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Assessment of Entrance Skin Dose for Adult Patients Undergoing Conventional X-Ray Examination in Sokoto Metropolis

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Abstract | **Original Research Article**

This research work assesses the entrance skin dose (ESD) received by adult patients undergoing conventional X-ray examinations in Sokoto Metropolis, Nigeria. The study aim to determine the average ESD for various X-ray procedures and compare them with national and international reference levels. The average ESDs for chest X-ray, Knee X-ray, abdominal X-ray, and lumbar spine X-ray were found to be significantly higher than those reported in other studies conducted in Nigeria and internationally. This suggests potential for overexposure of patients during these examinations in the Sokoto Metropolis. This research is intended for medical professionals, healthcare institutions, and the general public in Sokoto Metropolis and beyond. The findings highlight the need for improved radiation safety practices and adherence to established reference levels to ensure patient protection during X-ray examinations.

Keywords: Entrance skin dose, radiation safety, Sokoto Metropolis, X-ray examination.

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1. INTRODUCTION

Radiological imaging is a fundamental element in contemporary medical diagnosis, with traditional X-ray examinations constituting a considerable share of radiological procedures globally (Hendee, W.R., & Heyer, E.R 2000). Although they hold significant diagnostic importance, X-ray procedures subject patients to ionising radiation, which poses potential hazards, including deterministic and stochastic effects. Consequently, the precise evaluation and optimisation of patient radiation doses is an essential dose (ESD) which refers to the radiation absorbed by the skin at the point where the beam enters is a component of radiological protection, especially in developing nations where the maintenance and standardisation of equipment may differ (NIBIB, 2017).

The entrance skin crucial dosimetric measure utilized to assess patient exposure in diagnostic radiology (NIBIB, 2023). It provides a foundation for comparing patient doses against established diagnostic reference levels (DRLs), facilitating quality assurance and compliance with the principles of radiation protection, which include justification, optimization, and dose limitation (American College of Radiology.2023).

In Nigeria, particularly in Sokoto Metropolis, there is a scarcity of data regarding patient radiation doses, and routine monitoring of doses is frequently absent in numerous radiology centers. This deficiency poses a challenge in evaluating adherence to international standards and in executing dose optimization strategies. Therefore, the necessity for localized data to inform policy, enhance clinical practices, and safeguard patients from unnecessary radiation exposure is of utmost importance (Fred Gelderen, 2012).

This study aim to evaluate the ESD for adult patients undergoing prevalent conventional X-ray examinations in selected hospitals throughout Sokoto Metropolis. By analyzing these doses and juxtaposing them with international standards, this research will provide valuable information to the national database, foster awareness of radiation safety, and aid in the establishment of local diagnostic reference levels.

2. Theory

Several works have been published on entrance skin dose *(ESD)* for patients undergoing Conventional

X-ray examinations. Some of the research works published are as follows:

Anan Cecilia *et al.,* (2006); works on the evaluation of the *Entrance Skin Dose(ESD)*, the body organ dose *(BOD)* and effective dose *(E)* resulting from pediatric radiological procedures with the use of portable X-ray equipments. The software DoseCal was used to evaluate the doses imparted to patients. The children were classified according to their weight and age groups, and the study included three sectors of the intensive care unit of a large reference pediatric hospital in Rio de Janeiro. A total of 518 radiographs was performed, (424 for chest and 94 for abdomen). The statistical data were compared with previously published results. The *BOD* is presented for the most exposed organ. The mean value of *ESD and E* varied widely among neonates. The highest number of radiographs per infant peaked 33 for chest examination in the age group 0-1 year.

Suliman *et al.,* (2007); evaluated the *Entrance Skin Dose*s (ESDs) to patients undergoing diagnostic chest X-ray examinations in major Sudanese hospitals. The work was carried out in four major hospitals in the Sudanese capital Khartoum. Eight X-ray units were included in the study. ESD was estimated from X-ray tube output parameters in four hospitals comprising eight X-ray units and a sample of 346 radiographs. The hospitals that participated in the study were Ribat University Hospital (RUH), Khartoum Teaching Hospital (KTH), Omdurman Teaching Hospital (OTH) and Khartoum North Teaching Hospital (KNTH). For calculating the ESD, the following X-ray tube exposure parameters were recorded, for each patient undergoing the specified diagnostic procedure: peak tube voltage (KVp), exposure current–time product (mAs) and focus-to-film distance (FFD). The ESD was calculated in that work using the following relation:

$$ESD = \frac{O}{P} \times \left[\frac{kv}{80}\right]^2 \times mAs \times \left[\frac{100}{FSD}\right]^2 \times BS$$

Where $\frac{O}{P}$ is the tube output per mA s measured at a distance of 100 cm from the tube focus along the beam axis at 80 KVp, KV is peak tube voltage recorded for any given examination, mAs is the tube current–time product, E*SD* is the focus-to patient entrance surface distance and BSF is the backscatter factor. The tube output in mA/mAs was measured at a distance of 100 cm from the X-ray tube focus using RAD-CHECK PLUS model 06-526 X-ray exposure meter (Nuclear Associates, Victoreen Division, NY, (USA). The factor 0.00877 was applied to convert the tube output from mA/mAs to output in mGy/mAs. A value for the BSF of 1.35 was used in this study. The dose rate meter, RADCHECK PLUS used for the measurements has been calibrated at Sudan Atomic Energy Commission (SAEC) Secondary Standard Dosimetry Laboratory. Hospital mean ESDs estimated range from 0.17 to 0.27 mGy for chest AP. With exception of chest PA examination at two hospitals, mean ESDs were found to be within the established international reference doses.

