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Research Article

DOSE ESTIMATION OF SELECTED ABDOMINAL AND PELVIC ORGANS DURING CONVENTIONAL X-RAY EXAMINATION AT SELECTED HEALTH CARE CENTRES IN PLATEAU STATE, NIGERIA

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A B S T R A C T

The increasing use of X-ray procedure in the field of human medicine has made dosimetric evaluation and optimization of these procedures an important consideration. There is an ongoing effort to minimize dose to patient without compromising diagnostic information from such a procedure. A dose of a radiation is not only dependent on the type of radiation, imaging modality and distance from the source, but also the radiosensitivity of the organ or cell. This study aims to estimate the absorbed doses to selected organs of the abdominal and pelvic cavity. The materials that were used in the study include body phantom, thermoluminescent dosimeter, measuring cylinder, Digital Electronic Weighing Scale, glycerine and water. In the study, absorbed doses to the ovary uterus, prostrate, liver, and kidney where measured by the used of the TLD chips. The chips were placed inside the phantom probe holes (inserts). These inserts contained a water-glycerine solution having density equivalent to each organ considered for dose measurement. Exposed TLDs were read by a manual TLD reader. The results shows the mean dose to the ovary at health Centre H.1, and H.2 are 0.39mGy, and 0.44mGy respectively. For the uterus the result obtained were 0.40mGy, and 0.29mGy across health Centre H.1, and H.2, Mean organ dose to the prostrate was 0.39mGy, and 0.44mGy. The liver has 0.33mGy, and 0.33mGy. Lastly organ dose to the kidney was measured and the following results were obtained: 0.45mGy and 0.49mGy across Heath Center H.1 and H.2 respectively. These results were compared with similar available literatures in order to see level of coherence. Similarly, results were compared with reference levels established by national and international studies in order to see to have exceeded the established benchmark. Even though in this study, the mean dose to the abdominopelvic organs is much lower than established reference levels, there appear to be discrepancy in the organs absorbed doses. Thus, I will recommend that more of such study be carried out particularly in north central Nigeria as results such a study can be used in establishing of local, regional or even national reference level in this region.

INTRODUCTION

The human abdomen and pelvic cavity houses organs that are very sensitive to ionizing radiation and due to that, special care and protection should be taken when carrying out abdominal, pelvis or both examinations [1]. X-ray can cause direct damage to gonads and abdominal organs which could result in mutation [2].

Pelvic and abdominal shielding during diagnostic X-ray procedure is an effective way of reducing dose to patient reproductive and abdominal organs thus reduce the risk of genetic effects associated with exposure to ionizing radiation [3]. Knowing the potential harmful effect associated with ionizing radiation exposure, it is then not only of paramount importance to provide gonad and abdominal shielding, but to measure the organ dose most likely to be delivered to patients and reduce them when possible.

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Radiosensitivity is the relative susceptibility of cells, tissues, organs, organism or other substances to the injurious action of radiation. In general, it has been seen that radiosensitivity is directly proportional to the rate of cell division and inversely proportional to the degree of cell differentiation. In essence this means that actively dividing cells or those not fully mature are most at risk from radiation [4]. The use of X-ray cannot be overemphasized in medical imaging since Wilhelm Roentgen discovery of X-ray in 1895 [4].In Nigeria, reports have shown that there are over 4000 X-ray machines in use with <5% of them under any form of regulatory control [5]. In Nigeria, There is no standard reference dose levels for normal adult radiographic examinations, Therefore patients are either over exposed or under exposed to the effect of ionizing radiation [6]. A reference dose levels is defined by the International Commission on Radiological Protection (ICRP) as a form of investigation level, applied to an easily measured quantity, usually the absorbed dose in air, or tissue equivalent material at the surface of a simple phantom or a representative patient [7]

Although the overall risk of cancer induction from diagnostic imaging procedure involving ionizing radiation exposure is low or small, it has not been proven to be zero. Therefore it is important to ensure that patient radiation exposure is not only known but necessary to accomplish limiting exposure to ionizing radiation so as to maximize the benefit-ratio of imaging procedure. First use the appropriate criteria recommended to select the most suitable procedure for patient condition; avoid ordering procedures that are not likely to provide useful information. Secondly, prior to the ordering of an imaging procedure, review the patient history, results and clinical indication to determine whether the procedure can provide additional information to assist in patient management. This should be balance with any potential risk associated with the imaging procedure. Consider using imaging procedure that do not use ionizing radiation but only when they have similar test accuracy to the procedure that use ionizing radiation [8]

