ongoing monitoring and optimization to mitigate potential risks to patients.

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Ethical considerations: Patients' names or other demographic data identifying the patients and the facility centers were not used. Because the work is retrospective, the need for the patient's informed consent was waived.

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7. REFERENCES

1. Samuel, O. Inyang., Imeh, E. Essien and Akininyene, D. Anita (2015): Entrance Surface Air Kerma for Chest x-ray examinations in some diagnostic radiologic facilities İn Akwa Ibom State, Nigeria. IISTE; Advances in Physics Theories and Applications. Vol 48:28-35. ISSN 2224-719 X
2. ICRU (2003, Report 70): Image Quality in Chest Radiography. International Commission On Radiation Units and Measurement; Nuclear Technology Publishing, Ashford, Kent, UK. ISBN 1870965981.
3. Vano, E (2003): Radiation exposure to cardiologist, how it could be reduced. Herat; 89:123-124
4. Padovani, R and Rodella, C (2001): Staff dosimetry in interventional cardiology. Radiation Protection dosimetry; 94: 99-103
5. ICRP (2007): Recommendations of the International Commission on Radiological Protection Publication 103, Pergamon Press, Oxford and New York.
6. ICRP (2011): International Commission on Rdaition Protection Draft report on the International System of Radiological Protection. Bethesda, USA 4836-9539-0480.
7. Shahbazi-Gahrouree (2006): Entrance Surface Dose measurement for Routine X-ray Examination in chaharmahal and bakhtairi hospital. Iran Journal of Radiate Research, 4(1) : 29-33
8. Hamza, H.A., Sharpson, M.I and Auwal, Y.M (2018): Correlation of Entrance Skin Dose With Body mass index (bmi) for patients examined by diagnostic X-ray İnternational Journal of Creative Research Thoughts (ijcrt). Vol 6(1): 1643-1647
9. IAEA (2007): Dosimetry in diagnostic radiology, international code of practice IAEA Technical Report Series457, Vienna.
10. NNRA (2003): Nigerian Basic Ionizing Radiation Regulations. Federal government Press; Lagos Nigeria.
11. Anoopkumar, S.M., Aallshire, A and Conere, T.J (2003): Further Evidence for Biological Effects, Resulting from Ionizing Radiation Doses in the Diagnostic X-ray range. PNAS; 100: 4973-4975.
12. IAEA (1996): international basic safety standard for protection against ionizing Radiation and for safety of radiation sources. Safety series No 115 IAEA: Vienna, Austria.

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DOI: https://doi.org/10.55529/jhtd.26.17.29

13. Moors,B.M (2005): Radiation Dose Measurement and Optimization. British Journal of Radiology. 78: 866-868
14. Wall B.F (2006): Response to 'Radiation Dose Measurement and Optimization'. British journal of Radiology, 79:356-357.
15. Eric,K. Ofori., William,K.A., Diane, NSs and Matt Ward (2013): Patient radiation dose Assessment in Pelvic x-ray examination in Ghana. Omics journal of Radiolgy 2(8) 151 Doi: 10.4172/2167-7964. 1000151
16. Ogundare F,O.,Uche, C.Z.,and Balogun ,F.A (2004)Radiological Parameters and radiation Doses of Patients undergoing Abdomen, pelvics and lumber spin X-ray examination in three Nigerian Hospitals. British journal of Radiology; vol 77(923): pp 934-940.
17. Jumaa,Y.T., Mohamed,Y., Khadija, Mokhtar., Ahmed. Alfak and Abdelmoneim,S (2014): Assessment of Entrance Surface Dose for the patients from Common Radiology Examination in Sudan.life Science Journal 11(2): 1-5
18. Simo,C.R.T., Samba,O.N., Talla,P.K and Fai, I.C (2021): Radiation dose from three Phase x-ray Machines; a Comparison Between Different Models. International Journal of radaition Research.vol 19 (3): 559-567. Doi: 10.52547/ijrr.19.3.559
19. European Commission on Radiation Protection 109 (1999): Guidance on Diagnostic Reference Levels (DRLs) for Medical Exposures. Luxembourg: oopec.
20. Harpen, M.D (1996): A mathematical spread sheet application for production of entrance Skin exposure in mamograms. Medical physics, 23: 241-242
21. ICRU (2005): Patient dosimetry for x-rays used in medical imaging, international Commission on Radiation units and measurements publications.
22. Olivera,C.,Srpko,M and Dusko, K (2003): Patient Dosimetry in Diagnostic Radiology. Nuclear Technology and Radiation Protection; 36(1): 1-6
23. Nyathi,T.,Nethwadzi,I.C.,Mabhengu,T.,Pule,M.I and Merwe, D.G (2009): Patient dose Audit for Patient undergoing six common radiography examination: Potential Dose reference Levels. South African Radiography; 9-13
24. Kothan Suchart and Montrel Tungjai (2011): An Estimate of x-radiation output using Mathematical model, American Journal of Applied Sciences. 8(9); 923-926
25. Oluwasifoye, P.A.,Oluwokere,C.J.,Jibiri ,N.N.,Bello,T.O.,Alausa, S.K and Efunwole,H.O (2001): Quality Control and Environmetal Assessment of equipment used In diagnostic radiology. İnternational journal of research and reviews In Applied Sciences; 3(2),147-158
26. Halato,M.A., (2008): Dosimetry for patients Undergoing radiographic examinations in sudan, IX radiation physics And protection conference Nasr City – Cairo, Egypt, 15-19
27. Paydar, R., Takavar, A.,Kardan,M.R.,Babkhani,A., Deevband, M.R and Saber, S. (2012) Patients effective dose evaluation for chest x-ray examination in three Digital radiography centers, Iran Journal of Research; 10(3-4): 139-143
28. European Commission (1996): European Guidelines on Quality Criteria for Diagnostic Radiographic Images, EUR 16260 EN.

