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ESTIMATION OF ENTRANCE SKIN DOSE AND EFFECTIVE DOSE OF PATIENTS UNDERGOING X-RAY EXAMINATIONS USING MATHEMATICAL MODELS

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Abstract

The aim of the current work was to estimate entrance skin dose (ESD) using mathematical models for selected X-ray examinations at Federal Teaching Hospital (FTH) Gombe. Effective dose (ED) was also calculated. At the beginning, the patient's information's such as age, weight and height was recorded and then the patient was centered by technician 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) was recorded at the time of the examination. This information's was recorded for each patient undergoing the particular diagnostic procedure. A total number of 374 patients were examined at FTH Gombe. The mean calculated ESD values for Chan & Tsai, Edmond, Kumar and Arun models were found to be in the ranging between 0.02 - 4.60 mGy, 0.03 – 6.37 mGy, 0.01 – 3.65 mGy and 0.02 – 6.10 mGy respectively. For the EDs values for Chan & Tsai, Edmond, Kumar and Arun models were found to be in the ranging between 0.02 – 0.22 mSv, 0.03 – 0.28 mSv, 0.03 – 0.23 mSv and 0.04 – 0.35 mSv receptively. In the current work, the calculated mean ESD for Chest AP, Chest PA, Chest LAT, Pelvis AP, LSS AP, LSS LAT, Abdomen AP, C. Spine AP and C. Spine LAT are; 0.36, 0.51, 1.33, 1.24, 2.85, 4.60, 1.93, 0.49 and 0.42 mGy respectively. The calculated mean EDs for Chest PA, Chest LAT, Abdomen AP, Pelvis AP, LSS AP and LSS LAT are; 0.023, 0.08, 0.16, 0.073, 0.17 and 0.27 mSv respectively. On the basis of the current results obtained in this study, it implies that the radiation risk to an average patient in the hospital is low and the risk to workers in the hospital is also low.

Keywords: Entrance Skin Dose, Effective Dose, Mathematical Models, Patient, dosimeter.

1.0 INTRODUCTION

Diagnostic X-ray examinations play an important role in the health care of the population in Nigeria and worldwide. These examinations may involve significant irradiation of the patient and probably represent the largest man-made source of radiation exposure for the population. Radiation has been long known to be harmful to humans. The radiation exposure received in X-ray examinations is known to increase the risk of malignancy as well as, above a certain dose, the probability of skin damage and cataract. The biological effect of radiation depends on the total energy of radiation absorbed (in joules) per unit mass (in kg) of tissue or organ. This quantity is called absorbed dose and is expressed in Gray (Gy) [1].

If a patient is exposed to an X-ray beam, some X-ray photons will pass through the patient without any interaction, and therefore will produce no biological effect. On the other hand X-ray photons which are absorbed may produce effects.

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Absorbed dose of radiation can be measured and/or calculated and form basic evaluation of the probability of radiation induced effects. In evaluating biological effects of radiation after a particular exposure of the body, further factors such as the varying sensitivity of different tissues and absorbed doses to different organs have to be taken into consideration. To compare risks of partial and whole body irradiation in diagnostic radiology effective dose is commonly used, and is expressed in Sievert (Sv) [1].

The need for standardization of radiation exposure and guidance levels for various radiographic examinations has also been proposed by the International Atomic Energy Agency (IAEA) as a safety standard [2]. The guidance levels by IAEA are based on European studies. Several guidelines and dose reference levels were also published by number of international organizations and was summarized by ICRP [3]. These guidelines have stimulated worldwide interest in patients' doses and several major dose surveys have been conducted [4, 5, 6].

Patient dose has often been described by the entrance skin dose (ESD) as measured in the Centre of the X-ray beam. Because of the simplicity of its measurement, ESD is considered widely as the index to be assessed and monitored. ESD is measured directly using Thermo luminescence Dosimeter (TLD) placed on the skin of the patient or indirectly from the measurements of dose-area product using a large area Transmission Ionization Chamber (TIC) placed between the patient and the X-ray tube.

The use of TLD method in ESD assessment is a time consuming process. TLD technique requires prolonged annealing and reading process. Furthermore, the use of TLD technique requires special equipment's and thorough calibration facilities which may not be available in most X-ray departments. On the other hand TIC method does not provide direct measurement of skin dose and mathematical equations are needed to convert TIC reading into Skin dose.

