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# MEASUREMENT OF LEAKAGE RADIATION DOSE TO PATIENTS UNDERGOING CHEST X-RAY IN SOME X-RAY FACILITIES IN WARRI TOWN. NIGERIA.

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## ABSTRACT

*The increase in the application of x-ray in health management has necessitated the need to determine the risk associated with its use. This study is aimed at measuring the leakage radiation dose to patients undergoing chest x-ray in twenty (20) radiological facilities in Warri, Delta State. A portable GMC-600 digital Geiger Muller Counter (serial number: 36311386254310) was used to examine the facilities. The leakage radiation was measured from both the cathode and anode terminals of the machines across the facilities studied and their mean exposure readings were obtained. The leakage radiation (mR/hr) values for the cathode terminal ranges from 0.21 – 100.27 mR/hr with an average of 26.46 mR/hr while the anode terminal is from 0.21 – 99.70 mR/hr with an average of 24.88 mR/hr. From the obtained results, it was observed that only one machine, $A_{10}$ (100.27 mR/hr) exceeded the recommended limit (100 mR/hr) for leakage radiation as stipulated by American Association of Physicist in Medicine (AAPM). This indicates that the workers and members of the public in the said facility could be exposed to some level of harmful radiations.*

**Keywords:** Leakage radiation, Dose, X-ray, Risk, ALARA.

## INTRODUCTION

The most common radiographic procedure for illness screening and diagnosis is the chest x-ray (CXR) examination because it offers significant clinical data at a reasonable cost and little radiation exposure. Although x-rays have many advantages, their ionizing nature could be harmful to patients, medical professionals, and the general public. Scattered and leakage radiation measurements could be used to examine the safety of CXR facilities at a few public hospitals (justin et al, 2018). Background ionizing radiation from both natural and artificial radiation sources is continuously absorbed by living things. Radiation effects are typically classified as stochastic effects (Boumala et al, 2019). Cosmic rays and terrestrial sources make up the natural radiation used to evaluate outdoor gamma exposure (Muttalip et al, 2021). Despite improvements in magnetic resonance imaging and ultrasound procedures, x-rays are still the most often used ionizing radiation in Nigerian medicine (Oluwafisoye et al., 2010). Due to the negative health effects of ionizing radiation, the majority of people, including many intellectuals, are too concerned about the risk of radiation, even in very minute quantities (ICRP 2007; Mesfin et al 2017;

Mangset and Adesida, 2019; Osward 2021). It is generally recognized that when biological tissue is exposed to ionizing radiation, complex chains of biomolecular processes can occur, leading to biological damage that relies on the dose or dose rate. An exposed atom loses orbital electrons, which leaves it positively charged. Living cells can be harmed by ionizing radiation exposure during diagnostic radiological procedures (ICRP 2007). According to the As Low as Reasonably Achievable (ALARA) principle, every effort should be taken to reduce radiation doses to workers and the general public below the necessary radiation limits. Therefore, the advantages of exposure should balance the risks of ionizing radiation exposure, while also minimizing all other exposures. A single exposure's dose might not be a hazard, but the cumulative dose from additional exposures raises the possibility of developing stochastic consequences (ICRP, 1991). By measuring the scattered radiation dose, a patient receives during an exposure, radiation workers and the general public can be protected from unnecessary exposures while also experiencing a reduction in radiation burden. This is not straightforward, though, because any estimate must take into account the energy and quantity of photons used, the size of patients, and the susceptibility of exposed tissues. (Medical/health physicists frequently carry out extensive calculations to precisely estimate the dose of radiation received by a specific patient during a radiograph. In order to address the growing concerns about radiation-induced somatic and heritable mutations, national and international radiation protection agencies have recommended the ALARA principle for radiation workers. (ICRP, 1991).

