



Occupational Radiation Dose Absorbed by Radiographers in Port Harcourt, Rivers State

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Received: August 18, 2023 / Accepted: January 3, 2024

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Abstract

Radiographers in Nigeria are exposed to very high radiation risk because of their great dependence on refurbished x-ray equipment. This study therefore seeks to assess the level of dose adsorption by some personnel in radio-diagnostic centres in Port Harcourt, Rivers State in the Niger Delta region from 2020 to 2022. The research was a cross-sectional prospective survey that assessed the amount of absorbed dose among individuals working in radio-diagnostic centres in Port Harcourt, Rivers State. The study focused on government-owned hospitals and private imaging centres in the city. The entire study population was eighty (80). The acquired data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 21.0 developed and distributed by SPSS Incorporated, Chicago, Illinois. Analysis of the results reveals that the mean doses received by radiographers in government hospitals and private imaging centres are 0.4882 mSv and 0.5463 mSv over the two-year period under investigation respectively.

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These correspond to mean annual doses of 0.2442 mSv for radiographers in government hospitals and 0.2732 mSv for those in private centres. From these findings, we conclude that the occupational radiation dose received by government diagnostic workers is less than that of private centres in Port Harcourt, Rivers State. By comparison, the average mean doses for both government hospitals and private centres are well below the occupational dose limit of 20 mSv set by International Commission on Radiological Protection (ICRP). This essentially suggests that there were no circumstances of overexposure for the radiographers during the time under investigation. A greater knowledge of radiation protection techniques, as well as the use of advanced equipment and technology available in this field, has contributed immensely to an improvement in the status of radiation protection in the centres investigated. It is however recommended that radiation protection and safety training should be included in the required training of radiology practitioners, particularly for graduates. In addition, there is need for regular continuing professional education (CPE) in this field.

Keywords: Absorbed Dose; Exposure Rate; Ionizing Radiation; Average Dose, Radiographers

1.0 Introduction

Individuals worldwide frequently encounter natural, minimal-level background radiation as well as radiation originating from human activities, predominantly stemming from medical procedures. Ionizing radiation is recognized for its capacity to induce adverse impacts on various organs and systems within the human body, including the digestive system, skin, reproductive system, central nervous system, and, ultimately, the entire body, as documented by Edith and Philomina (2019). Exposure to ionizing radiation can result in outcomes like skin cancer, erythema, cataracts, and genetic mutations (Borhani and Alizade, 2009). There are both naturally occurring and man-made sources of radiation. Besides its scientific and industrial uses, radiation is also used medically for diagnostic and therapeutic purposes. However, these are not without the risk of potential harmful effects on both patients and staff. Medical exposure accounts for 90% of exposure to man-made radiation (Ishiguchi, 2000, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2012).

X-ray is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in effective healthcare delivery both in developed and developing countries (Olowookere *et al.*, 2012). It is known that of all man-made sources of ionizing radiation, diagnostic x-ray contributes the largest part to the collective population dose leading to somatic and genetic effects on human beings (UNSCEAR, 2012). Occupational doses are energies of radiation deposited or absorbed by individuals working in radiological industry. The basic quantity used to measure absorbed dose from ionizing radiation is gray (Gy). It is defined as 1 Joule of initial energy (of charged

particles released by the ionization events) per kg of tissue (UNSCEAR, 2012).

Some recently designed X-ray machines possess the capability to furnish information regarding radiation exposure in terms of absorbed dose. An illustration of such equipment is a spacious ionization chamber integrated into the X-ray machine, facilitating the direct measurement of radiation output. In cases where X-ray machines lack this feature, it becomes important to identify an alternative method for gauging radiation output. Radiographic film serves as a means to document the radiation exposure at the skin's entry point and is proficient in capturing substantial radiation doses. The exposure to radiation presents potential hazards for both healthcare providers and patients within healthcare facilities (HCFs). While radiographic imaging holds immense value as a diagnostic tool in the field of medicine, it's imperative to recognize the well-established risks associated with ionizing radiation and computed tomography (CT) scans. Implementing personnel and radiation safety monitoring emerges as a critical safety measure in the practice of radiography (Osahon *et al.*, 2017).