Because of the limitations associated with both TLD and TIC, several mathematical equations have been suggested to relate skin dose to the used exposure factors such as the applied Milliampere second (mAs), surface to skin distance (SSD), filtration, field size, output, and the applied kilo to peak voltage(kVp). These equations provide an easy and more practical means of estimating skin dose even before exposure. They also provide the easiest and cheapest technique that can be employed in any kind of patient dose survey or audit. Despite the attractive nature of the calculation methods of patient dose, one should make sure that the used X-ray equipment has an adequate quality control (QC) protocol that ensures the accuracy of the measured exposure factors.

Although ESD may be sufficient for quality control measurements where the stability of the X-ray equipment is often of concern, the entrance dose is not sufficient for comparison or evaluation of actual patient dose and associated risk. If the risk involved in an X-ray examination is to be estimated, ESD is not sufficient and patient dose needs to be described by other quantity that is more directly related to radiation effect. At present, it is considered that radiation-induced effect can be assessed by virtue of the radiation doses in different organs or tissues in the body [7]. Such data (organ dose) cannot be measured directly in patients undergoing X-ray examinations, and are difficult and time consuming to be obtained by experimental measurements using physical phantoms [1].

One way of estimating internal dose of a patient is the percentage depth dose method. Percentage depth dose is defined as the ratio of the absorbed dose at a certain depth to the dose at a reference depth (usually skin dose) [8]. Percentage depth dose is usually measured using a water phantom and ionization chamber. The dose is measured at the surface of the phantom and at various depths within the phantom. The percentage depth doses at various depths are then calculated. Patient's organ dose is then calculated from the knowledge of the organ depth and the previously calculated percentage depth [8].

Medical X-ray exposures are the largest man-made source of population exposure to ionizing radiation in many countries. Although information on medical exposure is already incorporated into national legislative documents, in Gombe there is no data on the assessment of patient's entrance skin dose (ESD) and the health risk from conventional radiography in daily clinical practice. With the information obtained, it will provide guidance on where efforts on dose reduction will need to be directed to fulfill the requirements of the optimization process and serve as a reference for future work, as well as provide information for comparison with patients of the same category in other countries.

Most of the radiographic center in Nigeria do not apply diagnostic reference levels, use same exposure factors to patients without using base line of practice. And provides different values of doses from conventional X-ray. Diagnosis X-ray radiation safety is key in medical examination. The quantity of patient radiation doses is beneficial for radiation protection of the patient. Radiation protection is concerned with the control of the manner in which sources of ionizing radiation are used so that the user of the sources and also members of the public are not irradiated above acceptable levels recommended by the International Commission on Radiological Protection (ICRP).Based on the needs for knowledge of the doses absorbed by patients and the consequences of the absorbed doses, National Occupational Health and safety Commission indicated that dose assessment of employee and members of the public are required, and appropriate to ensure compliance with recommendation. Directives from regulatory bodies stipulate that radiation should be measured in every hospital and compared to the reference doses established by the competent authorities. Although, diagnostic imaging using X-rays produces a net benefit, the potential for radiation-induced injury to the patients exist. As a result, understanding of absorbed doses and the factors that affect them therefore are very important.

The aim of this work is to estimate the entrance skin dose and effective dose of patients undergoing X-ray examination using mathematical models.

2.0 MATERIAL AND METHODS

2.1 Research design

This study was adopted using across sectional prospective design. Research ethics committee of the Federal Teaching Hospital (FTH) Gombe was sought to give the ethical approval for this study before data collection commencement.

2.1.1 Source of data and location of study

The Federal Teaching Hospital Gombe was the place where the data that was used in this research was sourced from. The location of the hospital is in Gombe, the capital of Gombe State. The latitude of hospital is 10^0 within the Sahel savannah belt.

2.2 SAMPLE SIZE

The samples of 374 patients undergoing routine X-ray examination at FTH Gombe were considered for this study. The entire selected samples were mainly from adults: men, women and included few cases for children.

2.3 EQUIPMENT AND MATERIAL

The machine that was used in this study is an X-ray machine, a floor mounted three phase at the FTH Gombe. The X-ray equipment technical specifications are given in the Table 2.1.