Suliman *et al* (2008); evaluated radiation doses to patients from some common pediatric chest X-ray examination in three hospitals in Khartoum state, Sudan. ESDs were measured for chest. Doses were estimated from X-ray tube output parameters in three hospitals comprising three units and a sample of 459 radiographs. The hospitals included in the study were Khartoum, Omdurman and A. Gasim pediatric hospitals. ESDs in that study were calculated using Dose Cal software developed by the radiological protection centre of Saint George' Hospital, London. The X-ray tube outputs, in mGy (mA s)$^{-1}$, were measured using Unfors Xi dosimeter (Unfors Inc., Billdal, Sweden). The dosimeter was calibrated by the manufacturer and reported to have accuracy better than 5%. The authors results showed that the Mean ESDs obtained from anteroposterior projection for chest for neonates falls in the range of 52–100 μ Gy, respectively. For a 1-y-old infant, mean ESD range was 80–114 μ Gy, respectively. Some doses for neonates and infants were exceeding the reference doses by >20%. The authors observed that patient's doses were high in departments using single-phase generators compared with those using constant potential.

Ademola A.K *et al.,* (2013); estimated the Entrance skin doses (ESD) and Effective dose (E) to pediatric patients during chest, skull, abdomen and pelvis examination in five Nigeria hospitals using DoseCal software. The mean ESD for Chest (PA) in age range 1 – 5 in the five hospitals (Hospital 1 –Hospital 5) were 70, 139, 130, 105 and 111μGy, respectively. The median ESD values in all the examinations were compared with the NRPB and EC reference level and were found to be lower except for Chest PA and Chest Lateral examinations. The mean effective doses were compared with those found in literature and were found to be comparable. Data shows that there is variation in the result of the ESD obtained and so adherence to guidelines should be demonstrated.

Taha *et al* (2014); estimated the entrance skin dose received by patients undergoing diagnostic X-ray examination, including the entrance skin dose *(ESD)* for 500 patients in six types of X-ray examinations in king Abdullah Medical city, Makkah, KSA. The entrance skin dose *(ESD)* was determined via indirect measurements and from knowledge of X-ray output factors. They entered the measurement parameters such as X-ray dose output, back scatter factor, and focus to skin distance (*SSD*) and the used questionnaire physical parameters such as mAs and KV in mathematical model. The mean and standard deviation for entrance skin doses for chest PA was 0.138 $\pm$ 0.04 mGy, respectively. The results obtained were compared with the reference levels of the International Atomic Energy Agency. The entrance skin dose calculation was taken into account the patient thickness.

Ibrahim *et al* (2014); the study was carried out to establish the trend of dose received by patient during X-ray examination in Federal Medical Centre, Keffii Nasarawa state, Nigeria. Entrance skin doses (ESDs) for a common type of X-ray procedures, namely chest AP/PA (anterior/posterior) were measured. A total of 200 data were collected from patients who were exposed to diagnostic X-ray during their routine chest X-ray examinations. The age of the patients ranged from 15 to 68 years old while the weight and height of these patients ranged from 37.5Kg to 98.5Kg and130.0cm to 175cm, respectively. The patent's skin dose were determined using Edmond's formula, which is based on the X-ray tube and the radiographic exposure parameters of KVp, mAS, SSD and the total filtration of the beams. The calculated mean skin dose ranges from 0.013 ± 0.01mGy to 0.851±0.023mGy. In general, the ESDs measured for this type of X-ray procedures were found to be lower than or in agreement with the guidance level set by the Nigerian Basic Ionizing Radiation Regulation (NBIRR, 2003) standard and other international bodies and does not pose any significant health risk to the patience or the workers.

2.1 Radiation

Radiation is the emission or transmission of energy in the form of waves or particles through space or a material medium. Which can be in the form of either: Electromagnetic radiation consists of photons, such as radio waves, microwaves, infrared, visible light, ultraviolet, x-rays, and gamma radiation (γ) or Particle radiation which consists of particles of non-zero rest energy, such as alpha radiation (α), beta radiation (β), proton radiation and neutron radiation. (farlex,2014). Radiation is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10 eV, which is enough to ionize atoms and molecules and break chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms. A common source of ionizing radiation is radioactive materials that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Other sources include X-rays from medical radiography examinations and muons, mesons, positrons, neutrons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere. (CNSC b), (2012)

Gamma rays, X-rays, and the higher energy range of ultraviolet light constitute the ionizing part of the electromagnetic spectrum. The word "ionize" refers to the breaking of one or more electrons away from an atom, an action that requires the relatively high energies that these electromagnetic waves supply. Further down the spectrum, the non-ionizing lower energies of the lower ultraviolet spectrum cannot ionize atoms, but can disrupt the inter-atomic bonds that form molecules, thereby breaking down molecules rather than atoms; a good example of this is sunburn caused by long-wavelength solar ultraviolet. The waves of longer wavelength than UV in visible light, infrared, and microwave frequencies cannot break bonds but can cause vibrations in the bonds which are sensed as heat. Radio wavelengths and below generally are not regarded as harmful to biological systems. (CNSC b), (2012)

2.2 Ionizing radiation

Ionizing radiation is a form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue. Ionizing radiation can travel unseen and pass through these materials.

