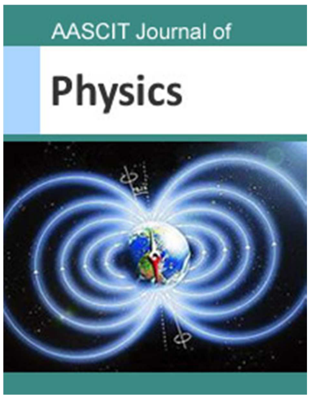
AASCIT Journal of Physics
2018; 4(1): 5-10
http://www.aascit.org/journal/physics
ISSN: 2381-1358 (Print); ISSN: 2381-1366 (Online)

American Association for Science and Technology



Keywords
X-rays,
Entrance-Skin-Dose,
Federal-Medical-Centre,
As-Low-As-Reasonably-Achievable,
Radiation,
Forearm,
Exposures

Received: September 6, 2017
Accepted: December 8, 2017
Published: January 11, 2018

Estimation of Entrance Skin Dose (ESD) in Patients Undergoing Forearm X-rays from Federal Medical Centre, Jalingo, Taraba State, Nigeria

Amaitem John Iseh[1, *], Catherine Ignatius[1], John Wansah[1], Bunmi Jacob Akeredolu[1], Cookey Iyen[1], John Actor Ocheje[1], Moses Onudibia[1], Justin Ime Ukpong[2]

[1]Department of Pure and Applied Physics, Faculty of Pure and Applied Sciences, Federal University Wukari, Wukari, Nigeria
[2]Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Ekpene, Nigeria

Email address
iseh@fuwukari.edu.ng (A. J. Iseh)
[*]Corresponding author

Citation
Amaitem John Iseh, Catherine Ignatius, John Wansah, Bunmi Jacob Akeredolu, Cookey Iyen, John Actor Ocheje, Moses Onudibia, Justin Ime Ukpong. Estimation of Entrance Skin Dose (ESD) in Patients Undergoing Forearm X-rays from Federal Medical Centre, Jalingo, Taraba State, Nigeria. *AASCIT Journal of Physics*. Vol. 4, No. 1, 2018, pp. 5-10.

Abstract
X-ray is a type of ionizing radiation and due to the fact that it is capable of causing DNA damage, there is need to monitor for the purpose of controlling, the amount of X-ray that patients are being exposed to. This research is a means of quality control on radiation exposure because it investigates the rate at which patients undergoing forearm X-rays from Federal Medical Centre (FMC) Jalingo, Taraba State are exposed through the measurement of their Entrance Skin Dose (ESD). The Entrance Skin Dose (ESD) for patients undergoing forearm X-rays was calculated using Edmond's 1984 formula for children with and without POP and adults with and without POP using X-ray exposure data collected for 40 patients, 20 for each age group and 10 for each category. The calculated Entrance Skin Dose (ESD) ranges from 0.3150mGy to 0.4990mGy for children without POP, 0.4371mGy to 0.5843mGy for children with POP, 0.3826mGy to 0.6716mGy for adults without POP and 0.4851mGy and 0.9774mGy for adults with POP. The maximum mean Entrance Skin Dose (ESD) of 0.6747mGy obtained is below the NNRA standard of 1mGy for a period of one year and does not pose any significant effect on patients undergoing forearm X-rays in the hospital. From the results, even though the estimated Entrance Skin Dose (ESD) is within NNRA's yearly limit, unavoidable exposures should be administered considering the NNRA's 5mGy for five years period when necessary while adhering to the ALARA principle of As Low As Reasonably Achievable.