Table 2.1: Technical specifications of the X-ray equipment used.

Manufacture	G.E Huanland Medical System
Model	XR – 6000
Year of manufacture	July, 2009
Year of Installation	2010
Inherent filtration	1.3 mm Al
Total filtration	1.3 mm Al
Anode type	Rotation
Processor type	Automatic
Phase type	3 phase

2.4 DATA COLLECTION

At the beginning, the patient’s data such as age, weight and height were recorded and then the patient was centered by technician to be ready for radiographic. The parameters such as peak tube voltage (kVp), exposure current, time product (mAs) and focus to skin distance (FSD) were recorded at the time of the examination.

2.5 CALCULATION OF ENTRANCE SKIN DOSE (ESD)

Entrance skin dose (ESD) values were calculated using different models proposed by different authors. Four different models for calculating were used because they depend on parameters that were known from the exposure parameters, the quality control data or from modeling of published data. The following are the models examined:

2.5.1 The Chan and Tsai Model

This model is represented mathematically by

$$ESD\ (mGy) = c\left(\frac{kVp}{FSD}\right)^2\left(\frac{mAs}{mm.\ Al}\right) \quad (2.1)$$

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 in mm) represents the measured distance between X-ray tube and patient part being exposed to X-rays. Al gives minimum inherent filtration Aluminum equivalent and c is constant which is equal to 0.2775.

2.5.2 The Edmonds Model

Edmonds demonstrated that the X-radiation dose to patients from diagnostic X-ray machines assume a simple functional dependence on radiographic exposure

$$ESD\ (\mu Gy) = \frac{836\ (kVp)^{1.74}}{(FSD)^2}\ mAs\ \left(\frac{1}{T} + 0.114\right) \quad (2.2)$$

where T is the total filtration which includes the inherent and the added in mm Al. The model does not account for the output of the machine and BSF.

2.5.3 The Kumar Model

This model is represented by the following equation

$$ESD\ (mGy) = \frac{0.00867\ \times (kVp)^{2.749}\ \times mAs}{(FSD)^2 \times P \times T} \quad (2.3)$$

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, T gives minimum inherent filtration Aluminum equivalent and P = 1 for three phase machine.

2.5.4 The Arun Model

Here Arun model is defined by the following equation:

$$ESD\ (mGy) = \frac{0.0129 \times (kVp)^{2.558} \times mAs}{(FSD)^2} \quad (2.4)$$

Where all the parameters are as defined in equation (2.3)

2.6 CALCULATION OF EFFECTIVE DOSE

Before effective dose is calculated, we need to calculate equivalent dose first to know the degree of damage in specific tissue. Equivalent dose (H) is the multiplication of the absorbed dose (D) by the quality factor (Q) which reflects the ability of a particular type of radiation to cause damage in tissues and is given by:

$$H = D \times Q \quad (2.5)$$

It has also been noted that different tissues have different susceptibilities to radiation, so in order to take this into consideration the effective dose was introduced by adding different weighting factors for different organs. The summation of equivalent dose multiply by the organ weighting factor is called effective dose and is given by:

$$ED\ (mSv) = \sum W_T\ H_T \quad (2.6)$$

Where W_T is a weighting factor represents the relative contribution of that tissue to the total detriment resulting from uniform irradiation of the whole body and H_T is the dose equivalent in tissue.

3.0 RESULTS AND DISCUSSION

3.1 Results

The anthropometric characteristics of the patient's information such as age, weight and height and technical parameters such as kVp, mAs and the distance from the X-ray machine to the skin of the patient's (focus to skin distance (FSD)) were entered into a capture sheet for each type of examinations. The mean values of patient's information and technical parameters were calculated and results presented in Table 3.1. 374 patients both male and female were examined. The mean values of the age, weight and height of the patients were ranges from 28.26 – 53.13 years, 63.78 – 90.42 kg and 108.6 – 165.00 cm respectively. The mean technical parameters values: kVp, mAs and ESD were ranges from 44.14 – 93.90, 1.43 – 150 and 111.0 – 167.8 cm respectively.