Thermo luminescent dosimeter (TLD) is a radiation dosimeter that measures ionizing radiation exposure by measuring the intensity of visible light emitted by a crystal inside the detector when the crystal is heated. The intensity of light emitted is dependent upon the radiation exposure [9]

The detection and measurement of ionizing radiation is the bases of the majority of diagnostic imaging. All detectors of ionizing radiation require the interaction of radiation with matter. Ionizing radiation deposits energy by ionization or excitation. Ionization is the removal of electrons from the atoms or molecules. Excitation is elevation of the electrons to an excited state in the atom or molecule. Excitation or ionization may produce chemical changes. Most energy deposited by ionization is ultimately converted into heat [4].
An imaging phantom is a specially design object that can be scanned by medical devices such as X-ray machine or computed tomography (CT) Scanners. Scanning the phantom allow technician to evaluate, analyze and tune the performance of the imaging devices for optimal result. Phantom is use instead of living tissue or Cadaver because phantom gives more consistent result and to avoid unnecessary exposing the patients to excess or unnecessary radiation. It is essential that imaging devises are tuned to ensure accurate and clear result and avoid misdiagnosis [10].

In both developed and developing countries, the number and range of X-ray facilities and X-ray equipment is increasing rapidly and hence make a major contribution to man's exposure to ionizing radiation from man-made sources [11]. While the use of ionizing radiation in medicine brings tremendous benefit to global population, the associated risk due to stochastic and deterministic effect makes it necessary to protects patients from potential harm particularly those from medical exposure. The Gonads are very susceptible to radiation and they fall directly in line of radiation exposure when pelvis X-ray is done. The two main roles of the gonads are production of sex hormones (testosterone and estrogen) and germ cell (ova and sperm) can be affected if exposed to radiation. The liver and kidneys have multitude of important and complex functions. Radiation can damage these organs and in turn affect the internal homeostasis.

Absorbed dose (*D*) is is the amount of energy deposited by radiation in a human tissue. It can cause the biological effects damaging the human cells. The biological effects are divided into stochastic effects and deterministic effects. The stochastic effects are the long-term effects of radiation. There is no threshold for the stochastic effect to occur and the probability of occurrence increases with the radiation dose. It is defined as the quotient of dε by dm, mathematically:

$$D = \frac{d\varepsilon}{dm}$$

Where dε is the mean energy imparted to matter of mass dm (Podgosak, 2010a). The traditional unit is the rad (radiation absorbed dose), which is equal to 100 ergs/gram. The SI unit for absorbed dose is the gray (Gy), equal to 1 joule/kg. 1 Gy = 100 rads [12]

MATERIALS AND METHOD

Conventional X-ray Scanner

The X-ray machines generate the X radiation that was measured. The research study was carried at two different health care centres in Jos-the Plateau State capital. The health care centres were code named H.1 and H.2. As at the time (April to August, 2019) of study, H.1 and H.2 were using MinXray HF120/60HPPWV and Philips Conventional X-ray Scanners respectively. The abdominal/pelvic exposure parameters commonly used by each health centre was what was use for the phantom exposure in this study. Tube voltage were 88kV$_p$ and 80 kV$_p$ while current were 12.50mA and 20mA for H.1 and H.2 respectively. In the two health centres, the same focus-film distance (FFD) was use for exposure and this was 100cm. 100 cm was used because most radiographic examinations in these centres are carried out with an FFD of 90 cm-100 cm.

Fig.1 Conventional X-ray Scanner used at one of the health care centre where the research study was conducted**.**

In orders to absorbed the low energy radiation dose which only contribute to patient's dose without adding anything on image quality. Aluminum grids are usually used by these heaths centres to remove these X-rays. Thus in these work, grid was interposed between the X-ray tube and the phantom.

Body Phantom

The phantom was obtained from Lagos University Teaching Hospital (LUTH), Nigeria. The Phantom which was Locally Developed was constructed using a transparent Perspex plastic with a thickness of 3 mm to follow the standard dosimetry. The body phantom is cylindrical in shape, 32cm in diameter with five probe holes; one at the center and the other four around the perimeter, 90˚ apart and 1 cm from the edge.