Nzotta and Chiaghanam (2010) have documented that radiographers in Nigeria are exposed to high radiation risks due to their dependence on refurbished equipment, it is therefore necessary that the values gotten from both the government and private establishment be compared for the sake of review. Radiographers are trained personnel who are licensed to dispense radiation, particularly ionizing radiation. Radiographers, as a result of their job, are exposed to chronic low doses of radiation mainly from scattered radiation and this constitutes an occupational hazard.

Frequent surveillance of the radiation exposure levels encountered by personnel within the radiology department holds significant

significance. This practice is essential for safeguarding the well-being of both staff members, patients and as well as the general public against the potential consequences of excessive radiation exposure during and following radiological procedures (Okaro *et al.*, 2010). Such vigilance ensures occupational safety by consciously avoiding exceeding established dose limits. According to the guidelines set forth by the International Commission on Radiological Protection (ICRP), the accepted dose limit for occupational personnel is 20 mSv per year, averaged over a five-year period (equivalent to 100 mSv in five years) (ICRP, 1991). The United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR, 2012) has reported that the worldwide mean annual occupational dose in nuclear medicine and diagnostic radiology is below 2 mSv. In recent times, accessibility to modern medical imaging machines in facilities in Rivers State has increased tremendously. This has resulted in an increased risk of radiation exposure for patients and health workers particularly radiographers who are daily involved in dispensing ionizing radiation. The Nigerian Basic Ionizing Radiation Regulations (NBIRR) has recommended an effective dose limit of 20 mSv/year averaged over 5 years, not to exceed 50 mSv in any one (1) year for an employee aged 18 years and above and 6 mSv for a trainee under the age of 18 years (NBIRR, 2003). Studies of occupational radiation dose have focused mainly on the physicians who carry out interventional radiological procedures (Chida *et al.*, 2013). There is limited data on the exposure records of radiographers in Rivers State who are essential in the radiology department. Radiographers in private practice have been adjudged to be mindful of radiation practices that reduce doses to patients and staff when compared to their government counterparts in the western world. The dangers of chronic exposure to ionizing radiation which

can cause somatic and/or genetic damage to radiographers in Port Harcourt, Rivers State and indeed to mankind can be mitigated when factual studies from the state are documented. Thus, this study is aimed at determining the occupational radiation dose to radiographers and their opinion on radiation protection measures in Port Harcourt, Rivers State, Nigeria.

2.0 Materials and Method

This research is a cross-sectional survey that assesses the amount of absorbed dose among radiographers in Port Harcourt, Rivers State. The study focuses on government hospitals and private imaging centres in Port Harcourt, Rivers State. This research is both quantitative and qualitative in nature. It involved the use of interviews through a questionnaire and observation via the collected dose information of the radiographers from government hospitals and private imaging centres. The tools for collecting data are a fourteen-item-semi-completed questionnaire and dose records from government hospitals and private imaging centres in Port Harcourt, Rivers State.

2.1 Location of Study

This study was carried out among radiographers in government hospitals and private imaging centres in Port Harcourt, Rivers State. The hospitals and imaging centres examined in this study are shown in Table 1. The hospitals and private centres are chosen because they have more than one (1) piece of imaging equipment, respectively.

2.2 Data Presentation

Table 2 shows that a total of eighty (80) questionnaires were distributed out of which fifty-five (55) were completely and correctly filled out and returned. These fifty-five (55) responses were utilized in this study, giving total of sixty-eight percent (66.8%) response rate.

Table 1: Location of study

Name of Hospital & Private Centers	Location	Designation
A	Old GRA	Center 1
B	East West Road	Center 2
C	Rukpoku	Center 3
D	D-Line	Center 4
E	Elelenwo	Center 5
F	Orazi	Center 6
G	Eliozu	Center 7

Table 2: Questionnaire Response Pattern

Number	Number	Number	Percentage
Administered	Returned	Used	Used
80	55	55	68.8%

2.3 Data Analysis

Information examination is the process of efficiently applying measurable as well as sensitive methods to depict, present and analyze information and data. The data obtained were analyzed using the Statistical Package for Social Science (SPSS) computer software. A descriptive statistical tool was used to analyze the quantitative variables which were expressed as mean, percentage and frequency. Also, the variables were represented both in bar charts and pie chart. A student t-test was used to analyze the correlation (how closely related two variables are) between doses received by radiographers in government hospitals and doses received by radiographers in private imaging centers. $P \leq 0.05$ was taken as the reference level. The results of the analysis were presented in tables, pie charts and bar charts.