1. Introduction

Ionizing radiation is a form of radiation with sufficient energy to remove electrons from their atomic or molecular orbital shells in the tissues they penetrate [8]. These ionizations received in sufficient quantities over a period of time can result in tissues damage and disruption of cellular functions at the molecular level. The dose delivered to tissue from ionizing radiation can either be acute (the energy from the radiation absorbed over a few hours or day) or chronic (the energy absorbed over a longer period of months years or over a lifetime). For radioactive materials with effective half-lives longer than a day, even if the intake are brief (minutes to a few days), the energy is deposited in tissue where it remains over a period longer than a few days, so that the exposure to the surrounding tissue is of a chronic duration. The healthy population would decline if ionizing radiation techniques were not available to diagnose diseases and detect trauma. Meanwhile there is no excuse for complacency and it is a basic premise of radiation protection practice that any exposure should be justified by weighing the potential harm against the perceived benefit [15] [31].

X-ray is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in effective health care delivery both in developed and developing countries [23] [36]. X-ray is said to be the major contributor to the collective effective dose of ionizing radiation to the general public (Personal and Public). The need for radiation dose assessment of the patients during diagnostic X-ray examinations has been highlighted by increasing knowledge of hazard of ionizing radiation [23] [35]. Because of the deleterious effect of X-rays, it is necessary to protect patients undergoing diagnostic and therapeutic procedures. The aim of any diagnostic X-ray examination is to produce images of sufficient and optimum quality. However, a good quality radiograph is not the one that is most appealing to the eye but, that in which sufficient details can be easily elicited.

In keeping radiation dose to patients to a minimum in hospitals, it is useful to be able to estimate prior to medical examinations the dose to patients as a function of radiographic exposure parameters [15] [23] [43]. According to [15] by Edmond's formula, radiation dose to patients from diagnostic X-ray machine assures a simple functional dependence on radiographic exposure parameters of tube potential (kVp) tube current and time of exposure (mAs), Source to Skin Distance (SSD), filtration and thickness. Monitoring of patients during the examination has been a major way of assessing radiation dose received in diagnostic and therapeutic radiography.

[23] further noted that for the purpose of optimization in radiation protection, dose delivered to patients during diagnosis is studied with assessment of image quality. This is a common practice in many parts of the world where patients with clinical cases requiring X-ray examination which are of ten times not properly done and it is largely due to lack of facilities and suitable qualified personnel, as a result there is no sufficient information about patient's radiation dose.

Patient's dose has often been described by the Entrance Skin Dose (ESD) as measured in the centre of X-ray beam. The ESD is a measure of the radiation dose absorbed by the skin where the X-ray beam enters the patient. 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 luminescent dosimeter (TLD) placed on the skin of the patient's or indirectly from measurements of dose area products using a large area transmission ionization.

In the early 1990s, the United States Food and Drug Administration (FDA) received reports of significant radiation induced skin injuries associated with interventional fluoroscopy, prompting the release in 1994 and 1995 of the guideline publications on documenting radiation use [4]. A number of professional radiological societies, including Society of Interventional Radiology (SIR) have been working since then to reduce the frequency of these events. In 2007, the American College of Radiology (ACR) published its recommendations on issues related to patient's radiation exposure in medicine. The document focused mostly on diagnostic imaging procedures

In radiological exposure, a periodic dose assessment should be made to enhance the optimization of the radiation protection of the patients and to deliver minimum dose to the examinations. Dose measurements are required to comply with some international guidelines and regulations [41].

In this research, ESDs for some patient's undergoing forearm X-rays at the Federal Medical Centre (FMC) Jalingo were measured by method of X-rays output factors.

2. Materials and Method

The X-ray machine at FMC Jalingo is the PLD500B Eschmed Medical England model with a source to skin distance (SSD) of 90cm and a filtration thickness of 1.5mmAl. With an exposure range of 10-20s and the focal spot reduced to small so as to cover just the forearm and reduce scattered radiation as the elbow was placed at 90^0 and the forearm placed against the cassette. The transparent positioning aid was centred on the cassette and the dominate forearm was placed on it. The forearm was then slightly positioned in ulna deviation so that it fell along a straight line before the patient was exposed to the radiation in which could either be anterior-posterior, posterior-anterior or lateral.