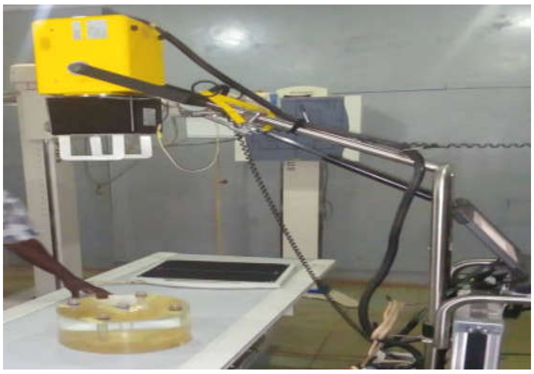

Fig 2 Getting the Phantom set on a Patient's Couch.

The phantom used in the study was tested and verified according to the qualities of the standard phantom and it's been qualified (verified)to be used for organ dose measurement [13].

Thermoluminescent Dosimeter (TLD)

Chips

Lithium fluoride doped with magnesium and titanium (LiF: Mg, Ti) were used in this study. Annealed TLDs were used in the research work. All the TLD chips that were used in this research were hired from Centre for Energy Research and Training (CERT) Zaria, Nigeria.

Glycerine

The pelvic and abdominal organs (prostrate, ovary uterus, kidney and liver) dose were measured by direct measurement. The Phantom organ inserts or probe holes were filled with a mixture of glycerine-water solution at a proportion (percentage) constituent equivalent to these organs.

Table 1 shows the organs and density of the abdominopelvic region whose dose were estimated.

Table 2 shows the density of glycerine-water solutions at different percentage concentration (average daily temperature of 25ºC).In this study, the values in Table 2 were validated using a weighing scale, measuring cylinder and glass stirring rod.

Table 1 Abdominopelvic Organ and Density (ICRP, 2009).

S/N	Organ	Density (g/cm^3)
1.	Prostrate	1.03
2.	Uterus	1.03
3.	Ovary	1.04
4.	Kidney	1.05
5.	Liver	1.05

Table 2 Density of Glycerine-Water Solution (Bosart & Snoddy, 1928).

Glycerine Percentage (%)	Density(g/cm^3) at 25ºC
14	1.03055
18	1.04035
23	1.05290

Forceps

Handheld instrument used for grasping and holding objects. Forceps were use handling the TLD chips order to avoid contamination.

Polythene Bags

Polythene bag were used to rap the TLD chips before inserting to the phantom organ insert. This is done in order to avoid contamination of the chips.

Masking Tape

Masking tape was used on the polythene in order for it to properly cover each of the TLD chip. It was also use for labeling.

Dose Measurement

For the measurement of organ dose, two TLDs were inserted in each of the probe holes of the phantom in order to improve the counting statistics. Each of the phantom probe holes contained specific organ for the different scanning protocols. All scans was perform using automatic control conventional X-ray Scanners. After exposure, scanning parameters, such as the tube voltage, current time, FFD were noted.

The chips were then removed using the forceps and taken to a laboratory at Centre for Energy Research and Training (CERT) Zaria, Nigeria for reading.

RESULTS

Estimated Absorbed Doses by the Abdominopelvic Organ at H.1

The measured value of organs doses for H.1 are shown in table 3. From our results for H.1, Kidney absorbed the highest dose (0.49mGy) while Uterus absorbed the lowest dose (0.29mGy). Prostrate and Ovary absorbed the same amount of dose (0.44mGy) of radiation at H.1. The X-ray background radiation was measured using a radiation survey meter and value was 0.25µSv. This value was used in reading of the organs doses on each of the thermoluminescent chip.

Table 3 Absorbed Doses by the Abdominopelvic Organ at H.1

Selected Organs	Absorbed Doses D_{TR} (mGy)		Mean Doses (mGy)	±
	$D_{.1}$	$D_{.2}$		
Prostrate	0.46	0.32	0.39	0.07
Ovary	0.38	0.40	0.39	0.01
Uterus	0.30	0.49	0.40	0.10
Liver	0.35	0.31	0.33	0.04
Kidney	0.40	0.49	0.45	0.05

Estimated Absorbed Doses by the Abdominopelvic Organ at H.2

Absorbed doses to the abdominopelvic organs at H.2 are shown in table 4. As seen in table, the measured value of organs absorbed doses has it highest lowest value at the Kidney and uterus respectively. The background radiation measurement at H.2 is 0.24µSv.