2.4 Demographic Analysis

The frequency and percentage distribution of respondent demographic information are shown in Table 3 and Figure 1. Out of the 55 respondents, the number of males was 40, constituting 72.7% while the number of female

was 15, constituting 27.3% of the respondents respectively. This shows that males are more than females in both government and private centres. Twenty-five (25) questionnaires were not utilized in this study as they were either completed incorrectly or not returned (Figure 1).

Table 4 and Figure 2 show the qualifications of the respondents as contained in the completed questionnaires. Seven of the respondents (12.7%) are the least educated with diploma from a Monotechnics. The number and percentage of B.Sc. and M.Sc holders are respectively 45 (81.8%) and 2 (6.7%) while 1 respondent (1.8%) has a Ph.D degree. The number of years of working experience of the respondents is summarized in Table 5 and Figure 3a. From the questionnaires, the number and percentage of radiographers with less than 5 years of working experience are 4 and 7.3%. Thirty-six (36) respondents (65.4%) had 6-10 years working experience while 15 (27.3%) had more than 10 years of working experience as shown in Table 5.

Table 6 and Figure 3b show the designations of

the radiographers both in government and private centers. 22 (40%) are intern, 26 (47.3%) are radiographers I and II and 7 (12.7%) are chief radiographers, respectively.

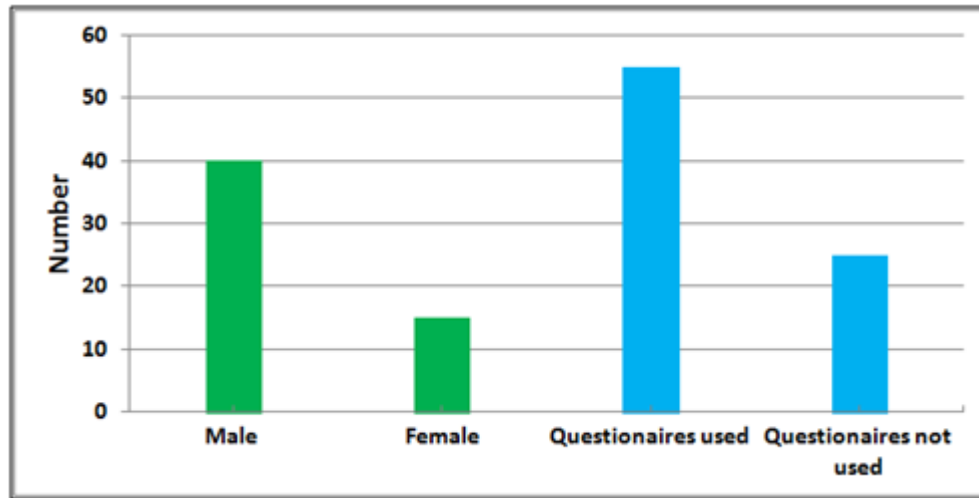


Figure 1: Distribution of respondent demographic information

Table 3: Number of male and female respondents

Gender	Frequency	Percentage (%)
Male	40	72.7
Female	15	27.3
Total	55	100

Table 4: Qualification of respondents

Qualification	Frequency	Percentage (%)
DRC	7	12.7
B.Sc	45	81.8
M.Sc	2	3.6
Ph.D	1	1.8
Total	55	100

* DRC is Dynamic Chest Radiography

Table 5: Years of Working Experience of the respondents

Years of Experience	Frequency	Percentage (%)
Below 5 years	4	7.3
6-10 Years	36	65.4
Above 10 years	15	27.3
Total	55	100