The survey method in this work was based on the guidelines established by the Nigerian Nuclear Regulatory Authority (NNRA). The skin dose to patients was determined by calculation from the X-ray tube parameters and exposure radiographic parameters using Edmonds (1984) skin dose formula which is given as:

$$SkinDose(\mu Gy) = 418(kVp)^{1.74} \times mAs \frac{\left(\frac{1}{T}+0.114\right)}{(SSD)^2} \quad (1)$$

Where kVp is the peak voltage responsible for the quality of penetration, mAs is the exposure current-time, responsible for quantity of electrons from the filament, T is the total filtration of the beams always a constant for each X-ray machine type and SSD is source to skin distance.

The sampling population/size used in this research was 40 patients which was broken into 10 samples for children without POP, 10 samples for children with POP, 10 samples for adults without POP and 10 samples for adults with POP

3. Results and Discussion

The resultsobtained from this research is presented in Tables 1 and 2 below. The maximum mean Entrance Skin Dose recorded was 0.6747mGy which was for adults with POP at and this is due to the age and body size of patients exposed to ionizing radiation in this hospital as well as the filtration thickness used in this hospital which is 1.5mmAl.

Table 1. *X-ray exposure Entrance Skin Dose (ESD) on Children with and without POP at Federal Medical Center (FMC), Jalingo.*

FEDERAL MEDICAL CENTER (FMC), JALINGO							
AGE 0-18							
Children without POP				**Children with POP**			
Peak kilo-voltage (kVp) (kV)	**Exposure Current-Time (mAs)**	**Entrance Skin Dose (mGy)**	**Mean Entrance Skin Dose (mGy)**	**Peak kilo-voltage (kVp) (kV)**	**Exposure Current-Time (mAs)**	**Entrance Skin Dose (mGy)**	**Mean Entrance Skin Dose (mGy)**
49.0000	10.0000	0.3516	0.4022	50.0000	15.0000	0.5463	0.4860
49.0000	12.0000	0.4220		50.0000	12.3000	0.4480	
46.0000	14.0000	0.4411		50.0000	12.3000	0.4480	
46.0000	10.0000	0.3150		49.0000	13.0000	0.4571	
48.0000	12.0000	0.4071		44.0000	16.2000	0.4724	
49.0000	11.5000	0.4044		50.0000	12.0000	0.4371	
49.0000	12.0000	0.4220		51.0000	15.5000	0.5843	
48.0000	10.4000	0.3528		51.0000	15.2000	0.5730	
48.0000	12.0000	0.4071		50.0000	12.0000	0.4371	
50.0000	13.7000	0.4990		49.0000	13.0000	0.4571	

Table 2. *X-ray exposure Entrance Skin Dose (ESD) on Adult with and without POP at Federal Medical Center (FMC), Jalingo.*

FEDERAL MEDICAL CENTER (FMC), JALINGO							
AGE 19-70							
Adult without POP				**Adult with POP**			
Peak kilo-voltage (kVp) (kV)	**Exposure Current-Time (mAs)**	**Entrance Skin Dose (mGy)**	**Mean Entrance Skin Dose (mGy)**	**Peak kilo-voltage (kVp) (kV)**	**Exposure Current-Time (mAs)**	**Entrance Skin Dose (mGy)**	**Mean Entrance Skin Dose (mGy)**
52.0000	13.0000	0.5069	0.5207	67.0000	11.0000	0.6667	0.6747
52.0000	13.0000	0.5069		68.0000	14.0000	0.8707	
58.0000	10.9000	0.5140		55.0000	16.3000	0.7007	
50.0000	15.0000	0.5463		50.0000	15.0000	0.5463	
64.0000	12.0000	0.6716		45.0000	16.0000	0.4851	
49.0000	17.0000	0.5978		63.0000	13.0000	0.7079	
60.0000	11.0000	0.5502		65.0000	17.0000	0.9774	
40.0000	16.8000	0.4150		63.0000	13.1000	0.7133	
47.0000	11.7000	0.3826		53.0000	14.6000	0.5885	
55.0000	12.0000	0.5159		47.0000	15.0000	0.4906	