A familiar example of ionizing radiation is that of x-rays, which can penetrate our body and reveal pictures of our bones. We say that x-rays are "ionizing," meaning that they have the unique capability to remove electrons from atoms and molecules in the matter through which they pass. Ionizing activity can alter molecules within the cells of our body. That action may cause eventual harm (such as cancer). Intense exposures to ionizing radiation may produce skin or tissue damage. (National Council on Radiation Protection and measurement, 1987).

The tiny particles of electromagnetic radiation that an X-ray machine emits pass through all but the most solid objects in the body. As such, the image it creates, known as a radiograph, allows healthcare providers to visualize internal structures in a human body.

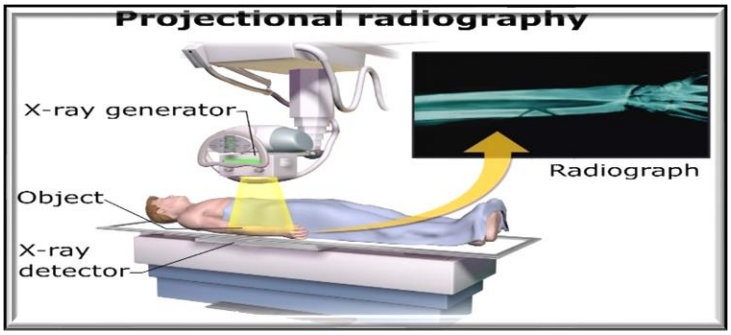

Fig. 1.0: Projectional Radiography

2.3 X-ray imaging

An X-ray, also known as radiography, is a medical imaging technique. It uses tiny amounts of electromagnetic radiation to create images of structures inside the body. These images can then be viewed on film or digitally. X-rays often are done to view bones and teeth, making them helpful in diagnosing fractures (broken bones) and diseases such as arthritis. (Fred Gelderen, 2012)

2.4 How the X-ray works

The tiny particles of electromagnetic radiation that an X-ray machine emits pass through all but the most solid objects in the body. As such, the image it creates, known as a radiograph, allows healthcare providers to visualize internal structures in a human body. (K.R Thwaites,2008)

Sometimes a contrast medium, a type of dye, is given to help images appear in greater detail. You might receive these via injection into a blood vessel, orally, or rectally.

X-ray images appear in various shades of white and grey. Because bones and metal objects are solid, less radiation passes through them, making them appear white on the radiograph. On the other hand, skin, muscle, blood and other fluids, and fat are grey because they allow most radiation to pass through. Areas where there is nothing to stop the beam of radiation, such as air, or even a fracture, (Harry E. Martz, 2012).