The data obtained from patients information and technical parameters shown in Table 3.1, were used to calculate ESD (mGy) with the help of the models given in [9, 10, 11, 12] respectively. The results are presented in Table 3.2 along with the mean values.

Table 3.1: Mean values of exposure parameters and Patients in formations.

Diagnostic type	view	No. of patients	Patient age (year)	Weight (kg)	Height (cm)	FSD (cm)	Mean kVp	Mean mAs
Chest	AP	5	56.24	71.74	120.31	115.6	93.90	4.54
	PA	73	42.55	77.92	116.85	120.9	108.8	5.02
	LAT	27	46.84	70.04	121.75	167.8	130.0	15.60
Abdomen	AP	26	43.20	72.92	115.00	130.3	75.40	50.69
Pelvis	AP	20	45.00	73.60	120.90	116.7	72.20	28.62
	LAT	3	53.13	78.29	122.73	112.3	70.85	27.28
KUB	AP	32	48.6	84.81	118.54	113.6	75.90	52.39
LSS	AP	25	47.64	82.24	121.92	118.8	73.80	65.25
	OBL	2	45.36	70.22	118.33	110.9	80.09	27.29
	LAT	15	39.50	82.66	114.62	114.5	85.04	70.95
Humerus	AP	6	33.28	77.83	117.81	112.1	60.13	4.78
	LAT	3	47.58	76.95	133.49	116.8	61.62	3.50
C. spine	AP	17	45.41	82.67	117.64	120.9	62.13	13.17
	LAT	11	43.40	84.65	136.81	119.2	65.42	12.68
Knee	AP	15	46.30	73.22	115.76	117.4	62.92	4.72
	LAT	6	42.60	83.12	118.46	115.0	60.76	3.80
Foot	AP	5	37.82	82.33	117.71	113.8	62.49	1.92
	LAT	2	48.36	81.9	125.00	111.0	56.35	1.84
	OBL	6	43.83	80.54	110.04	112.5	58.36	2.20
Femur	AP	6	40.26	90.42	123.3	116.2	65.89	20.13
	LAT	3	42.22	68.85	132.94	118.4	73.84	25.82
Dorsal Spine	AP	9	40.24	66.77	120.55	112.1	72.90	41.53
	LAT	8	37.88	68.00	124.21	114.2	76.91	82.27
	Spot	1	37.00	66.00	120.00	106.00	60.00	150.0
Shoulder	AP	5	42.00	83.00	127.08	136.6	65.70	15.85

Table 3.1: Continued…

Diagnostic type	View	No. of patients	Patient age (year)	Weight (kg)	Height (cm)	FSD (cm)	Mean kVp	Mean mAs
Wrist	AP	4	43.80	85.72	118.60	116.3	46.55	1.91
	PA	1	38.00	70.00	117.00	111.0	50.00	2.00
	LAT	7	38.54	70.64	121.39	117.5	47.87	2.10
	OBL	5	32.63	81.2	108.60	108.6	46.31	1.68
Hand	AP	3	31.54	74.68	118.10	116.9	45.16	1.43
	PA	1	36.00	70.34	125.00	114.0	51.00	2.00
	LAT	6	35.00	63.78	123.61	112.2	44.14	1.78
	OBL	2	36.82	80.90	115.00	111.5	54.18	1.60
Ankle	AP	5	28.26	86.28	113.88	114.6	52.32	2.97
	LAT	1	30.00	71.00	106.00	112.5	54.00	2.00
	OBL	1	43.00	82.00	123.00	111.6	58.00	3.00
Leg	AP	1	45.00	85.00	96.00	119.0	62.00	3.00
	LAT	2	38.00	80.20	165.00	116.4	63.25	2.38
Elbow	AP	3	36.62	78.63	125.57	113.2	55.29	1.86
	LAT	1	39.00	81.00	158.00	113.2	56.00	2.00

Table 3.2: Mean value of entrance skin dose (mGy) calculated with different models.