## MATERIALS AND METHODS

### Description of the study area

**Study Area**: Warri is recognized as the commercial center of Delta state since the majority of social, economic, and industrial activity in the state take place there rather than in Asaba, the state's capital. The city serves as a transit and conference town due to its advantageous location along the boundary between Nigeria's Eastern and Western regions. Due to the presence of hydrocarbons (oil and gas) within the city and surrounding areas, many oil and gas companies have their facilities (tank farms, gas plants, oil and gas wells, maintenance workshops, and offices) in the city as well as the Warri sea port, the Warri refinery, and the Warri petrochemical company. These elements, together with the existence of an army barracks and a naval base, contribute to Warri city's dense population. With nearly a million residents, the city is the fourth-most populous in Nigeria (Agbalagba, 2017). Figure 1, Show the map of the location of the x-ray centers in Warri metropolis.

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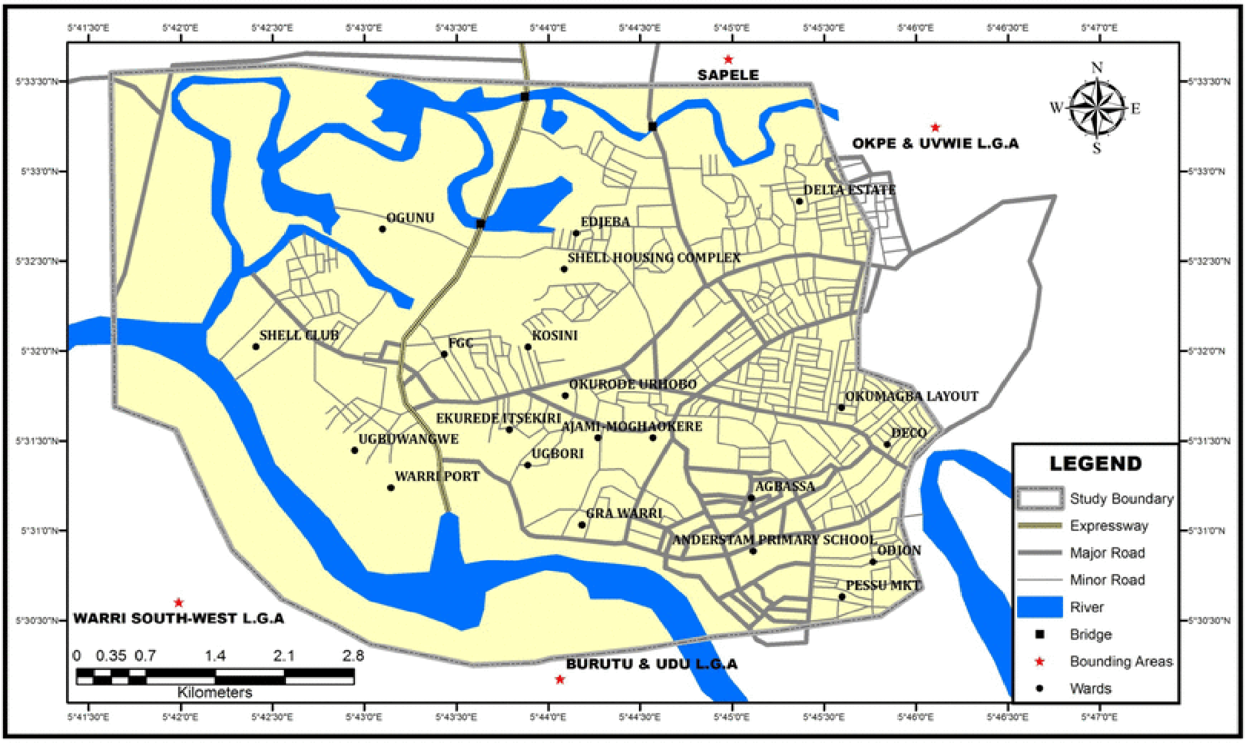