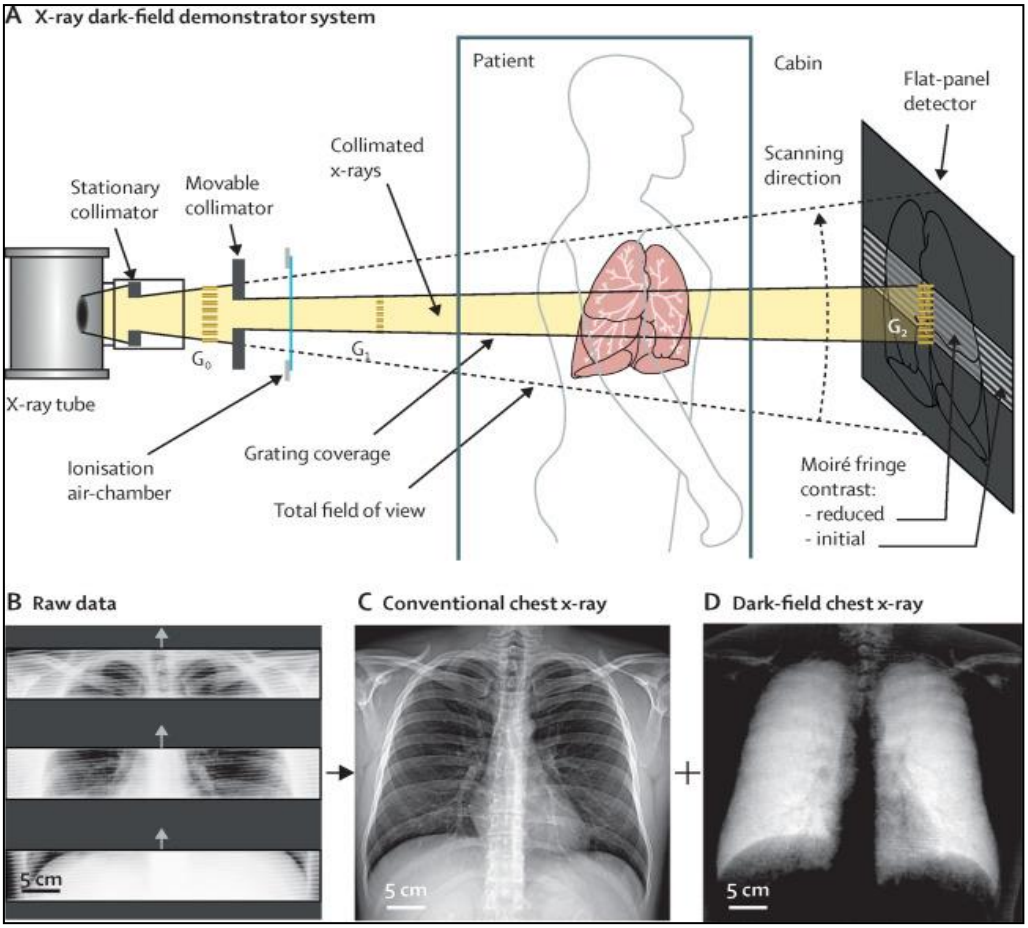

Fig. 2.1: X-ray Imaging

2.5 Risks associate to X-ray technology

Having an X-ray doesn't hurt and isn't particularly dangerous. However, there are a few things to be aware of and discuss with your medical personal provider.

Radiation Exposure

Having frequent X-rays carries a very low risk of developing cancer later in life. That is because the radiation has enough energy to potentially damage DNA.

There are varying estimates as to how significant this risk is. What is known is that fluoroscopy and computed tomography both expose the body to more radiation than a single conventional X-ray. The Food and Drug Administration (FDA) says that the risk of cancer from exposure to X-rays depends on:

- Exposure frequency
- Age at exposure
- Which reproductive organs a person has
- Area of the body exposed

The more times a person is exposed to radiation from medical imaging throughout their life and the larger the dose, the greater the risk of developing cancer. In addition, the lifetime risk of cancer is more significant for someone who's exposed to radiation at a younger age than for a person who has X-rays when they're older.

Studies have shown that those with female reproductive organs are at a somewhat higher lifetime risk for developing radiation-associated cancer. Researchers believe that since reproductive organs absorb more radiation and people with ovaries typically have more reproductive organs than those with testicles, this may be why.

It is essential to weigh the risks and benefits of having an X-ray, CT scan, or fluoroscopy with your healthcare provider. Ask if the imaging study will make an impact on your care. If not, it may be advisable to skip the test. However, if a diagnosis or potential changes in your treatment are likely to depend on the X-ray results, it will most likely be worth the minor risk.

Barium Sulfate Risks

There may be some minor risks associated with contrast mediums used during X-ray procedures, particularly for people who have asthma or other conditions.

Barium sulfate contrast materials are perfectly safe for most people. However, some circumstances can put a person at an increased risk of severe side effects such as throat swelling, difficulty breathing, and more. These include: Having asthma or allergies, which increases the risk of an allergic reaction cystic fibrosis, which increases the risk of small bowel blockage

Severe dehydration, which may cause severe constipationan intestinal blockage or perforation that, could be made worse by the contrast agent contraindications. Pregnant women are usually discouraged from having an X-ray unless it's vital. That's because there is a risk that the radiation from an X-ray could cause changes in developing fetal cells and thereby increase the risk of birth defects or cancer later in life. The risk of harm depends on a fetus's gestational age and the amount of radiation exposure.

That said, this recommendation is mainly precautionary. These risks are associated with very high doses of radiation, and a regular diagnostic X-ray does not expose you to high-dose radiation. Therefore, the benefits of what an X-ray could reveal often outweigh any risks. If you need an X-ray during pregnancy, the following can reduce your risks: Cover with a leaded apron or collar to block any scattered radiation Abdominal X-rays Inform the X-ray technician if you are or could be pregnant. In addition, if you have a child who needs an X-ray, don't hold them during the procedure if you are or might be pregnant. (Ulrich Speck, 2018)

2.6 Radiation Dose Units

What Radiologic Technologists must know about Radiation Dose Units (mGy, mSv). One of the primary responsibilities of a radiologic technologist is to get X-rays images with satisfactory image quality at a radiation dose that is As Low as Reasonably Achievable (ALARA). With this in mind, you must have a good understanding of the basic concepts in radiation dose measurements and the units for measuring radiation dose. (Micheal J.B, Stephen B.V, 2019)

2.6.1 Exposure

Exposure can be thought of like the concentration of x-ray energy per unit area and it is measured in units of Roentgen or the SI units C/kg (Coulomb per kilogram of air). In the context of an x-ray system there are two major knobs we have to change the exposure. The first method to increase the exposure is increasing the mA or increasing the quantity of x-rays generated. If the mA is increased there will be more x-rays passing through a region of fixed size (i.e. more x-rays per mm^2) If we want to change beam quality, i.e. change the energy of the x-rays, we change the kVp (i.e. the tube potential). If we increase the kVp, there will be an increase in the average energy of photons. If the mA is left fixed while the kVp is increase there will be more photons and on average these photons will have higher energy. Under these conditions more energy will be deposited in the patient (i.e. the patient will receive a higher radiation dose).

