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Evaluation of Radiological Health Hazard Indices Arising from Diagnostic X-Ray Rooms

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Abstract: The effective dose of selected health care workers who are constantly exposed to X-ray radiation was measured using thermoluminescence dosimeters (TLD) placed over the lead apron at the chest region in all categories of medical personnel investigated. The objective is to conduct radiation measurements in various chosen hospitals to determine the level of exposure from X-ray machines precisely at a distance of 1 meter from the primary source. The work was carried out within a year in each of the selected centers. The personnel examination records containing the type of examination each day, peak tube voltage, tube current, and exposure time, including the actual number of films used, were obtained. A total of 40 personnel were examined in the Government Hospital, Agbor, 21 in Central Hospital Owa Alero and 18 in Okonye Hospital. The method used here has also been used by other researchers. Findings showed that the results obtained from the three hospitals investigated in this work were found to conform with the recommendations of the National Commission on Radiological and Protection {NCRP} 70 and 116 protocols. The Radiologists in the three study areas have the highest dose level, but of particular note is the dosage of the radiologists in Okonye hospital. This, as observed, is because the protective shielding parameters were inadequate and this could result in severe health consequences over time.

Keywords: Agbor, Okonye, Owa, Radiology, X-Ray.

1. INTRODUCTION

X-rays are harmful to human tissues and cells. X-ray machines are commonly used in hospitals for clinical diagnosis. They produce electromagnetic waves of very high frequency and short wavelengths. X-rays have a shorter wavelength than ordinary light. It is produced in the X-ray tubes, as shown in Fig. 1

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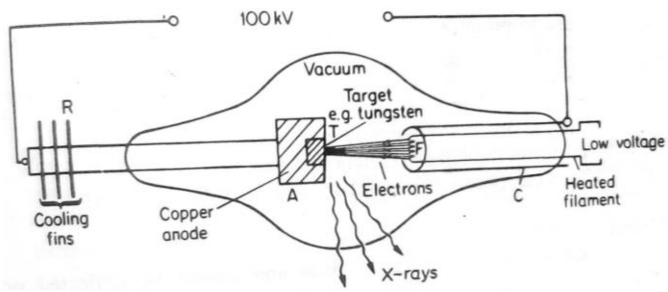

Fig. 1 X-ray production tube [Idialu & Obi 2003]

X-rays are generally produced when an electron beam bombards certain materials with a high velocity. The rapid deceleration of the electrons generates electromagnetic forces, which produce radiation. X–rays are similar to gamma (Y) rays because both are electromagnetic but differ in their production. Gamma (Y) rays are produced during radioactive decay, while x–rays are produced when electrons bombard certain materials at high velocity. The apparatus used in producing X–rays are shown in Fig. 1. A significant quantity of heat is produced during X–ray production. The copper anode significantly helps conduct the heat away if the system is cooled by external circulating oil. The tungsten is not affected since it has a high melting point. Electrons colliding with the walls or electrodes of a discharged tube can also produce it [Idialu & Obi 2003].

Description of X-Ray Tubes

The X-ray tube consists of a glass envelope containing the cathode filament concave in nature, the anode or tungsten target, and the vacuum, i.e., the tube evacuated of air so that electrons from the cathode are not hindered. When the cathode filament is heated electrically (by current from the source), a stream of electrons called the cathode rays (i.e., rays from the cathode) are emitted, potentially about 100,000 V, so that the electrons reach the anode target with high energy (Farai, and Jibrin, 2000). The cathode must be at a very high energy, rays strike the target, a tiny part of the energy is converted to x-radiation (x-rays), and the other energy is converted to heat so that the anode becomes hot. In the hospitals, the anode is cooled by water.

Uses of X-Ray

X-rays are used for the following purposes:

v Medical purposes for photographic films or radio graphs by allowing X-rays to pass through the human body so that it detect fractured bones or joints.

- To discharge electrified bodies, whether positive or negative electricity.
- To produce photoelectric emission.
- To detect defects in metals.
- To check and study crystal structures.
- Employed by medical experts for the treatment of tumors.
- To detect metals such as guns at airports

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Disadvantages of X-Rays

Frequent exposure of the body to X–rays damages the cells of the body, including the chromosomes in the nucleus of the cell (Niklason et al.,1994), which may lead to severe genetic problems.