Table 4 Absorbed Doses by the Abdominopelvic Organ at H.2

Selected Organs	Absorbed Doses D.(mGy)		Mean Absorbed Doses (mGy)	±
	$D_{.1}$	$D_{.2}$		
Prostrate	0.38	0.50	0.44	0.06
Ovary	0.38	0.50	0.44	0.06
Uterus	0.22	0.35	0.29	0.07
Liver	0.28	0.37	0.33	0.05
Kidney	0.48	0.49	0.49	0.01

Comparison of Abdominopelvic Absorbed Doses from the Health Care Center

The measured value of absorbed dose for the five different organs were measured at two different health care centres. These absorbed dose values by each organ were compared with corresponding values between the two health centres. Charts were used for the comparison as shown by figure 1 and figure 2.

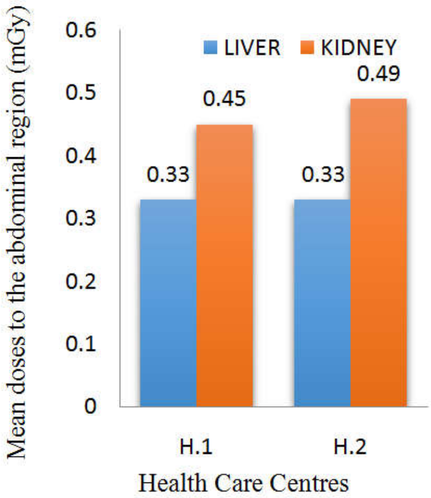

Figure 1 Mean Doses to the Abdominal Organs at H.1 & H.2

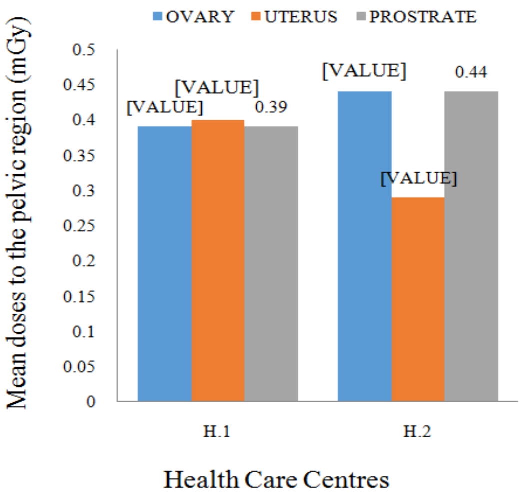

Figure 2 Mean Doses to the Pelvic Organs at H.1 & H.2

The mean doses of organs at the Abdominal organs which are kidney and liver are shown by figure 1, at the two health care centres, as seen there was no variation in the dose deposited to the liver at the two health care centres. Similarly, doses deposited at the kidney show very little variation (0.04mGy).

For doses to the pelvic organs, there seems to be equal dose deposition at each health care centre to the organs. At H.1, ovary and prostrate show the same amount of dose (0.39mGy), uterus has dose only 0.01mGy higher than that of uterus and prostrate at this centre. At H.2, ovary and prostrate doses were 0.44mGy each. However uterus shows considerably lower dose (0.29mGy). Figure 2 shows the dose distribution to the pelvic region.

DISCUSSION

In the present study, the doses to selected abdominopelvic organs were measured (estimated) during routine X-ray examination from two health care centre in Jos, Plateau state, Nigeria. Findings from this study shows kidney to have received the highest dose (0.49mGy) as seen in figure 1. Since organs of the pelvic cavity have a high or fairly high radiosensitivity, then they tend to have a more adverse effect from radiation [4]. Results from this study shows equal doses to the ovary and prostrate at H.1 and H.2 though doses at H.2 were higher than that of H.1 as seen in figure 2. Furthermore, the exposure parameters used at H.1 were: tube voltage was 88 kVp while tube current was fixed at12.50mA. At H.2, tube voltage, and tube current were 80kVp and 20mA respectively. Patient dose measurement in common medical X-ray examinations the first local dose reference levels to diagnostic radiology in Iran was carried out by Behrouz *et al.* [14], the main purpose of their study was to investigate patient dose in pelvic and abdomen X-ray examinations and to provide the local diagnostic reference levels (LDRLs) in Khuzestan region, southwest of Iran to help establish the national diagnostic reference levels (NDRLs).From their results, the mean Entrance Skin doses (ESDs) for pelvic, and abdomen examinations were2.32mGy and 3.72mGy respectively. These results are higher than the present study.