Energy of x-rays can be measured by passing photons through an ion chamber which has an air filled region between two plates, one positively and one negatively charged. Thus, in an ion chamber there is a difference in electrical potential between the two plates. This potential will pull any charged particles that are generated within the air. If x-rays pass through the air chamber they can ionize the air within the chamber (i.e. knock out electrons from the air molecules). Since electrons are negatively charged they will be attracted to the positive plate in the ion chamber. The higher the radiation dose the more electrons will be attracted to the positive plate. These electrons passing through the positive plate will generate an electrical signal (i.e. an increase in the electrical current in the circuit). The exposure is reported in units of Coulombs per kilogram of air. In this way it is fair to compare the measurements made on a small ion chamber to measurements made with a large ion chamber. The electrical charge is measured in Coulombs and mass of air in the chamber in kilograms. We can calculate the exposure after correct calibration of the device. Therefore, typically we just need to read from the ion chamber. The SI units are nice as they are consistent with other measurement units but in practice we don’t use a chamber that is nearly large enough to use a kg of dry air. In this table we provide the

traditional unit that is named after Roentgen who discovered x-rays.

Table 2.1: The units of exposure1

Traditional Unit	SI Unit
R (Roentgen)	C/kg
1 R	2.58 *104 C/kg
3876 R	1 C/kg

2.6.2 Air KERMA

The exposure is measured by measuring the charge that is deposited on plates from ions produced in air. A related quantity is the Air KERMA (Kinetic Energy Released per unit Mass).

The Air KERMA measures how much energy is deposited in the air due to the radiation, rather than how much charge is deposited in the ion chamber.

The SI units for energy are J and again it is normalized to how much air is in the chamber so the SI units for Air KERMA are J/kg.
Air KERMA can be computed from a calibrated ion chamber as well.

2.6.3 Absorbed Dose

Absorbed dose is a measure of the energy deposited per unit mass of tissue. The SI units are Gray (Gy) which is 1 Joule of energy per kilogram (J/kg). Often, in radiology equipment, we're looking at doses that are much lower than Gray, so we often talk about units of milliGray for instance of 1/1000 of a Gray.

The absorbed dose is different from the exposure in that it is a measurement in a tissue like material and we are interested in the energy absorbed within the material (whereas exposure measures the charge collected).

The traditional unit for measuring the absorbed dose is the rad. In this table we have the conversion between rad and Gy (mGy).

Table 2.2: Units of absorbed dose

Traditional Unit	SI Unit
rad	Gy
100 erg/g	1 J/kg
1 rad	10 mGy
100 rads	1 Gy
100 mrads	1 mGy

Depending on the type of radiology equipment different methods for estimating the absorbed dose may be used. It is not feasible to insert ionization chambers into the body during the exams so estimates of the absorbed dose have been developed.

In mammography the practice is to measure the entrance exposure or air kerma, as discussed above, and use that measurement to estimate the absorbed dose to the breast.

On the other hand, for CT the absorbed dose is measured in tissue like phantoms by inserting ion chambers into the phantom itself during the measurements.

2.6.4 Equivalent Dose

The damage caused by radiation to individuals depends of type of radiation that is incident on the body and the anatomy that is irradiated. In this section we will cover how the type of radiation is accounted for in dose measurement and the associated radiation dose units.

Equivalent dose is calculated by multiplying the absorbed radiation dose by a weighting factor specific to each type of radiation.

The need to have these radiation weighting factors is described in the description of LET and RBE. As different types of radiation have varying biological effects even if the radiation dose is the same.

Table 2.3: The relative weighting factor that converts from Absorbed Dose to Effective Dose

Organ	Tissue Weighting Factor W_T
Gonads	0.08
Red Bone Marrow	0.13
Colon	0.19
Lung	0.16
Stomach	0.12
Breasts	0.12
Bladder	0.04
Liver	0.04
Esophagus	0.04
Thyroid	0.04
Skin	0.01
Bone surface	0.01
Salivary glands	0.01
Brain	0.01

Rest of body	0.12
Total	**1**

Equivalent Dose (Sv) = Absorbed Dose (Gy)*W_R 2.1

For all x-ray Radiography and CT

$W_R = 1$

Equivalent Dose (Sv) = Absorbed Dose (Gy) 2.2

When the dose has been converted to Equivalent dose it is measured in Sieverts (Sv) rather than in Gray(Gy).

Patients may be exposed to other types of radiation with different relative biological impact, for example, alpha radiation, will have more sever effects given the same radiation dose. Thus, the need to track the Equivalent Dose in addition to the physical unit of the Absorbed Dose.

2.6.5 Effective Dose

Not all organs are equally radiosensitive and a means is needed to account for this varied radio sensitivity across organ and tissue types. For instance, hereditary effects are only possible in the gonads when germline cells receive radiation damage so a relatively high weight is given to the gonads.

Additionally, in the somatic (non-germline cells) there is varying radiosensitivity which is directly dependent upon how frequency the different tissue types are reproduced within the body.