Objectives of Research

This research aims to investigate and evaluate the radiological health indices/hazards to health workers associated with the operation of x-ray machines in and around three selected hospitals in Agbor and Owa metropolis in Delta State, Nigeria.

2. RELATED WORKS

Several studies have explored the evaluation of radiological health hazard indices associated with diagnostic X-ray rooms, shedding light on healthcare workers' potential risks. Molua et al. (2022a) work focused on measuring radiation exposure in different medical facilities using various dosimetry methods. The findings underscored the significance of continuous monitoring to ensure compliance with safety standards and to mitigate potential health risks among medical personnel. Additionally, the study conducted by Eseka et al (2018) delved into the impact of X-ray radiation on specific categories of healthcare workers. Their research categorized health professionals based on their roles and responsibilities, highlighting variations in radiation exposure levels. This categorization proved essential in identifying high-risk groups, emphasizing the importance of tailored safety measures for individuals with distinct roles within diagnostic X-ray rooms. The research conducted by Molua, et al (2022) provided insights into the effectiveness of shielding parameters in reducing radiation exposure. Their investigation evaluated the impact of different shielding materials and techniques on minimizing scatter radiation in X-ray rooms. This work contributes valuable knowledge to the current study by emphasizing the pivotal role of shielding parameters in ensuring the safety of healthcare workers and patients alike. Moreover, the international perspective on radiological health hazard indices is explored in the work of Molua, O. Collins (2023). Their study compared and contrasted the radiological protection protocols and dose limits set by various global health organizations. Understanding these international standards is crucial for contextualizing the current research findings within the broader framework of global radiological safety guidelines. In summary, the existing body of literature evaluating radiological health hazard indices from diagnostic X-ray rooms provides a comprehensive foundation for the present study. Collectively, these works underscore the importance of continuous monitoring, role-based risk assessments, effective shielding parameters, and adherence to international safety standards in ensuring the well-being of healthcare workers exposed to X-ray radiation.

3. METHODOLOGY

The study covers one year, from January 2nd, 2020, to December 31st, 2021, and includes 40 health personnel from Central Hospital Agbor, 21 from Owa-Alero Hospital, and 18 from Okonye Hospital. Various categories of health workers were investigated, and their effective

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dose was measured using thermoluminescence dosimeters (TLD) placed over the lead apron at the chest region (More et al., 2011). In this study, we tried to evaluate effectively the amount of radiation dose received by health workers in the selected hospitals for a period of 1 year (January 2nd, 2020, to December 31st, 2021); a total number of 40 health personnel were chosen for the investigation from Central Hospital Agbor, 21 from Owa-Alero Hospital and 18 from Okonye Hospital. In each of these hospitals, the monitored workers were grouped into different categories based on their area of responsibility (Nassef & Kinsara, 2017; Molua et al., 2022). The group includes Orthopedic surgeons, cardiologists, neurosurgeons, cleaners, catheterization nurses, urologists, clerical personnel, surgical nurses, radiologists, and radiology technicians. Their effective dose was measured using thermo luminescence dosimeters (TLD) placed over the lead apron at the chest region in all categories of medical personnel investigated. It should be noted that the method applied here has also been employed by other researchers (Gourzoulids et al., 2018; Molua O Collins, 2023; Eseka et al., 2022b). Breaking radiation occurs when an electron beam strikes a specific substance at high speed. The rapid deceleration of electrons creates an electromagnetic force that produces radiation. X-rays are similar to gamma rays (Y) because they are both electromagnetic but have different outputs. Gamma rays (Y) are produced by radioactive decay, whereas X-rays are produced when electrons collide with certain substances at high speed (). The device used to take X-rays is shown in Fig. 1. When X-rays are generated, a large amount of heat is released. The copper anode helps dissipate heat significantly if the system is cooled with external circulating oil. Because tungsten has a high melting point, it is not affected by this.

