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Correlation Between Entrance Surface Doses and Body Mass Index (BMI) for Students Undergoing Chest X-Ray Examination, at Olabisi Onabanjo University Clinic

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ABSTRACT
The campus environment is a congregation of students from all over the nation, and the possibility of transmission of contagious diseases such as tuberculosis cannot be ruled out; hence, it is compulsory for all newly admitted students to undergo chest X-ray examination. In this study, the correlation between the entrance surface dose (ESD) and body mass index (BMI) has been investigated. The anthropometric /biodata parameters, such as age, weight, height, and radiographic parameters such as tube voltage (kV), tube current (mAS), and film focus distance (FSD) were collected for 500 students at the clinic. A model equation was used to estimate the entrance surface dose (ESD). Statistical Package for Social Sciences was used to establish the relationship between the radiographic parameters and the body mass index for the newly admitted students. The result of the study shows that the estimated entrance surface dose ranged from 0.02 – 0.63) mGy, with a mean of 0.09 mGy. The tube voltage and the mAs ranged from (68 – 74) kV with the mean of 71kV and (10–30) mAs with the mean of 20 mAs, respectively. The mean of the estimated entrance surface dose for the present study is lower than the diagnostic reference level (DRL) recommended by the International Atomic Energy Agency (IAEA) and the National Radiation Protection Board (NRPB) with values of 0.40 mGy and 0.30 mGy, respectively. A fair correlation with a value of 0.544 exists between the BMI and the entrance surface dose estimated for the study. In conclusion, the chest X-ray examination carried out in the University clinic is within the safe limit; the management may offer their services to the public so as to increase their internally generated revenue (IGR) of the University.

Keywords:
Correlation,
Entrance Surface Dose,
Body mass index,
Chest X-ray examination.

INTRODUCTION

X-rays are a widely used diagnostic tool in modern medicine, providing valuable imaging for a variety of conditions. Chest X-rays are among the most common types of radiographic examinations performed, providing clinicians with important information about the lungs and heart. Medical applications of ionizing radiation are defined as the second source of exposure to man after the natural sources of radioactivity (Schauer and Linton, 2009). However, exposure to ionizing radiation carries potential health risks, including the development of cancer and genetic mutations (National Research Council [NRC, 2006). In order to minimize these risks, it is essential to measure and monitor the radiation dose received by patients during X-ray examinations. There is a practice by some radiographers, parameters such as the tube voltage and current adopted during chest X-ray shots are simply selected based on the physical appearance of the students. There seems to be no direct transfer of students' anthropometric records between the records and X-ray departments before taking the X-ray. Such selections of radiographic parameters based on only physical observations may not be completely free from human error and possibly administering tube voltages that may not be appropriate for the patient. Chest X-ray examination is very important for newly admitted students into the University, since many are in the practice of squatting in their hostels, which may be congested and also possible congestion in some lecture rooms may not be completely ruled out. The entrance surface dose (ESD) is a measure of the radiation dose received by a patient at the skin surface. The ESD is an important parameter for assessing the radiation dose received by patients and estimating the potential risk of radiation-induced health effects, as recommended by the International Atomic Energy Agency (IAEA, 2017). It is typically measured using a dosimeter placed on the skin surface at the point of X-ray beam entry (IAEA, 2017). The ESD can vary depending on several factors, including the type of X-ray machine used, exposure parameters, patient size, and thickness of the body part being examined (Aliasgharzadeh et al., 2015). While the risk of radiation-induced cancer is relatively small, it is not zero, and it is important to minimize radiation exposure whenever possible (Brenner & Hall, 2007). Radiation protection measures are used to minimize the risks associated with ionizing radiation exposure in medical imaging. These measures include justification of the examination, optimization of the examination parameters, and use of shielding and protective clothing (IAEA, 2017). Justification of the examination ensures that the benefits of the examination outweigh the potential risks. Optimization of examination parameters involves adjusting the exposure settings to minimize the radiation dose while still achieving the necessary diagnostic information. Shielding and protective clothing are used to reduce the amount of radiation exposure to staff and patients. There have been several studies on the investigation of the ESD for chest X-ray examinations. One study measured the ESD for chest X-rays using thermoluminescent dosimeters (TLDs) in 150 patients and found a mean ESD of 0.23 mGy (Maaruf *et al.,* 2022). While these studies provide valuable information about the typical ESD for chest X-rays, there is little information available about the ESD specifically for newly admitted students undergoing chest X-rays in many Universities. The present study is a case study for students admitted into Olabisi Onabanjo University, Ago-Iwoye. To the best of the knowledge of the researcher, there has been no study of such in the University. The study is quite important because it attempts to investigate the safety level of the dose administered during the chest X-ray examination for the students, and it can serve as a baseline for further study in the X-ray department of the University Clinic.