For instance bone marrow cells are continuously being reproduced and thus will have a higher sensitivity to radiation. This is also why the a severe Acute Radiation Syndrome is linked to the bone marrow.

Effective Dose (Sv) = $\sum Equivalent\ Dose(Sv) * W_T$ 2.3

If we want to calculate the Effective Dose, we take our Equivalent Dose and then we multiply it by a weighting for each organ that is irradiated. So for each of the organs which is exposed, we have a weighting factor. Multiplying the Equivalent Dose that each organ receives with weighting factor and adding up all of the contributions gives an Effective Dose. The effective dose is an important quantity to understand and it is applicable to estimate potential risk to a large population. However, for a given individual, it is difficult to define the likelihood of harm. (William R. Hendee & Eric C Wilderman)

3.0 MATERIAL AND METHOD

The following materials were used while conducting this research; X-ray Machines, Data Collection Forms, Weight Scale, Height Measurement Device, Calibration Tools, Radiation Protection Equipment, Computer and Software, Statistical Software Package, Utilize statistical software, such as SPSS or Excel, Qualified Research Personnel, Ethical Approval forms and Permissions.

3.1 METHODOLOGY

The consent form from each participant were obtained, and demographic information of patient on the data collection form was recorded and also the record of X-ray tube parameters were taken (kVp, mAs, FSD) from the X-ray unit.

The method applied to investigate the entrance skin dose of a patient undergoing conventional x-ray examination was indirect method. In present work, the Chuan and Tsai formula is applied to calculate the ESD for patients coming to the X-ray radiographic centre. The entire selected samples were mainly from adult patients; men and women.

The formula is given as follows:

$$ESD = c\left(\frac{Kv}{FSD}\right)^2\left(\frac{MAs}{mmAl}\right) \quad 3.1$$

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 obtained data was analyzed using mini-tap software (17)

3.1.2 Data analysis

Descriptive statistics: Calculate the following; Mean, Median, Range, and Standard Deviation for ESD values.

Comparative Analysis: Compare ESD values across different types of convection X-ray examinations and patient subgroups.

Correlation analysis: Identify factors that correlate with ESD values, such as X-ray tube parameters, patient positioning, and body thickness.

Statistical significance: Use appropriate statistical tests to determine the significance of findings

4.0 RESULTS AND DISCUSSION

The study assessed the entrance skin dose (ESD) for adult patients undergoing convection X-ray examination in two diagnostic centres within Sokoto Metropolis. The data of 40 patients were collected, 20 patients from each centre, with the majority being males (65%) and the average age is 45 years. The study included various types of convection X-ray examinations which includes; chest, abdomen, pelvis, and spine examinations. The data collected was analyzed using

mini tab software; Mean, SD, and Third quartile were calculated for each centre. The data collected include weight, height, FFD, FSD, Kv, and MAs, the ESD was calculated using the formula bellow:

$$ESD = c\left(\frac{Kv}{FSD}\right)^2\left(\frac{MAs}{mmAl}\right) \quad 4.1$$

Table 4.0: ESD for Centre A

s/n	Clinical indication	Examination projection	Sex	Age	Weight (kg)	Height (cm)	FFD (cm)	FSD (cm)	Kv	MAs	ESD (mGy)
1	HHDX	Chest	M	20	41	152	150	140	74	12.5	0.3
2	COPD	Chest	M	40	42	155	150	130	80	32	1.1
3	HHDX	Chest	F	55	42	152	180	170	80	16.5	0.3
4	R T A	Ankle	M	16	38	148	90	85	68	8	0.5
5	L B P	Lumbosacral spine	M	66	63	150	100	97	95	80	7.0
6	R T A	Ankle	M	17	39	146	90	87	70	10	0.6
7	L B P	Lumbosacral spine	M	65	64	148	100	95	45	100	2.0
8	L B P	Lumbosacral spine	F	26	38	165	100	97	105	80	8.6
9	L B P	Lumbosacral spine	F	27	37	167	100	95	12	100	14.7
10	D A	Knee	M	30	63	167	80	77	66	10	0.6
11	R T A	Knee	M	32	64	167	80	76	66	10	0.6
12	HR T S	Chest	M	55	64	174.5	100	97	76	16	0.9
13	P.ABD.	Abdominal	F	53	150	100	80	95	95	80	10.4
14	P T B	Chest	F	20	50	160	100	86	74	16	1.0
15	GUN SHOT	Chest	M	27	42	159	100	85	72	12.5	0.8
16	K U B	Abdominal	M	38	65	169	90	79	95	80	10.7
17	RL B P	Lumbosacr	M	40	63	169	100	79	95	80	10.7
18	P T B	Chest	M	56	46	160	100	83	72	12.5	0.8
19	RIBS	Chest	M	57	63	163	150	132	76	16	0.6
20	NECK PAIN	Spinal	F	40	72	150	130	114.5	80	20	0.5

Table 4.0 above present the ESD calculated in centre A which shows that a lumbosacral spine(LS) scan present the highest value of 14.7 mGy and chest scan present with the lowest dose of 0.3 mGy.