4. RESULTS AND DISCUSSION

Table I: Total Number of Health Workers Monitored Showing work-Based Classification

Role of Health Worker	**Number Investigated**
Orthopedic surgeons	10
Cardiologist	4
Neuro surgeons	3
Cleaners	4
Catheterization nurses	5
Urologist	2
Clerical personnel	5
Surgical nurses	9
Radiologist	6
Radiology technicians	5
Total	52

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Table II Number of Health Workers Monitored in Central Hospital Agbor showing Work Base Classification of Monitored Personnel

Role of Health Worker	Number Investigated
Orthopedic surgeons	5
Cardiologist	2
Neuro surgeons	1
Cleaners	1
Catheterization nurses	2
Urologist	2
Clerical personnel	1
Surgical nurses	3
Radiologist	2
Radiology technicians	2
Total	21

Table III Number of Health Workers Monitored in Owa- Alero hospital showing Work Base Classification of Monitored Personnel

Role of Health Worker	Number Investigated
Orthopedic surgeons	3
Cardiologist	1
Neuro surgeons	1
Cleaners	3
Catheterization nurses	2
Urologist	1
Clerical personnel	2
Surgical nurses	3
Radiologist	2
Radiology technicians	2
Total	18

Table IV Measured Radiation Dose Obtained in Central Hospital Agbor: Workers' Current Average Annual Dose. {Msv}

Role of Health Worker	Average Annual Dose
Orthopedic surgeons	0.14
Cardiologist	0.33
Neuro surgeons	0.17
Cleaners	0.11
Catheterization nurses	0.54
Urologist	0.57
Clerical personnel	0.23
Surgical nurses	0.87
Radiologist	2.55
Radiology technicians	1.89

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Unscear Limit: 20 mSv

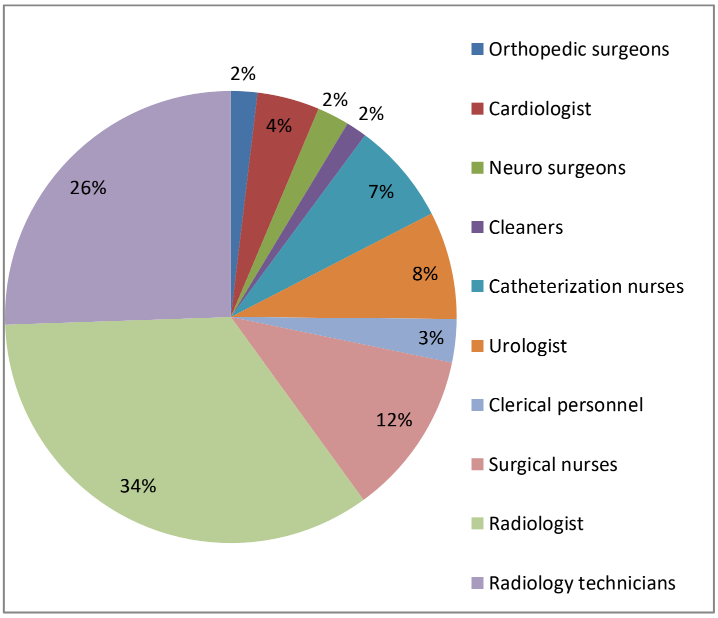

Fig. 2 Average annual radiation dose for workers at Agbor Hospital

Table V Measured Radiation Dose in Central Hospital Owa-Alero: Workers' Current Average Annual Dose. {mSv}

Nature of Health Worker	Average Annual Dose
Orthopedic surgeons	0.34
Cardiologist	0.53
Neuro surgeons	0.19
Cleaners	0.45
Catheterization nurses	2.40
Urologist	3.57
Clerical personnel	0.12
Surgical nurses	0.67
Radiologist	5.01
Radiology technicians	3.00

Unscear Limit: 20 mSv

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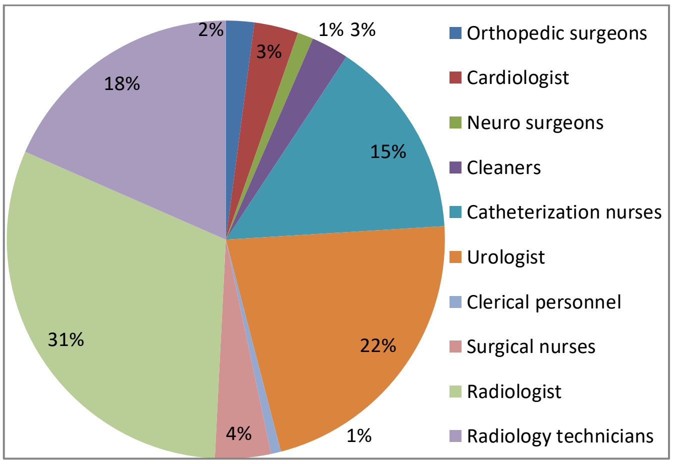