Diagnostic type	View	Chan & Tsai [9]	Edmond [10]	Kumar [11]	Arun [12]	Mean
Chest	AP	0.29	0.35	0.32	0.49	0.36
	PA	0.38	0.46	0.49	0.72	0.51
	LAT	1.16	1.01	1.31	1.83	1.33
Abdomen	AP	1.62	2.10	1.54	2.44	1.93
Pelvis	AP	1.05	1.38	1.00	1.54	1.24
	LAT	1.04	1.38	1.00	1.51	1.23
KUB	AP	2.23	2.90	2.14	3.38	2.66
LSS	AP	2.40	3.16	2.25	3.58	2.85
	OBL	1.89	1.75	1.36	2.12	1.78
	LAT	3.75	4.73	3.91	6.02	4.60
Humerus	AP	0.13	0.18	0.11	0.17	0.15
	LAT	0.10	0.13	0.10	0.13	0.12
C. spine	AP	0.34	0.99	0.27	0.45	0.49
	LAT	0.37	0.49	0.31	0.51	0.42
Knee	AP	0.13	0.18	0.11	0.18	0.15
	LAT	0.11	0.14	0.10	0.14	0.12
Foot	AP	0.06	0.07	0.05	0.08	0.07
	LAT	0.05	0.06	0.03	0.06	0.50
	OBL	0.06	0.08	0.04	0.07	0.06
Femur	AP	0.62	0.84	0.53	0.86	0.71
	LAT	1.00	1.26	0.90	1.43	1.15
D. Spine	AP	1.68	2.21	1.56	2.48	1.98
	LAT	3.57	4.63	3.03	5.43	4.16
	Spot	4.60	6.37	3.65	6.10	5.18
Shoulder	AP	0.35	0.47	0.30	0.49	0.40
Wrist	AP	0.03	0.04	0.02	0.03	0.03
	PA	0.03	0.05	0.02	0.04	0.04
	LAT	0.04	0.05	0.02	0.04	0.02
	OBL	0.03	0.04	0.02	0.03	0.02

Table 3.2: Continued…

Diagnostic type	view	Chan & Tsai [9]	Edmond [10]	Kumar [11]	Arun [12]	Mean
Hand	AP	0.02	0.03	0.01	0.02	0.02
	PA	0.03	0.04	0.02	0.03	0.03
	LAT	0.03	0.04	0.02	0.03	0.03
	OBL	0.02	0.05	0.02	0.05	0.03
Ankle	AP	0.06	0.08	0.04	0.07	0.06
	LAT	0.05	0.06	0.03	0.06	0.05
	OBL	0.05	0.07	0.04	0.07	0.06
Leg	AP	0.07	0.09	0.06	0.09	0.08
	LAT	0.07	0.09	0.06	0.09	0.08
Elbow	AP	0.04	0.06	0.03	0.05	0.05
	LAT	0.05	0.06	0.03	0.06	0.05

3.2 DISCUSSION

Table 3.3 compares the mean values of calculated ESDs (mGy) with corresponding values reported in the other studies such as NRPB [13], Iran [14] , ICRP, [3]; Malaysia[6] , Estonia [15], UK [16] and China[17] respectively.

Table 3.3: Compares the mean ESD (mGy) results of the current work with those conducted in other countries or recommended by different scientific organizations.

Projection	Current work	Iran [14]	Estonia [15]	China [17]	Malaysia [6]	UK [16]	ICRP [3]	NRPB [13]
Chest AP	0.36	0.74	**	**	**	0.14	**	**
Chest PA	0.51	0.67	0.31	0.34	0.28	0.15	0.30	0.18
Chest LAT	1.33	**	0.9	1.54	1.4	0.85	1.5	0.99
Pelvis AP	1.24	2.98	3.90	2.65	8.41	3.60	10.4	**
LSS AP	2.85	4.85	6.4	5.18	10.56	5	10.5	7.68
LSS LAT	4.60	5.68	10.7	10.53	18.6	11.7	10.5	19.7
Abdomen AP	1.93	2.56	**	3.71	10	11.7	10.5	6.68
C. Spine AP	0.49	1.48	**	0.28	1.02	**	**	**
C. spine LAT	0.42	1.68	**	0.36	1.6	**	**	**

Note: ** indicate data not available.

For the Chest AP scan, the mean calculated ESD (0.36 mGy) in the current work was less than that of Iran. The lower ESD found in the current work compared to that for Iran survey can be attributed to the lower mAs found in the current work compared to that found in Iran (4.54 versus 31). But the mean calculated ESD in the current work was higher than that of UK [16] . The higher ESD found in the current work compared to the UK survey can be attributed to the high kVp found in the current work compared with that found in the UK survey (93.9 versus 76).