MATERIALS AND METHODS

Description of the Study Area

Olabisi Onabanjo University main campus is situated in Ago-Iwoye, between longitude $3^{0}51^{\prime}49.32''$E and $3^{0}52^{\prime}45.12''$E and latitude $6^{0}55^{\prime}24.24''$N and $6^{0}56^{\prime}9.96''$N. The University is one of the most desired by students with a population of 32,239, which include undergraduate and postgraduate students. There are 72 academic Departments in the University. The staff strength is 1,859. The ranking of our academic programmes, by National University Commission (NUC) in 2020 and 2021, placed the University higher in professional programmes. The University's programmes at both undergraduate and postgraduate levels are highly desired by new candidates across the nation. The reputable status of the University has an inherent potential to attract thousands of students in the nearest future (Ayodeji, 2025).

Study Sample

Sample size consisted of 500 students, of which 400 were females and 100 were male. Their age bracket falls within the range of 16- 22 years.

Inclusion Criteria

The students are largely youths undergoing chest X-rays as a criterion for being admitted to study courses offered by the University in the various faculties and departments. Their age bracket falls with the range of 16-22 years.

Exclusion Criteria

Other types of radiographic investigation, such as abdominal x-ray, kidney, ureter, and bladder x-ray, neck x-ray, hand x-ray, joint x-ray, and skull x-ray, are excluded from the study.

Ethical Consideration

Specific consideration was given to the right of the confidentiality and anonymity for all the students used in the study. Anonymity was achieved by omitting the names and the departments of the students used for the study Also; confidentiality was achieved by concealing specific data of each student from the general public. The privacy of the students was also ensured when changing in the dressing room in preparation for the X-ray shots. Permission for conducting the study was obtained from the medical director of the University clinic before embarking on the study.

The X-Ray Machine Used for the Study

Mars 6 is a medium-powered Mobile High Frequency X-Ray unit manufactured by Allengers Medical Systems Ltd., India. The technical specifications include a voltage of operation that lies within 40- 110 kV and operating mAs of 1 -200 mAs (maximum of 150 mAs). The X-ray generator operates with a high frequency of about 40 kV, and 6kW wattage. An assumed minimum aluminum filtration of 25mm was adopted for the study as recommended by US guidelines for X-ray tubes operating above 70kVp. The power supply voltage is 230V AC ±10%, 50/60 Hz.