**Figure 1: Map of x-ray facilities study centers.**

**Table 1: Description of the studied facilities**

| S/N | EQUIPMENT NAME | MANUFACTURES | MODEL | MACHINE SERIAL NUMBER | DATE OF MANUFACTURE |
|---|---|---|---|---|---|
| 1 | COMET | COMET AG BERN SWITZERLAND | MULTISTATE 94-118 | MS-1 | |
| 2 | TOSHIBA | TOSHIBA ELECTRON TUBES AND DEVICES CO. LTD STOCHIGI JAPAN | E/876X | 14H235 | AUGUST 2014 |
| 3 | HYUN-DAI M EDICAL X-RAY | HYUN DAI MEDICAL X-RAY CO. LTD. 297-3 PAJU-CITYKYONGGI-DO KOREA | BMX1100 | 12MU81002 | MARCH 2012 |
| 4 | DHANWANTARI MEDICAL SYSTEM | DHANWANTARI MEDICAL SYSTEM | DIAGNOSTE-100 | - | 2012 |
| 5 | SIEMENS POLIMOBILE 2 | SEIMENS GERMANY | 8463468 X 1706 | 03055 S 02 | 2015 |
| 6 | PHILIPS | PHILIPS GERMANY | SUPER ROTALIX ROT 350 10 | 15532 | |
| 7 | COMET CH 3097 | COMET SA SUISSE LIEBEFELD SWITZALAND | DI 9-30/50-125 | 42-6628 | |
| 8 | GE MACHLETT | GEC MEDICAL EQUIPMENT LIMITED | MACHLETT | | |
| 9 | GENERAL ELECTRIC | GENERAL ELECTRIC COMPANY JAPAN | 46-270615P1H | 056-8 | DECEMBER 1992 |
| 10 | GENERAL ELECTRIC | GENERAL ELECTRIC COMPANY USA | 46-12368633 | 287874182 | 1993 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | GENERAL ELECTRIC | GENERAL ELECTRIC INDUSTRIAL PARK BANGALORE INDIA | 5331186 | 160/622BC1 | 2017 |
| 12 | MINDRAY | SHENZHEN MINDRAY BIO-MEDICAL ELECTRONICS CO LTD | CX-03 | 1A140641 | SEPTEMBER 2014 |
| 13 | TOSHIBA | TOSHIBA ELECTRON TUBES AND DEVICES CO. LTD OTAWARA-SHI JAPAN | E7876 | 4G0974 | AUGUST 2014 |
| 14 | TOSHIBA | TOSHIBA ELECTRONIC TUBES AND DEVICES CO. LTD JAPAN | E7884X | 18L350 | 2013 |
| 15 | TOSHIBA | TOSHIBA ELECTRONIC TUBES AND DEVICES CO. LTD JAPAN | E7884X | 18H1090 | 2019 |
| 16 | GENERAL ELECTRIC | GENERAL ELECTRIC COMPANY, MILWAUKEE, WISCONSIN U.S.A | OPTIMA XR | 21C1988 | JUNE 2018 |
| 17 | GENERAL ELECTRIC | GENERAL ELECTRIC COMPANY, MILWAUKEE, WISCONSIN U.S.A | E7894X | DF2402100415WK | JANUARY 2018 |
| 18 | SIEMENS POLY MOBILE PLUS | SIEMENS HEALTHCARE GERMANY | X22/XI01/01 | 240-0560-2 | 2020 |
| 19 | SIEMENS POLY MOBILE PLUS | SIEMENS HEALTHCARE GERMANY | X22/R103 | 214-338-XX5 | 2017 |
| 20 | ECORAY | ECORAY CO. LTD. KOREA | ULTRA 200 PLUS | ECO-M20-122-013 | 2019 |

(i) **Measurement of leakage radiation**

The main equipment used are:

GQ GMC -600 PLUS radiation detector, zamo digital laser tape.

## METHODS

Measurements were done in twenty (20) different x-ray facilities in Warri Delta State. Radiation detector**,** GMC 600 PLUS with serial number 36311386254310 by GQ Electronics, calibrated by National Institute of Radiation Protection and Research (NIRPR) with calibration certificate number: NIRPR/JUTH/22/231 was used. The lowest tube current (50 mA) station was selected that is appropriate for the ionization survey meter's response time. The highest tube potential (80 kVp) allowable was selected. Without exceeding the total heat capacity of the anode and the x-ray tube housing during the survey. With the Zamo digital tape a position on the surface of an imaginary sphere of 1 m radius with its-center located at the focal spot was used to position the radiation detector. Exposures were made with close collimator blades or block the collimator port with at least 10 half-value layer (HVL) equivalent of lead. The leakage radiation at the selected positions was then measured. The Instantaneous dose rate (IDR) readings were taken in μSv/hr directly from the display screen of the radiation detector. The results were then converted from micro-Sievert per hour (μSv/hr) to milli-roentgen per hour (mR/hr).