For the chest PA scan, the mean calculated ESD (0.51 mGy) in the current work was less than that measured in Iran, but was higher than measured in Estonia, China, Malaysia, UK, ICRP and NRPB.

The higher ESD found in the current work compared to Malaysian and UK survey can be attributed to the high kVp used in this work (108 kVp against 79 and 85 kVp respectively).

For the chest LAT scan, the mean calculated ESD (1.33 mGy) in the current work was less than that measured in China and ICRP and pretty close to that measured in Malaysia, but was higher than that measured in Estonia, UK and NRPB. The higher ESD found in the current work compared to the survey made in UK can be attributed to the high kVp (130 versus 98 kVp).

For Pelvis AP scan, the mean calculated ESD (1.24 mGy) in the current work was less than measured in other countries. The lower ESD found in the current work compared to that for Iran, UK and Malaysia surveys can be attributed to the lower mAs used in this work (28 versus 61, 35 and 40 respectively).

For LSS AP scan, the mean calculated ESD (2.85 mGy) in the current work was much less than measured in other countries.

For LSS LAT scan, the mean calculated ESD (4.60 mGy) in the current work was much less than measured in other countries. The lower ESD found in this work compared to that of Iran, UK and Malaysia surveys can be attributed to the lower mAs values (28 versus 84, 79 and 79 respectively).

For Abdomen AP scan, the mean calculated ESD (1.93 mGy) in the current work was much less than measured in other countries.

For C. Spine AP scan, the mean calculated ESD (0.49 mGy) in the current work was a slightly higher than that measured in China, but is less than that measured in Malaysia and Iran.

For C. Spine LAT scan, the mean calculated ESD (0.42 mGy) in the current work was close to that measured in China, but less than that measured in Malaysia and Iran.

Table 3.4, compares the calculated mean Effective doses (EDs) values for all the models used.

When comparing the mean calculated ED values for Chest PA scan it shows that Chan & Tsai model was less than other models used while Edmond and Kumar models are the same. But Arun model is higher than the other models used. The mean calculated ED for all the models used in the current work for Chest PA was found to be 0.023 mSv.

For Chest LAT, the mean calculated ED values of the Chan & Tsai and Kumar models are in agreement while Edmond models is less than the other models values. But Arun model is higher than the other models used. The mean calculated ED for all the models used in the current work for Chest LAT was found to be 0.08 mSv.

For Abdomen AP, the mean calculated ED values of the Chan & Tsai and Kumar models are in agreement. But Arun model values are is higher than those obtained using other models. The mean calculated ED for all the models used in the current work for Abdomen AP was found to be 0.16 mSv.

For Pelvis AP, the mean calculated ED values of the Chan & Tsai and Kumar models are in agreement. Edmond and Arun models gave also values in close agreement. The mean calculated ED for all the models used in the current work for Pelvis AP was found to be 0.073 mSv.

For LSS AP, the mean calculated ED value of the Chan & Tsai and Kumar models are in closer in agreement. But Arun model gave higher value. The mean calculated ED for all the models used in the current work for LSS AP was found to be 0.17 mSv.

For LSS LAT, the mean calculated ED values of the Chan & Tsai and Kumar models were found in closer agreement. But Arun model gave higher value. The mean calculated ED for all the models used in the current work for LSS LAT was found to be 0.27 mSv.

Table 3.4: Mean value of effective dose (mSv) calculated with different models.

Examination	Chest PA	Chest LAT	Abdomen AP	Pelvis AP	LSS AP	LSS LAT
Chan & Tsai	0.02	0.07	0.13	0.06	0.14	0.22
Edmond	0.03	0.06	0.17	0.08	0.19	0.28
Kumar	0.03	0.07	0.13	0.06	0.13	0.23
Arun	0.04	0.12	0.20	0.09	0.21	0.35
Mean	0.023	0.08	0.16	0.073	0.17	0.27

Table 3.5 compares the calculated mean Effective doses EDs (mSv) of the current work with corresponding values reported in other studies; Iran[18], UK[16] and UNSCEAR, reference doses[19].