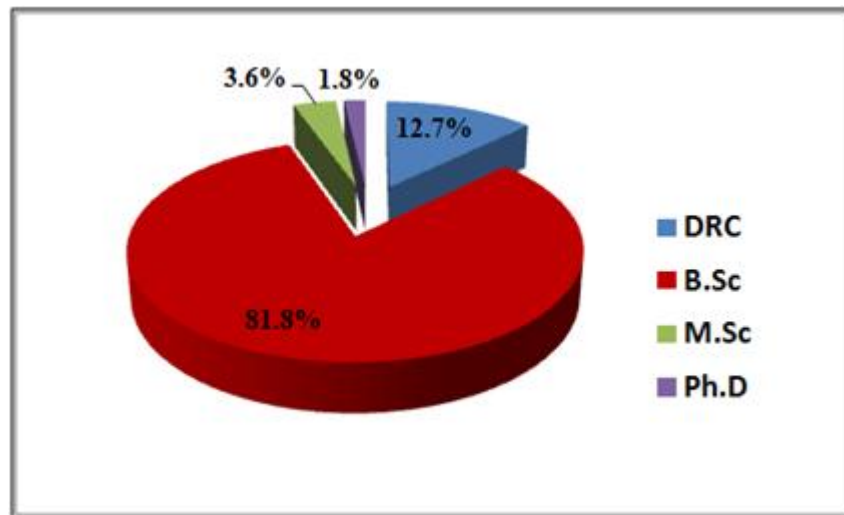


Figure 2: Pie chart showing the Qualifications of the respondents

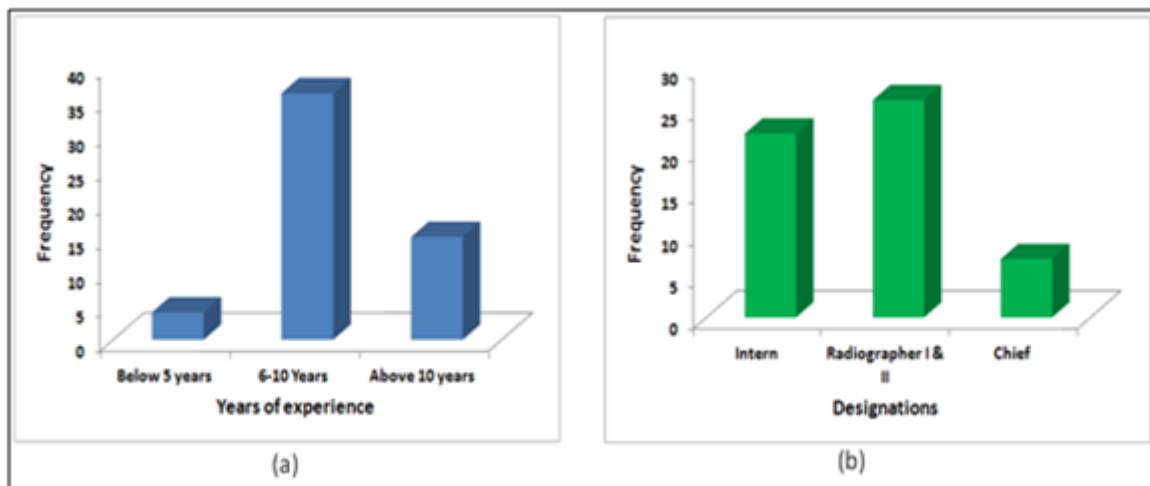


Figure 3: Bar chart showing (a) Years of experience of respondents (b) Designations of respondents

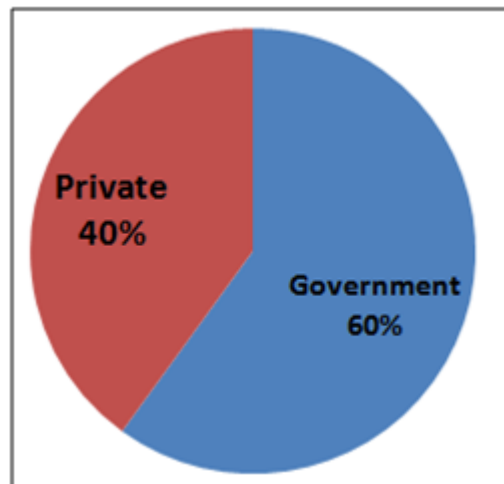
Out of the Fifty five (55) Radiographers that completely filled and submitted their questionnaires, 33 (60%) radiographers are from government centers while the remaining 22 (40%) are from private centers as shown in Table 7 and Figure 4 respectively