Table 4.1: ESD for centre B

S/n	Clinical Indication	Examination Projection	Sex	Age	Weight (kg)	Height (cm)	FFD (cm)	FSD (cm)	kV	MAs	ESD (mGy)
1	METEOSIS	Chest	M	52	40	157	111	93	88	10	0.8
2	HHDX	Chest	F	50	41	150	106	83	75	10	0.7
3	R T A	Leg	F	67	50	157	72	54.5	64	6.4	0.8
4	HEAD ORIF	Head	M	35	67	174	95	67.5	66	8	0.7
5	KNEE	Knee	F	60	90	160	57.7	45	70	12	2.6
6	FAMURE	Famure	F	60	90	160	80	71	75	20	2.0
7	HHDX	Chest	F	20	43	155	118	92	70	10	0.5
8	HEART FALURE	Chest	M	58	96	160	125	92.5	70	10	0.5
9	KNEE	Knee	M	40	60	160	103	74	78	16	1.6
10	HEART FALURE	Chest	M	40	90	22	89	68	66	8	0.6
11	P T B	Chest	M	37	67	30	117	95	70	10	0.5
12	HHDX	Chest	F	35	84	160	85.5	70.5	72	12.5	1.1
13	RIBS	Chest	M	38	72.2	182	120	92	70	10	0.5
14	HHDX	Chest	M	41	59	142	116	80	72	10	0.7
15	BIND RIB	Chest	M	50	45	156	85	65.5	70	10	1.0
16	DRY COUGH	Chest	M	25	45	165	88	69	70	10	0.9
17	LAS	Chest	F	80	41	160	92	72	70	10	0.8
18	PTB	Chest	F	45	27	150	90	77	70	10	0.7
19	ASTHMA	Chest	M	24	90	178	130	112	72	12.5	0.4
20	HHDX	Chest	M	53	64	165	150	132	76	16	0.9

Table 4.1 above present the ESD calculated in centre B which shows that a knee scan present the highest dose of 2.6 mGy and chest scan have the lowest dose of 0.5 mGy.

Table 4.2: Mean, SD and Third quartile for centre A and B

Centers	Mean (min & max)	SD	3rd quartile
Centre A	3.63 (0.30 ± 14.70)	4.71	8.20
Centre B	0.91 (0.4 ± 2.6)	0.60	0.98

Table 4.2 above shows the calculated Mean, Standard Deviation (SD) and Third quartile (3rd Q) value of ESD for the both centers which shows that centre A have the highest dose scan value of 3.63(±4.71) mean and 3rd Q value of 4.71 while centre B present ESD value 0f 0.91(±0.60) with 3rd Q value of 0.98.

Table 4.3: Comparison of the ESD with other Nigeria studies

STUDIES	ESD (mGy) VALUE
Centre A	8.20
Centre B	0.98
Buhari & Bello	0.29
Akpamio et al 2019	0.26
Olama etal 2014	0.54

Table 4.3 above present the comparison of the values of this studies with some Nigeria studies which show that centre A present the highest value and also centre B have higher value than all the literature.

Table 4.4: Comparison of the ESD with established Diagnostic Reference Levels (DRLs)

STUDIES	ESD (mGy) VALUE
Centre A	8.20
Centre B	0.98
E.C 1999	0.40
Nigeria	0.59

Table 4.4, above present the comparison of ESD with the established DRLs which show that the study present the higher value with established DRLs

5.0 DISCUSSION

The data collected were analyzed using mini-tab (17), the assessment of entrance skin dose (ESD) for adult patients undergoing conventional X-ray examinations in Sokoto Metropolis revealed several not worthy findings. Centre A emerged with the highest scan parameters, reflected in elevated values for both kV and milliampere-seconds (mAs). Correspondingly, the calculated ESD values at Center A were the highest among the assessed centres, reaching 14.7mGy. Comparing these results with Nigerian studies, Centre A's ESD values far exceeded the reported averages (8.20mGy). Additionally, Centre B, while lower than Centre A, still surpassed the compared Nigerian studies (0.98mGy). These disparities indicate potential variations in imaging practices, patient demographics, or equipment calibration between the studied centers and the referenced studies.

Furthermore, a comparison with European Commission reference values highlighted that Centre A's ESD values were notably higher than the established international standards. This raises concern regarding compliance with global radiation safety benchmarks and emphasizes the need for corrective measures. The implications of these findings extend to the potential risks associated with higher radiation doses during X-ray examinations. Elevated ESD values may pose health risks to patients, underscoring the importance of optimizing imaging protocols to minimize radiation exposure and prioritize patient safety.

6.0 CONCLUSION

The assessment of entrance skin dose (ESD) for adult patients undergoing conventional X-ray examinations in Sokoto Metropolis is fund 8.20 mGy for centre A and 0.98 mGy in centre B. The study identified Centre A as having the highest scan parameters and ESD values, surpassing both Nigerian studies averages and European Commission reference values. The implications of these findings underscore the urgency for corrective actions to align with international radiation safety standards. Elevated ESD values, particularly at Centre A, may pose health risks to patients, emphasizing the imperative to optimize imaging protocols and prioritize patient safety in radiological procedures.