Ibrahim *et al.* [15] did a study to establish the trend of dose received by patient during X-ray examination in Federal Medical Centre Keffi, Nasarawa state, Nigeria. From their study, the calculated mean skin dose for human chest X-ray ranges from 0.013±0.01mGy to 0.851±0.023mGy. These values and results from the present study fall within the same range. However Ibrahim *et al.* study was carried out on patients while the present study uses a body phantom.

Nurul *et al.* [16] study organ absorbed dose in pediatric chest X-ray examination using a phantom and optically stimulated luminescence dosimeter (OSLD). Organs selected for dose estimation by Nurul *et al.* were lungs and heart. Results from their study shows absorbed dose to the heart to be 0.474 mGy at 50 kVp, and 0.603 mGy at the highest kVp, 60 kVp. Similarly, absorbed dose to the lungs were taken at three levels in their study, the values of absorbed dose at the first, second and third levels are 0.3995mGy, 0.3563mGy and 0.3378mGy, respectively. As seen results from this study are in consonant with results from the present study though different type of dosimeters and phantom were used by the researchers.

Establishment of local diagnostic reference levels (DRLs) for radiography examinations in north eastern Nigeria was done by Joseph *et al.* [17]. DRLs established by Joseph *et al* study for abdominal AP and pelvic AP radiographic examinations were 1.01mGy and 0.82mGy respectively. All organs doses from the present study and fall within abdominal and pelvic local diagnostic reference levels established in north eastern Nigeria by Joseph *et al*. study in 2017.

During the past few decades, patient's dose measurement has been of interest. Dose measurements has been carried out and results obtained were compared with dose reference levels reported by international legislative organizations like the International Atomic Energy Agency (IAEA) and European Commission (EC). The IAEA and EC dose reference levels are; pelvis-9 mGy and abdomen-10 mGy [18, 19].

Table 5 Mean Absorbed Doses (mGy) across H.1and H.2 as well as literature and International DRLs.

Organs/Exam	This Study	Behrouz *et al.* (2017)	Ibrahim *et al.* (2014)	Nurul *et al.* (2020)	Joseph *et al.* (2017)	IAEA (2004)	EC (1999)
Prostrate	0.415±0.0698						
Ovary	0.415±0.0698						
Uterus	0.340±0.0791						
Liver	0.328±0.0349						
Kidney	0.465±0.0377						
Lungs				0.3645			
Heart				0.5385			
Pelvic AP		2.32			0.82	9	9
Abdomen AP		3.72			1.01	10	10
Chest X-ray PA			0.432		0.59		
Chest X-ray Lateral					1.02		

AP- Antero posterior, PA- Posterior anterior, IAEA- International Atomic Energy Agency, EC- European commission,

CONCLUSION

The mean organ dose to abdominopelvic organs was successfully estimated from two health care centres in north central Nigeria. No previous studies have been done on organs dose measurement in north central Nigeria, thus findings of this study can be used as a baseline/guideline for future studies on dose measurement, local or regional reference level in conventional radiography. This work also provides evidence that dose reduction in the conventional X-ray examinations is feasible at both national and international level. Patient exposure in diagnostic radiology dependson a large number of interrelated factors, such as machine age, radiographer experience, exposure factors, patient body mass etc. However this study has provided dose estimates to some of the most radiosensitive and very essential human organs.