## RESULTS AND DISCUSSION

### Results

A total of twenty (20) measurements of x-ray leakage radiation were measured in Warri metropolis, Delta State. There was visual assessment on the x-ray machines before carrying out the reading to ascertain the level of functionality of the machines at the various centers. From the assessment, all x-ray

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machines passed all the visual checks except for two x-ray unites, $A_6$ and $A_{10}$. The indicator lights of $A_6$ was not working and hence the lights brightness cannot be determined nor can the collimators field type assessed. $A_{10}$ collimator displays sign of lights even when shutters were closed, this will surely have significant influence on the leakage radiation test. However, all the x-ray machines were functioning and in use at the time of the study.

Table 2, Present the values of the leakage radiation measured from the different radiological facilities at 1 m, while Table 3, described Statistical of the x-ray facilities. Table 1, Show the description of the studied facilities. Figure 3, Show the comparison of the cathode terminal leakage radiation to standard limit and Figure 4, Show the variation of the anode terminal leakage radiation to standard limit.

**Table 2. Leakage radiation from the studied x-ray machines**

| **X-RAY MACHINE** | **LEAKAGE RADIATION (mR/hr)** | | |
|---|---|---|---|
| | CATHODE TERMINAL | ANODE TERMINAL | MEAN |
| **$A_1$** | 6.12 | 4.82 | 5.47 |
| **$A_2$** | 0.39 | 0.32 | 0.36 |
| **$A_3$** | 37.79 | 37.12 | 37.46 |
| **$A_4$** | 91.97 | 91.97 | 91.97 |
| **$A_5$** | 0.21 | 0.21 | 0.21 |
| **$A_6$** | 7.01 | 6.64 | 6.83 |
| **$A_7$** | 6.82 | 6.63 | 6.73 |
| **$A_8$** | 20.11 | 17.68 | 18.90 |
| **$A_9$** | 4.07 | 3.13 | 3.60 |
| **$A_{10}$** | 100.84 | 99.70 | 100.27 |
| **$A_{11}$** | 11.55 | 11.39 | 11.47 |
| **$A_{12}$** | 9.85 | 9.03 | 9.44 |
| **$A_{13}$** | 42.03 | 47.12 | 44.58 |
| **$A_{14}$** | 84.03 | 68.06 | 76.05 |
| **$A_{15}$** | 32.11 | 31.55 | 31.83 |
| **$A_{16}$** | 12.03 | 11.46 | 11.75 |
| **$A_{17}$** | 16.33 | 13.76 | 15.05 |
| **$A_{18}$** | 7.83 | 6.15 | 6.99 |
| **$A_{19}$** | 16.03 | 12.11 | 14.07 |
| **$A_{20}$** | 22.07 | 18.65 | 20.36 |
| **MINIMUM** | **0.21** | **0.21** | **0.21** |
| **MAXIMUM** | **100.84** | **99.70** | **100.27** |
| **MEAN** | **26.46** | **24.88** | **25.67** |

**Table 3: Statistical description of the studied facilities**

| Parameters | leakage radiation (mR/hr) |
|---|---|
| Min | 0.21 |
| Max | 100.27 |
| Range | 100.60 |
| Mean | 25.67 |
| Standard deviation (S.D) | 28.91 |