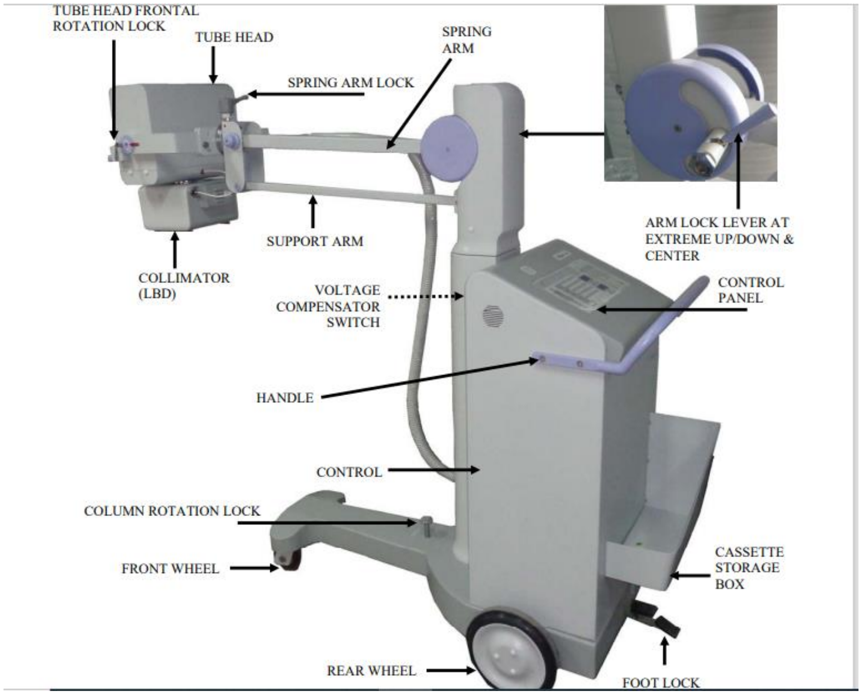

Figure 1: Allengers X-ray machine

Estimation of Entrance Surface Dose (ESD)

The ESD was calculated according to the following equation, which was applied by (Tung and Tasi; 1999).

$$ESD = C\left(\frac{KV_P}{FSD}\right)^2\left(\frac{mAS}{mmAl}\right) \quad (1)$$

ESD stands for Entrance skin dose, c= constant = 0.2775, Kvp=Applied Tube potential, mAs =Tube current multiplied by exposure time, FSD =Focus to skin distance, Al=Aluminum Filtration (1.83m).

Data Analysis

The anthropometric/biodata parameters, such as age, gender, weight, height, for the students were collected from the records department of the University clinic. Radiographic parameters like tube voltage (kvp), tube current (mA), time of exposures (sec), and film focus distance (FSD) were collated per candidate through oral interview with the radiographers in the X-ray department. All the collated information (data) was recorded in an exercise book and then transferred to a Microsoft Excel sheet for calculation of the entrance surface doses. The BMI per student was calculated using Microsoft EXCEL. The SPSS statistical tool was used to determine the correlation that existed between the entrance surface dose (ESD) and body mass index (BDI) and other radiographic parameters adopted for each–ray shots per student of students taking chest X-ray shots.

RESULTS AND DISCUSSION

The section presents the results of the study with respect to measures anthropometric parameters (Table1), demographic and radiographic parameters (Table 2), comparison of the estimated entrance surface dose (ESD) with other countries (Table 3), the correlation between body mass Index (BDI) and the entrance surface dose (ESD), Table 4, and correlation between mAs and the entrance surface dose (ESD) (Table 5) respectively.

Table 1: Measured Anthropometric/Biodata Parameters for the Study

Range	Age (yr)	Weight (Kg)	BMI (Kg/m^2)	Height (m)
1-100	15-23	34-105	15.10-37.75	1.46-1.90
101-200	15-24	36-97	15.12-33.56	1.48-1.87
201-300	15-23	33-84	14.67-32.47	1.41-1.85
301-400	15-24	37-112	15.61-39.68	1.45-1.87
401-500	15-23	42-98	15.61-35.58	1.45-1.87
Mean	**18.20**	**58.99**	**21.42**	**1.66**

The range of the biodata and anthropometric parameters presented in Table 2 shows that they are really newly admitted. The mean values for their ages, weights, body mass indices (BMI), and heights are 18 years, 58.99 kg, 21.42, and 1.66 respectively. The normal values for body mass index ranged from (18.5–24.9) kg/m^2, according to the World Health Organization, W.H.O. (2010)