The column chart in Figure 1 below indicates that the Entrance Skin Dose (ESD) increases with POP and with age. Even though the mean Entrance Skin Dose (ESD) for Federal Medical Center (FMC), Jalingo could be high when compared to some other hospitals, it is not above the 1mGy per annum of NNRA standard. Also from this results, children without POP could make use of the X-ray machine at Federal Medical Center (FMC) Jalingo two times in a year and will still be within the NNRA's 1mGy per year limit considering the fact that children are more likely to incur fractures, broken arms and dislocations from playgrounds, etc., as any exposure above this could increase the patients risk level to effects of X-ray radiations. Adults with or without POP who wish to make use of the X-ray machine at Federal

Medical Center (FMC) Jalingo can be exposed to X-ray radiation only once for a period of a year as exposures above this will place the patients at risk of effect of high exposure to X-ray radiations.

However, when need for higher or more frequent exposures to X-rays as discussed above for a period of one year from the hospital arises, patients could be exposed to X-rays bearing in mind that the 5mGy limit for a duration of 5years must not be exceeded.

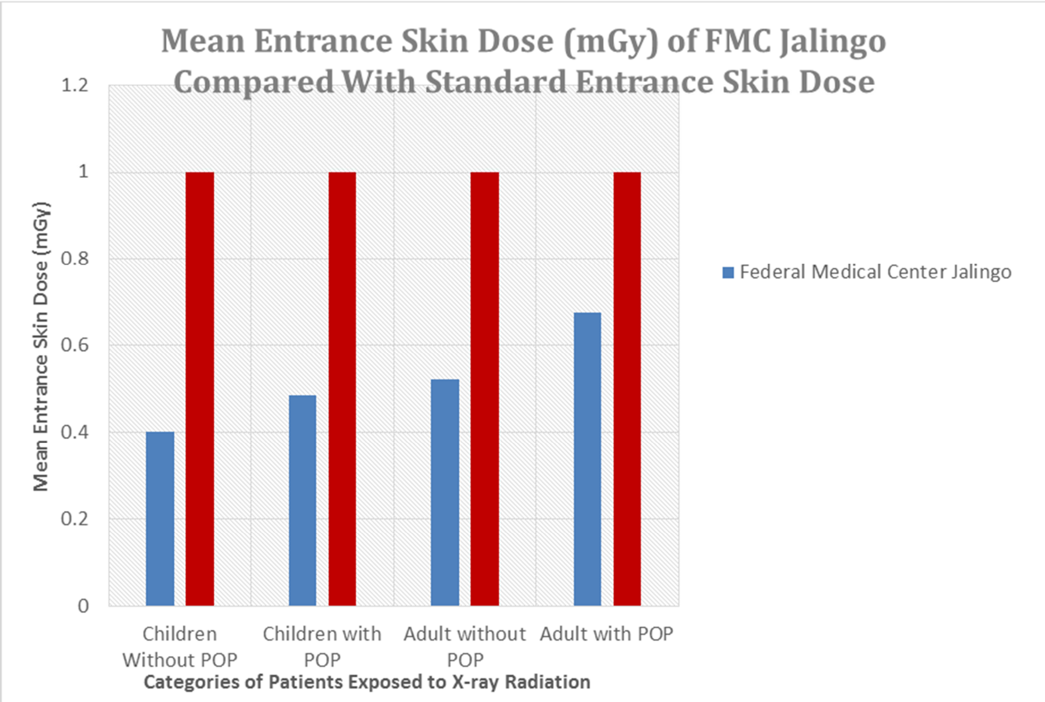


Figure 1. *Chart of Mean Entrance Skin Dose (mGy) at FMC Jalingo grouped according to age group with or without POP.*

4. Conclusion

Results presented in this research work indicates that Entrance Skin Dose (ESD) received by patients undergoing forearm X-rays in Federal Medical Center (FMC), Jalingo is not above the 1mGy standard guideline of the Nigerian Nuclear Regulatory Agency (NNRA) for a year, and exposure of patients to X-ray radiation at such rate can be done more than once in a year for children with and without POP. The maximum mean Entrance Skin Dose (ESD) recorded is 0.6747mGy for adults with POP from Federal Medical Center (FMC), Jalingo and this rate can only exceed 1mGy if patients are exposed twice in a year.