Table 6: Designations of respondents

Designations	Number	Percentage (%)
Intern	22	40
Radiographer I & II	26	47.3
Chief	7	12.7
Total	55	100

Table 7: Ownership of Establishment

Ownership	Frequency	Percentage (%)
Government	33	60
Private	22	40
Total	55	100

**Figure 4:** Ownership of Radiological centre

3.0 Dose Data

Table 8 below gives the statistics of the effective dose for two (2) years received by radiographers in the private centers in the sampled centers in Port Harcourt, Rivers State. The average mean dose over the period was 0.5463 mSv. Table 9 shows the average dose taken by radiographers at government hospitals to be 0.4883 mSv for a period of two years.

Table 10 gives a comparison of occupational radiation doses received by radiographers with local and international values. The annual mean doses obtained from this present study for both private and government hospitals are 0.2442 mSv and 0.2732 mSv respectively. These doses are lower than the doses presented in Table 10 except for Nsolta (Nigeria, 2010).

Table 8: Statistics of the effective doses and type of Equipment Used for Private Centres

Centre	Number of respondents	Minimum dose (mSv)	Maximum dose (mSv)	Mean dose (mSv)	Standard Deviation	Equipment type
A	8	0.45	0.81	0.61	0.18	X-ray, CT
B	5	0.46	0.85	0.655	0.83	X-ray, CT
C	4	0.41	0.42	0.415	0.005	X-ray, CT
D	5	0.41	0.56	0.48	0.075	X-ray, CT
Total	22	-	-	0.5463	0.5183	-

Table 9: Statistics of the effective doses and type of Equipment used for Government Hospital Dose Records

Centre	Number of respondents	Minimum Dose (mSv)	Maximum Dose (mSv)	Mean Dose (mSv)	Standard deviation	Equipment Type
E	10	0.36	0.49	0.425	0.065	X-ray, CT
F	9	0.35	0.48	0.415	0.064	X-ray, CT
G	14	0.35	0.9	0.625	0.275	X-ray, CT
Total	33	-	-	0.4883	0.52	-

Table 10: Comparison of occupational radiation doses received by radiographers with local and international values

Centre	Location	Year	Average mean dose (mSv)
Present Work	Port Harcourt	2023	Government Hospital = 0.49 Annual mean Dose = 0.24 Private Centre = 0.55 Annual Mean Dose = 0.27
Ogundare	Nigeria	2003	7.7
Ibitoye	Nigeria	2011	0.58
Nzolta	Nigeria	2010	0.11
Won	Ghana	2009	1.05
Chida	Pakistan	2012	0.60
Al	Kuwait	2014	1.05
Rasaq	Pakistan	2016	1.67

4.0 Data on awareness of radiation protection

All the centers in Port Harcourt, Rivers State had evidence of structural building/shielding. Personal monitoring did not cover all the radiographers in the centers. Responses to other radiation-based questions show that there were inconsistencies in radiation protection practices at the centers. Table 11 below shows that radiation shielding was provided in both the government hospitals and the private centers. However, there were inconsistencies in the following area: Personnel radiation monitoring, the use of personal protective devices, annual radiation training, the presence of a radiation

safety adviser (RSA), a radiation safety officer (RSO), quality control measures and the availability of a physicist.

5.0 Results and Discussion

The results presented in Tables 2 and 3 show the sequence of distribution of respondent demographic information. The total number of respondents was fifty-five (55) radiographers, of which 40 (72.7%) were males and 15 (27.3%) were females. Similarly, on the basis of qualification, 17(12.7%) had DCR (Dynamic Chest radiography), 45 (81.8%) had B.Sc, 2 (3.0%) had M.Sc. and 1 (1.8) had Ph.D. as shown in Table 4. In Table 5, the working

experience of the radiographers was considered with a view to determining the respondents with the highest years of experience. This shows that those with less than five (5) years of

experience were 4 (7.3%), between 6-10 years were 36 (65.4%) and 10 years and above were 15 (27.3%).