This study serves as a pivotal call to action for the concern in Sokoto Metropolis. Immediate attention to optimizing scan parameters, implementing robust quality assurance measures, and fostering ongoing training for radiology staff is essential. Collaborative efforts within

the Physicist, along with further research to identify specific contributing factors, are warranted to ensure the delivery of safe and effective conventional X-ray examinations.

REFERENCES

1. Ademola K. A. (2013). Assessment of Entrance Skin Dose in routine X-ray examinations of chest, skull, abdomen and pelvis of children in five selected hospitals in Nigeria. *IOSR Journal of Applied Physics*, *5*(2), 47–50. https://doi.org/10.9790/4861-0524750
2. Ana Cecilia pedrosa de Azevedo, Adelaja Otolorin Osibote, Marcia Cristina BastosBoechat (2006) Survey of doses and frequency of X-ray examinations on children at the intensive care unit of a large reference pediatric hospital, Applied Radiation and Isotopes 64 (2006) pp. 1637-1642
3. Canadian Nuclear Safety Commission (CNSC b), (2012). Introduction to Radiation. Published by the Canadian Nuclear Safety Commission (CNSC). ISBN 978-1-100-21572-3.
4. I. Suliman and E. H. A. Elshiekh (2008). Radiation doses from some common pediatric X-ray examinations in Sudan. Radiation Protection Dosimetry, Vol. 132, No. 1, pp. 64–72.
5. IAEA Tech.Rep. (2007). Dosimetry in diagnostic radiology: an interventional code of practice, Technical Report series No 457 (IAEA) pp: 20-25. IAEA, Vienna.
6. Ibrahim U., Daniel I. H., Ayaninola O., Ibrahim, A., Hamza A. M., Umar, A. M. (2014).
7. Determination of Entrance Skin Dose From Diagnostic X-ray of Human Chest At Federal Medical Centre Keffi, Nigeria. *Science World Journal*, *9*(1), 14–18.
8. ICRP, (1991). *1990 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 60. Ann. ICRP 21.
9. Joseph, D., Igashi, J., Shem, S., Eshiet, P., Yabwa, D., luntsi, G., Mundi, A., Goriya, K., and Joseph, G., (2014). Assessment of Entrance Skin Dose and Image Quality of Chest X- rays in Two University Teaching Hospitals, North East Nigeria. IOSR Journal of Nursing and Health Science (IOSR-JNHS). 3 (6) II: 65-75, ISSN 2320–1959. www.iosrjournals.org.
10. National Aeronautics and Space Administration (NASA), (2014). Types of Radiations in Space. NP-2014-03-001- JSC.www.nasa.gov.
11. National Council on Radiation Protection and measurement (1987). NCRP report No.93," Ionizing Radiation Exposure of the population of the United States" NCRP, Bethesda Maryland.
12. Hendee, W. R., & Heyer, E. R. (2000). Medical physics and radiation protection for technologists. John Wiley & Sons, Inc. p. 222.
13. National Institute of Biomedical Imaging and Bioengineering. (2017). X-ray fact sheet. https://www.nibib.nih.gov/sites/default/files/Xray%20Fact%20Sheet%202017_0.pdf
14. National Institute of Biomedical Imaging and Bioengineering (NIBIB). (2023, July 20). X-rays.
15. American College of Radiology. (2023). X-rays: What to expect. Retrieved from https://www.radiologyinfo.org/en.
16. National Cancer Institute. (2020, May 14). Radiation risks from medicalimaging. https://dceg.cancer.gov/research/what-we-study/medical-radiation-exposure.
17. Brink, J. A., & Sibata, C. H. (2009). Cone-beam computed tomography (CBCT) imaging in dentomaxillofacial radiology: An overview. Imaging Science in Dentistry, 39(2), 52-68. https://pubmed.ncbi.nlm.nih.gov/32501720/
18. Patel, S., & Karellas, A. (2014). Cone beam computed tomography in oral and maxillofacial surgery: A review of the literature. Journal of Oral and Maxillofacial Surgery, 72(10), 1980-1992. https://pubmed.ncbi.nlm.nihAuthor: Wikipedia(2023) .
19. A Synopsis of Radiology by Fred Gelderen (Springer, 2012). X-Ray Imaging: Fundamentals, Industrial Techniques and Applications by Harry E. Martz, Clint M. Logan, Daniel J. Schneberk, and Peter J. Shull (CRC Press, 2013). (Chapter 2, pages 13-42).
20. The Physics of Radiology and Imaging by K.R. Thwaites (IOP Publishing, 2008). (Chapter 3, pages 43-72).
21. Diagnostic Radiology by Helmut Ricke, Ulrich W. Thomann, and Matthias Weisser (Springer, 2016).(Chapter 1, pages 1-10).X-Ray Contrast Media by Ulrich Speck (Springer, 2018).
22. The Science and Practice of Radiotherapy by Michael J. Bronskill, Stephen B. Vines, and Timothy J. Webb (Cambridge University Press, 2019). Chapter 2, pages 20-35).
23. Radiation Oncology: A Practical Approach by William R. Hendee and Eric C. Wilderman (Cambridge University Press, 2016). (Chapter 3, pages 30-45)