References

[1] Abdoelrahman, H. A. B., Mohamed, E. M. G., Yousif, M. Y. A., and Omer, A. O., (2015). Outfield Dose Calculation in Treatment of Breast Cancer Using Radiotherapy TPs. *International Journal of Science and Research (IJSR)*. www.ijsr.net. 4 (1): 2536.

[2] Abel, R.., Casey, B., Seth, T., and Octavia, T., (2006), *Health Risks of Ionizing Radiation. An Overview of Epidemiological Studies*. Community-Based Hazard Management the George Perkins Marsh Institute Clark University Worcester, USA.

[3] American Academy of Orthopedic Surgeons (AAOS), (2015). Forearm Fractures in Children. *Orthoinfo.org*.

[4] Amis, E. S., Butler, P. F., Applegate, K. E., Birnbaum, S. B., Brateman, L. F., Hevezi, J. M., Mettler, F. A., Morin, R. L., Pentecost, M. J., Smith, G. G., Strauss, J. K., and Zeman, R. K., (2007). Radiation Dose in Medicine. *Journal of American College of Radiology*. 4: 272-281.

[5] Attwood, D. T., (2000). *Soft X-rays and Extreme Ultraviolet Radiation*, *Principles and Applications.* Cambridge: Cambridge University Press. p. 2.

[6] Cakir, T., Gur, A. and Arasoglu A. (2012). The Comparison of Absorbed Dose Measurements for Water and Artificial Body Fluid. *Iran. Journal of Radiation Research*, 10 (3-4): 157

[7] Canadian Nuclear Safety Commission (CNSC a), (2012). *Introduction to Dosimetry.* Published by the Canadian Nuclear Safety Commission (CNSC). CNSC catalogue number: INFO-0827. ISBN 978-1-100-19735-7.

[8] Canadian Nuclear Safety Commission (CNSC b), (2012). *Introduction to Radiation.* Published by the Canadian Nuclear Safety Commission (CNSC). ISBN 978-1-100-21572-3.

[9] Carl, A. C. and Gudrun A. C. (1996). *Basic Physics of X-ray Imaging.* Department of Medicine and Care Radio Physics Faculty of Health Sciences. Second Edition, 8. pp. 5, 22.

[10] Cullity, B. D., (1956). *Element of X-ray Diffraction.* New York: Addison-Wesley Publishing Company Inc.

[11] Eljak, S. N. A., Ayad C. E., and Abdallah, E. A., (2015). Evaluation of Entrance Skin Radiation Exposure Dose for Pediatrics Examined by Digital Radiography at Asser Central Hospital-KSA. *Open Journal of Radiology*, 5: 126. http://dx.doi.org/10.4236/ojrad.2015.53019.

[12] Gerber, T. C., Jeffrey, J. C., Arai, E. A., Dixon, R. L., Ferrari, V. A., Gomes, A. S., Heller, G. V., McCollough, C. H., McNitt-Gray, M. F., Mettler, F. A., Mieres, J. H., Morin, R. L. and Yester, M. V, (2009). Ionizing Radiation in Cardiac Imaging. *American Heart Association, Inc.* http://circ.ahajournals.org.

[13] Goodhead, D. T. (2014). What is Radiation Quality? *Medical Research Council, UK. EURADOS Winter School Budapest*.