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References

1. Bosart, L.W. & Snoddy, A.D. (1928). Density of Glycerine-Water Solutions. *Industrial and Chemical Chemistry.* 20(4), 1377-1379. Retrieved on 26th April, 2019 From http://www.aciscience.org/docs/physical-properties-of-glycerine-and-its-solutions.pdf&sa
2. International Commission on Radiological Protection, (2009). *Annex A. IDListing, Medium, Density, Mass, Minimum/Maximum Column, Rows and Slices Occupied by Each Organ/Tissue, and Organ Centre of Mass.* Message Posted to "Sage Journals". Retrieved on 28th April, 2019 from https://journals.sagepub.com/doi/pf/10.1016/j.icrp.2009.07.005
3. International Commission on Radiological Protection (ICRP) (1991).
4. Recommendations of the International Commission on Radiological Protection. Ann ICRP, 21(1-3).Pergamon Press. Oxford, United Kingdom. 1–201.
5. Podgosak, E. B. (2005a). *Radiation Oncology Physics: A Handbook for Teachers and Students.* IAEA. Vienna, Australia. Tautran, A. & Somerset, T. (2013).Conventional Radiography. Message posted to Musgrove Park Hospital. Retrieved on 20th February 2019 fromhttps://www.tsft.nhs.UK/ward-and departments/ departmentservices/radiology
6. Sikand, M., Stinchcombe, S. & Livesley,P.J. (2003). Study on the Use of Gonadal Shields During Pediatric Pelvic X-rays. Ann. R. Coll. England. 85(2), 422-425.
7. Dooland, A., Brennan, C. P., Rainford, L. A.& Haely, J. (2004). Gonad Protection for Antero-Posterior Projection of the Pelvis in Diagnostic Radiology in Dublin Hospitals. *Journal of Diagnostic Imaging and Radiation Therapy*,10(1), 5-21
8. Bushberg, J.T., Anthony, J.S., Edwin, M.L. & John, M.B. (2002). *The Essential Physics ofMedicalImaging* (2nd Ed.). William & Wilkins Publisher. Philadelphia, U.S.A.
9. Elegba, S. B. (2013). Keynote Address on Diagnostic and Interventional Radiology. University of Ibadan, Ibadan, Nigeria. Message posted to "ResearchGate". Retrieved on 16th April, 2019 from http://www.researchgate.net/publication/2567022741
10. Akpochafor, M.O., Omojola, A.D., Adeneye. S.O., Aweda M.A. Ajayi H.B. (2016). Determination of Reference Dose Levels Among Selected X-Ray Centers in Lagos State, South- West Nigeria. *Journal of Clinical Sciences*, 13(1), 167-172.
11. International Commission on Radiological Protection (ICRP). (1996). *Radiological protection and safety in medicine: ICRP publication 73. Ann 26*
12. Wisley, I. (2017). Radiation Safety in Adult Medical Imaging. Retrieved 5thApril, 2019 fromhttps://www.imagewisely.org/?CSRT=13475489096137197581
13. Khan, F.M. (2003). Physics of Radiation Therapy. Lippincott Williams. Baltimore, Maryland,U.S.A.
14. Annemari, G. (2015). All-in-one Diagnostic X-ray Imaging Phantom. Message posted to Innovus. Retrieved on 8th April, 2019 from http://www.nnovus.co.za/media/Technologies%for%20lincening/phantom_project_Eng.pdf.
15. Mesfin, Z., Elias, K. & Melkamu, B. (2017). Assessment of Pediatrics Radiation Dose from Routine X- ray Examination at Jimma University Hospital, Southwest Ethiopia. *Ethiopian Journal of Health Science*, 27(5), 481-490.
16. International Atomic Energy Agency (IAEA). (2007). *Dosimetry in Diagnostic Radiology: An International Code of Practice. Technical Report Series NO 457.* IAEA. Vienna,Australia
17. Akpochafor, M.O., Adeneye. S.O., Habeebu M.Y., Omolola A.D., Adedewe N.A., Adedokun A.R., Joseph A.O., Etim V.E. & Aweda M.A. (2019). Organ Dose Measurement in Computed Tomography Using Thermoluminescence Dosimeter in a Locally Developed Phantoms. *Iranian Journal of Medical Physics*, 16(1), 126-132.

18. Behrouz, R., Ali, M., Mohammad, G.,Raheleh, T. J.& Mozafar, N.(2016). Patient Dose Measurement in Common Medical X-ray Examination in Iran. *Journal of Applied Medical Physics*,17(1), 133-141.
19. Ibrahim, U., Daniel, I. H., Ayaninola, O., Hamza, A.M. & Umar, A.M. (2014). 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.
20. Nurul, H.M.J, Inayatullah, S. S., Waliullah, S.S. (2020). Estimation of Organ absorbed dose in pediatric chest X-ray examination: A phantom study. *Radiation Physics and Chemistry*, 1-6.
21. Joseph, D.Z., Christian, C.N., Mohammed, S.U., Ameh, P. O., Njoku, G., Malgwi, F. D., Moi, A.S. & Shem, S. L. (2017). Establishment of Local Diagnostic Reference Levels (DRLs) for Radiography Examinations in North Eastern Nigeria. *Science World Journal*,12(4), 51-57.
22. International Atomic Energy Agency (IAEA). (2004).Optimization of the Radiological Protection of Patients Undergoing Radiography, Fluoroscopy and Computed Tomography. IAEA. Vienna, Australia.
23. European Commission (EC). (1999). Guidance on Diagnostic Reference Levels (DRLs) for medical exposures, Radiation Protection 109.

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