Table 3.5: Comparison of mean calculated EDs (mSv) values with that of other countries.

Countries	Chest PA	Chest LAT	Abdomen AP	Pelvis AP	LSS AP	LSS LAT
Current work	0.023	0.08	0.16	0.073	0.17	0.27
Iran	0.04	0.10	0.28	0.28	0.23	0.13
UK	0.014	0.038	0.43	0.28	0.39	0.21
UNSCEAR	0.05	0.20	0.80	1.00	1.20	1.20

From Table 3.5, Comparing the calculated mean ED values applied in this study for chest PA projection (0.023mSv) with the guide levels of UK revels that the ED of the current work is above the guide levels of UK (0.014 mSv). However, the calculated mean ED for chest PA scan was found to be less than those of Iran (0.04 mSv)) and UNSCEAR (0.05 mSv). Similarly, when comparing the results of the current work for chest LAT scan (0.08 mSv) with that of UNSCEAR (0.20 mSv), our calculated ED were found to be less than that of UNSCEAR. Also when comparing the current ED for chest LAT with that of UK (0.038 mSv), it was found to be above that of UK.

When comparing the calculated mean ED values for Abdomen AP in the current work (0.16 mSv) for that of Iran (0.28 mSv), UK (0.43 mSv) and UNSCEAR (0.80 mSv), our calculated ED was found to be less than that of Iran, UK and UNSCEAR. Also, the ED values of Iran, UK and UNSCEAR for Pelvis AP scan (0.073 mSv) were found higher than this work values.

Comparing the results of the current work for LSS AP scan (0.17 mSv) with that of Iran (0.23 mSv), UK (0.39 mSv) and UNSCEAR (1.20 mSv), the calculated ED values were found to be less. But when comparing the calculated mean ED values applied in this study with the guide levels of Iran and UK for LSS LAT scan (0.27 mSv) our calculated ED were found to be above these guide levels.

4.0 CONCLUSION

Dose monitoring helps to ensure that the best possible protection of the patient is maintained at all times and provides an immediate indication of incorrect use of technical parameters or equipment malfunction. During diagnostic X-ray, the kVp and mAs are very important parameters which control the quality of X-ray picture. The calculated ESD in the current work was found to be (in general) less than that published in other countries. The high dose found in Chest PA (0.51 mGy) which is higher that recommended by ICRP need be reduced. It was noted that apart from Edmond model for calculated mean ESD with ranges from 0.03 – 6.37 mGy, the other models' values compared well with other countries or with recommended values given by different scientific organizations. It was also noted that Kumar model for calculated ESD ranging from 0.01 – 3.65 mGy was superior to Chan & Tsai, Edmonds, and Arun models.

The results of ED follow the same pattern as that of ESD. The EDs for Arun model ranging from 0.04 – 0.35 mSv is higher than that of other models used. While Chan & Tsai model with values ranging from 0.02 – 0.22 mSv is lower than the other models used. The mean calculated EDs for Chest PA (0.023 mSv) and LSS LAT (0.27 mSv) was higher than that found in UK which shows that the patients in the current work has the high risk than those in the UK. But for the rest of the EDs they are lower than the reference level.

On the basis of the current results obtained in this study, it implies that the radiation risk to an average patient in the hospital is low and the risk to workers in the hospital is generally low. The use of the proper radiological parameter such as the large distance between patients and X-ray source, high tube potential and low tube current can significantly reduce the absorbed dose. It also demonstrated that using the results from the factors that contribute to the patient dose to estimate the entrance dose could be an alternative reliable and cheap method for patients dose monitoring in the everyday routine of a diagnostic radiology department.

5.0 RECOMMENDATIONS

Due to the high universal demand of chest X-rays request and the important role of this test in patient's cumulative doses, specific strategies must be adopted to reduce dose imparted on patients.

The ALARA (As Low as Reasonable Achievable) principle should be used when carrying out X-ray activities.

Training of personal and consistency in quality assurance program will go a long way in reducing the radiation doses received by the patients.

Further studies are required in other radiographic centers within Gombe in order to optimize radiation dose and establish local diagnostic reference level (DRL).

Estimation of entrance skin dose for patients undergoing Computed Tomography (CT) should be carried out.

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