Table 2: Demographic and Radiographic Data for the Study

RANGE	AGE (yr)	KV (v)	mAS (As)	FSD (m)	ESD (mGy)
1-100	16-25 (18)	68-74(71)	10-30 (20)	1.83	0.02 - 0.63 (0.07)
101-200	16-29 (18)	68-74(71)	10-30 (20)	1.83	0.02 - 0.63 (0.11)
201-300	16-22(18)	68-74(71)	10-30 (20)	1.83	0.02 - 0.63 (0.12)
301-400	16-22(18)	68-74(71)	10-30 (20)	1.83	0.02 - 0.06 (0.09)
401-500	16-26(18)	68-74(71)	10-30 (20)	1.83	0.02 - 0.63 (0.08)

The estimated entrance surface dose for the study ranged from (0.02-0.63) mGy with a mean of 0.09 mGy. The Kv and mAs used for the chest x-ray examination ranged from (68-74) kV with the mean of 71 KV and (10 - 30) mAs with a mean of 20 mAs, respectively. The FSD for the investigation is constant with a value of 1.83.

Table 3: Comparison of the Entrance Surface dose for the Present Study and Similar Studies in Nigeria and other Countries

Projections	Examinations	Present Study	Entrance surface dose (ESD) in the previous study (mSv)			
			(Eke et al., 2011)	(Joseph and Igashi, 2014)	(Sadele et al., 2018)	(Nijiti et al., 2014)
AP	Chest	0.09	0.35	0.50	0.11	0.76
Lat	Chest	-	-	-		-
PA	Chest	-		-		-

The ESD estimated in the study is less than the value reported by (Eke et al, 2011) and Nijiti et al, 2014 who reported that (0.35) mSv and 0.76 mSy. Similarly, the estimated entrance surface dose is again lower than the work reported by (Joseph and Igashi 2014) with a value of 0.50 mSv

Table 4: Correlation Between Body Mass Index and ESD

		BMI	ESD
BMI	Pearson Correlation Sig. (2-tailed)	1	.544
ESD	Pearson Correlation Sig. (2-tailed)	.544	1

Correlation is significant at the 0.01 level (2-tailed)

There is a fair correlation (0.544) between the BMI and the entrance surface dose adopted for the study. Since the mean value of the BMI for the study is within the normal range, low values of tube voltage and mAs are required for a sharp X-ray image. A high value for BMI due to more fat adipose layer in the skin requires high values for tube voltage and mAs, which may not promote safety practice. The more the tissue layers (fat adipose layer), the higher the tube voltage and other radiographic parameters needed for a sharp x-ray image. High BMI requires higher dose of radiation for a good image quality, and hereby increasing ionizing radiation exposure risk. Also, poor-quality images due to underexposure can lead to repeat exposures, which radiation dose, hereby affecting safety.

Table 5: Correlation Between mAs and ESD

Radiographic Parameters		mAs	ESD
mAs	Pearson Correlation Sig. (2-tailed)	1	.982”
ESD	Pearson Correlation Sig. (2-tailed) N	.982”	1

Correlation is significant at the 0.01 level (2-tailed)

The correlation between the ESD and mAs is high and positive, with a value of 0.98. This indicates that the higher the current adopted in the study, the higher the ESD estimated. This calls for caution in the choice of radiographic parameters during chest X-ray examination. For safety practice, an inverse relationship between the ESD and the safety of X-ray shots for students undergoing chest X-ray examination. The goal of safety practice is to keep the dose as low as reasonably achievable, (ICRP, 2007) for ALARA principle.

CONCLUSION

The estimated ESD is below the (DRL) diagnosis reference level recommended by regulatory bodies. The result of the study shows that the Chest X-ray examinations conducted for students are within the safe limits. The fair correlation between the BMI and the entrance surface dose for the study also support the safety of the chest X-ray examination carried out for the new intake into the university.

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