Table 11: Respondents responses on awareness of radiation protection

Questions	Responses		Inference
	Yes	No	
Personnel Radiation Monitoring (PRM) provided?	32 (58.2%)	23 (41.8%)	Inconsistent
Radiation shielding provided?	55 (100%)	0	Available
Do you always use Personal Protective Device (PPD)?	38 (69%)	17 (31%)	Inconsistent
Annual Radiation Training conducted?	40 (72.7%)	15 (27.3%)	Inconsistent
Presence of Radiation Safety Officer (RSO) or Radiation Safety Adviser (RSA)?	21 (38.18%)	34 (61.8%)	Inconsistent
Quality control measure available?	48 (87.3%)	7 (12.7%)	Inconsistent
Registered with certified physicist?	35 (63.6%)	20 (36.6%)	Inconsistent

Also, the ownership of the establishment was assessed and it was discovered that 33 (60%) were owned by the government and 22 (40%) were private imaging centres as shown in Table 6. On the basis of position, 22 (40%) were interns, 26 (43.3%) were radiographer I and II and 7 (12.7%) were chief as shown in Table 7 above.

From the analysis, it was discovered that respondents with the highest qualifications were those with Ph.D. In the same vein, respondents with the highest experience were those with 10 years and above of experience followed by 6-10 years and those with less than 5 years of experience. It was also observed that the respondents with the highest designation were chief radiographers.

The mean doses received by radiographers in government hospitals and private imaging

centres in Port Harcourt, Rivers State as shown in Table 10 are 0.4882 mSv and 0.5463 mSv over a period of two years respectively. For the purpose of annual dose values, the mean dose has been divided by the factor of two (2) to give the annual dose for radiographers in government hospitals as 0.2442 mSv while that of radiographers in private centres is 0.2732 mSv respectively.

By comparison, the average mean dose for government hospitals and private centres is below the ICRP occupational dose limit of 20 mSv. This is similar to what was found by Ibitoye *et al.* (2011), Chida *et al.* (2013) and Jabeen *et al.* (2010), where their average annual doses were found to be well below the established standard. The average mean dose values obtained are compared with other work done locally and internationally as shown in Table 10.

The findings of this research can also be compared with the findings of the study that was conducted by Rasaq *et al.* (2016) on occupational exposure to external radiation that was employed in medical practice in Pakistan through film badge dosimeter. According to their findings, the annual dose is 1.67 mSv throughout the period of study. The dose value is very low and fall significantly below the yearly limit of 20 mSv, which have been averaged over the course of five (5) years. This is because there was no single individual who had a radiation dose higher than 50 mSv in any of the five years that were measured, implying that there were no over-exposure conditions.

6.0 Conclusion

This study examined the radiation dose received by radiographers in Port Harcourt, Rivers State. This study also compares the dose received by radiographers in government hospitals and private centres in Port Harcourt, Rivers State and assesses their awareness of radiation protection measures through self-opinion from radiographers in government hospitals and private centres. The average effective dose incurred by radiographers over a period of two years is less than the maximum occupational dose of 20 mSv over five years set by the ICRP. However, the monitoring of radiographers in both centres does not meet the requirements of the International Standard and best practice around the world as shown in Table 11 because there were inconsistencies in the monitoring practices. This in essence implies that they were no over-exposure conditions for the personnel over the period investigated. A greater knowledge of radiation protection and techniques has resulted in the improvement of radiation protection in both government hospitals and private centres throughout the course of time. It is recommended that radiation protection and safety training should be included in the required training of radiology practitioners,

particularly for graduates. Equally, there is need for regular continuing professional education (CPE).

Conflict of interest: The authors declare that there are no known conflicts of interest.

Data availability: The datasets utilized in the current research are obtainable from the corresponding author on reasonable request.

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