Fig. 3 Average annual radiation dose for workers at Owa Hospital

Table VI Measured Radiation Dose in Okonye Hospital: Workers' Current Average Annual Dose {Msv}

Nature of Health Worker	Average Annual Dose
Orthopedic surgeons	0.94
Cardiologist	3.43
Neuro surgeons	0.67
Cleaners	0.41
Catheterization nurses	7.94
Urologist	5.17
Clerical personnel	0.45
Surgical nurses	2.10
Radiologist	8.18
Radiology technicians	2.11

Unscear Limit: 20 mSv

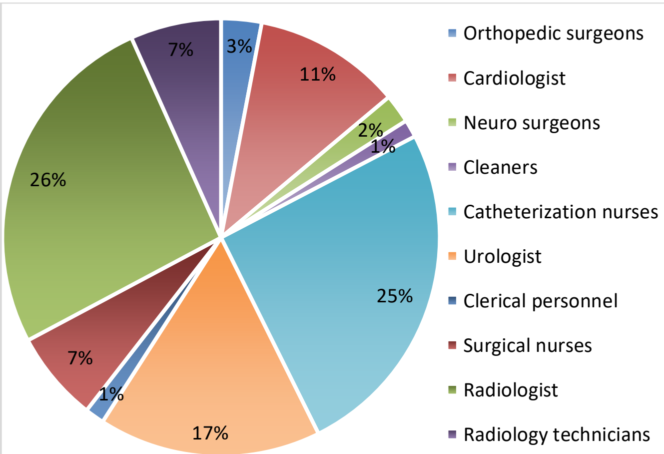

Fig. 4 Average Annual Radiation Dose for Workers At Okonye Hospital

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From Table IV, all the results obtained from the Central Hospital Agbor were far below the recommended average annual practical dose limit, which, according to UNSCEAR, is placed at a value of 20 mSv (Eseka et al., 2018). Again, it was also observed from Agbor Hospital that the Radiologist had the highest dose limit of 2.55 mSv, while it was lowest for the cleaners at 0.11 mSv. The high annual doses obtained for the radiologists in all the hospitals can be attributed to their roles as radiologists. Also, from Tables V and VI, it was observed that the dose limit from the Radiologist in Owa-Alero and Okonye hospitals was found to be 5.01 mSv and 8.13 mSv, respectively. The Radiologist in Okonye Hospital has the highest dose value of 8.13 mSv; this is the highest among all three hospitals investigated and can be attributed to the inadequate shielding parameters observed in the x-ray room in the hospital, probably because it is located in a rural setting (Eseka et al., 2022a). The results present the measured radiation doses obtained in each hospital, categorizing health workers based on their roles. The findings indicate that the annual adequate dose limits for all health personnel were below the recommended limit of 20 mSv, according to the UNSCEAR guidelines. The radiologists consistently had the highest dose levels, with the Radiologist in Okonye Hospital recording the highest dose value of 8.13 mSv. The outcome of these findings has been made known to the management of these hospitals, particularly those at the Okonye Hospital, for possible improvement in the provision of modern shielding parameters.

5. CONCLUSION

The results emphasize the importance of adherence to safety protocols and the potential health consequences of inadequate shielding parameters. The higher radiation doses for radiologists, particularly in Okonye Hospital, are attributed to inadequate shielding, possibly due to the hospital's rural location. The study suggests that improvements in shielding parameters are necessary to mitigate potential health risks for radiologists and other health workers. The study concludes that the measured annual dose limits for health personnel in the investigated hospitals were well below the international recommended average dose limit. The findings have been communicated to the hospitals' management, emphasizing Okonye Hospital, where inadequate shielding parameters were identified. The conclusion reinforces the importance of protecting healthcare workers by maintaining radiation exposure within safe limits. In summary, the research presented provides valuable insights into the radiological health hazard indices in diagnostic X-ray rooms, emphasizing the importance of adherence to safety protocols and the need for continuous monitoring and improvement in shielding parameters to ensure the well-being of healthcare workers exposed to X-ray radiation.

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The researchers are genuinely grateful to the Management and Staff of Central Hospital Agbor, General Hospital Owa, and Okonye Hospital for their permission and cooperation throughout the study; special thanks go to the health personnel who made themselves available for the research.

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