[14] Hussien, A. A. B. (2008). Estimation of Surface Dose (Skin Absorbed Dose) for the Patient Undergoing Standards Radiologic Examinations. *Journal of Kerbala University*, 6 (1): 1-7

[15] Ibrahim, U., Daniel, I. H., Ayaninola, O., Ibrahim, A., Hamza, A. M. and 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. ISSN 1597-6343.www.scienceworldjournal.org,

[16] International Agency for Research on Cancer (IARC), (2013). *IARC Monographs on the Evaluation of Carcinogenic Risk on Humans. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields*. France. 102: 97. ISBN 978-92-832-1325-3.

[17] International Atomic Energy Agency (IAEA), (2007). Dosimetry in Diagnostic Radiology: An International Code of Practice. Technical Reports Series No. 457. 92–0–115406–2.

[18] International Atomic Energy Agency (IAEA), (2014). *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards.* IAEA Safety Standards for protecting people and the environment. IAEA Safety Standards Series No. GSR Part 3. http://www-ns.iaea.org/standards.

[19] International Commission on Radiological Protection (ICRP) (2008). *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP Publication 106. 34 (1-2): 26.

[20] International Commission on Radiological Protection (ICRP), (2005). *Basis for Dosimetric Quantities Used in Radiological Protection.* Draft for Discussion. http://www.icrp.org.dosimetricquantites.

[21] International Commission on Radiological Protection (ICRP), (2011). *Effective Dose: A Radiation Protection Quantity.* ICRP Symposium on the International System of Radiological Protection. www.icrp.org.

[22] Jabbari, N., Zeinali, A. and Rahmatnezhad, L. (2012). Patient Dose from Radiographic Rejects/Repeats in Radiology Centers of Urmia University of Medical Sciences. *Iran Health.* 4 (2): 94-100. http://dx.doi.org/10.4236/health.2012.42015.

[23] 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.

[24] Kundu, M. R., White. S. M., Gopalswamy, N. and Lim, J. (1993). Millimeter, Microwave, Hard X–ray and Soft X–ray Observations of Energetic Electron Populations in Solar Flares. *Astrophysical Journal Supplement*.

[25] Kwan-Hoong Ng, (2003). Non-Ionizing Radiations–Sources, Biological Effects, Emissions and Exposures. Proceedings of the International Conference on Non-Ionizing Radiation at UNITEN (ICNIR2003).

[26] Latin American Experts Committee (LAEC), (2010). *Non-Ionizing Electromagnetic Radiation in the Radiofrequency Spectrum and its Effects on Human Health.* The Edumed Institute for Education in Medicine and Health Independent Research Group on the Impacts of Mobile Technologies on Health.

[27] Lawson, R. S., (1999). *An Introduction to Radioactivity.* Nuclear Medicine Department Manchester Royal Infirmary.

[28] Maine Center for Disease Control (MCDC), (2010). *Health Effects of Non-ionizing Radiation.* Government or Government Affiliated Resources.

[29] Medoff, R. J. (2009). Radiographic Evaluation and Classification of Distal Radius Fractures. In*: Fractures and Injuries of the Distal Radius and Carpus*; 17-31 DOI: 10.1016/B978-1-4160-4083-5.00005-6.

[30] Muhammad, A. M., Idris, I. S., Simon, P. M., and Abdulahi, S. A. (2010). Determination of Absorbed and Effective Dose from Natural Background Radiation around a Nuclear Research Facility. *American Journal of Environmental Sciences,* 7 (2): 173-177

[31] National Aeronautics and Space Administration (NASA), (2014). *Types of Radiations in Space.* NP-2014-03-001-JSC.www.nasa.gov.

[32] National Radiological Protection Board (NRPB), College Radiographers, Royal College of Radiographers and Royal College of General Practitioners, (2001). *X-rays: How Safe are they?* Chilton: NRPB, www.nrpb.org.uk, www.sor.org, www.rcr.ac.uk, www.rcgp.org.uk.

[33] Nigerian Nuclear Regulatory Authority (NNRA), (2006). *Arrangement of Regulations. Nuclear Safety and Radiation Protection*. pp. B691-B692. www.vertic.org/.../Nigeria/_Nigerian.

[34] Okoye, P. C. and Avwiri, G. O., (2013). Optimization of Absorbed Dose in Chest X-Rays of Pediatric Patients at Braithwaite Memorial Specialist Hospital, Port Harcourt. *American Journal of Scientific and Industrial Research Science*, 4 (4): 349-358. http://www.scihub.org/AJSIR.

[35] Olowookere, C. J., Babalola, I. A., Jibiri, N. N., Obed, R. I., Bamidele, L. and Ajetumobi, E. O., (2012). A Preliminary Radiation Dose Audit in some Nigerian Hospitals: Need for Determination of National Diagnostic Reference Levels (NDRLs). *The Pacific Journal of Science and Technology.* 13 (1): 487-491. http://www.akamaiuniversity.us/PJST.htm.

[36] Oluwafisoye, P. A, Olowookere, C. J., Obed, R. I., Efunwole, H. O. and Akinpelu, J. A. (2009). Environmental Survey and Quality Control Tests of X-Ray Diagnostic Facility of a Large Nigerian Hospital. *International Journal of Research and Reviews in Applied Sciences*, 1 (2): 157. ISSN: 2076-7366.

[37] Papadogiannis, K. P., (2012). *Dosimetry of Upper Extremities of Personnel in Nuclear Medicine Hot Labs.* University of Patras School of Medicine, Department of Physics. pp. 1-100.

[38] Paragjyoti, G., Krishanu, K., Sunil, P., Aditi. D., (2013). A Rare Case of Fish Bone Penetrating Injury to Radius Causing Osteitis and Non-Healing Sinus. *Open Journal of Orthopedics*, 3: 220 & 223. (http://www.scirp.org/journal/ojo). http://dx.doi.org/10.4236/ojo.2013.35041.

[39] Radiographic Procedures Manual (2014). *Remote Operators Radiographic Licensing.* Department of Health. Northern Territory Government. pp. 1-95.

[40] Roesler, S., and Silari, M., (2012), Radioactivity and Radiation Protection. *European Council for Nuclear Research (CERN)*.

[41] Stecker M. S., Balter, S., Towbin, R. B., Miller, D. L., Vañó, E., Bartal, G., Angle, F., Chao, C. P., Cohen, A. M., Dixon, R. G., Gross, K., Hartnell, G. G., Schueler, B., Statler, H. D., de Baère T. and Cardella, J. F., (2009). Guidelines for Patient Radiation Dose Management. *Journal of Vascular and Interventional Radiology* 20 (7S): S263–S273.

[42] Sulieman, A. (2014). Current Status of Radiation Dose Levels in Conventional Pediatric Radiography: A Review Study. *Open Journal of Radiology*, 5: 105-106. http://dx.doi.org/10.4236/ojrad.2015.52016.http://www.scirp.org/journal/ojrad.

[43] Taha, M. T., Al-Ghorabie, F. H, Kutbi, R. A. and Saib, W. K. (2014). Assessment of Entrance Skin Doses for Patients Undergoing Diagnostic X-ray Examinations in King Abdullah Medical City, Makkah, KSA. *Journal of Radiation Research and Applied Sciences*, 8: 100

[44] United Nations Scientific Committee on Effect of Atomic Radiation (UNSCEAR).(2010). *Sources and Effects of Ionizing Radiation.* New York: United Nations, 1: 24

[45] United States Nuclear Regulatory Commission (USNRC) (2006). *Radiation Protection and the NRC.* Washington, D. C.

[46] University of Washington (UW), Environmental Health and Safety (2004). *Personnel Exposure and Monitoring.* Radiation Safety Manual pp. 3-5.

[47] World Health Organization (WHO) (2009). Children and Radiation. Children's Health and the Environment, WHO Training Package for the Health Sector World Health Organization. pp. 3-37. www.who.int/ceh.