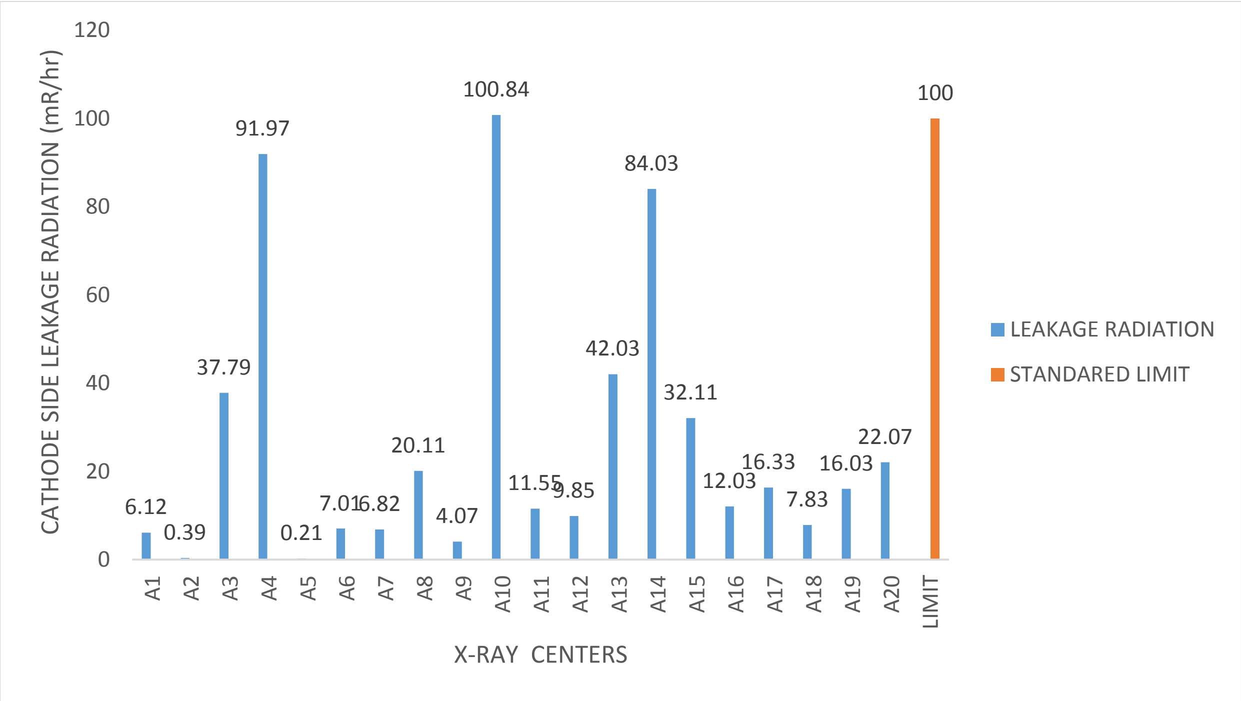


**Figure 3: Comparison of the cathode terminal leakage radiation to standard limit**

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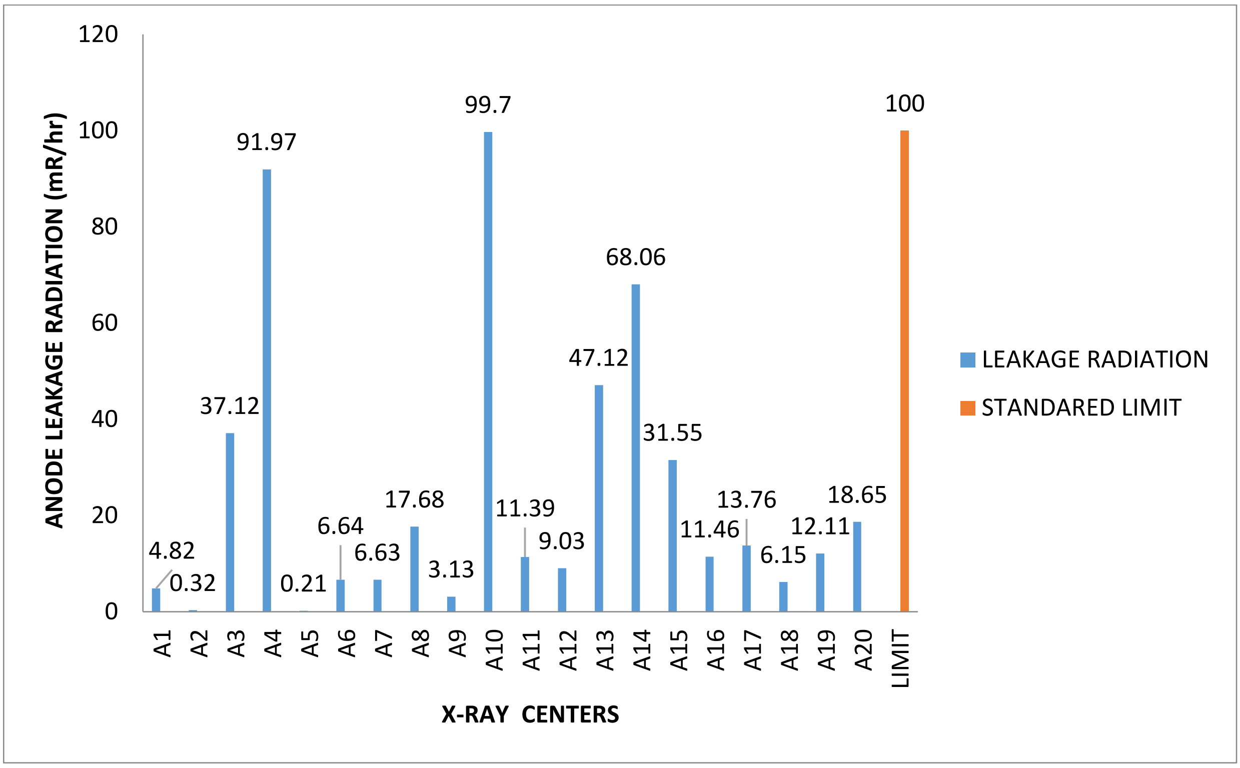


**Figure 4: Variation of the anode terminal leakage radiation to standard limit.**

## DISCUSSION

The leakage radiation from the cathode were; 6.12, 0.39, 37.79, 91.97, 0.21, 7.01, 6.82, 20.11, 4.07, 100.84, 11.55, 9.85, 42.03, 84.03, 32.11, 12.03, 16.33, 7.83, 16.03 and 22.07 mR/hr and anode were; 4.82, 0.32, 37.12, 91.97, 0.21, 6.64, 6.63, 17.68, 3.13, 99.70, 11.39, 9.03, 47.12, 68.06, 31.55, 11.46, 13.76, 6.15, 12.11 and 18.65 mR/hr corresponding to $A_1$ to $A_{20}$ respectively. Table 2, Shows the leakage radiation from the cathode and that of the anode of the x-ray tube. The peak from the cathode was observed with facility $A_{10}$ while $A_5$ was observed to have the minimum cathode leakage. The x-ray unit $A_2$ also shows a relatively low cathode radiation leakage 0.39 mR/hr. The peak cathode leakage radiation was closely followed by $A_4$ and $A_{14}$ with cathode leakage of 91.97 mR/hr and 84.04 mR/hr respectively. John (2018) work showed a maximum leakage radiation dose rate of 5.969 µSv/hr. This study shows higher values of leakages in all the investigated x-ray units. The mean cathode radiation leakage from this study was 26.46 mR/hr and this is within standard limit. The American Association of Physicists in Medicine (AAPM) has set a standard for the maximum permissible leakage limit, 100 mR/hr, from any give x-ray tube. From the chart, only one x-ray machine, $A_{10}$ failed this test and this could be as a result of the shutters that display sign of lights even when it was closed, resulting to a 5% failure rate and 95% pass rate.

## CONCLUSION

The leakage radiations have a significant effect in the quality of radiographic examinations and is very important for reduction of radiation doses to patient, personnel and members of the public. Leakage radiations tests were performed on twenty (20) x-ray units among some x-ray centers in Warri metropolis in Delta State. These studies show a leakage radiation test compliance rate of 95% and 5% non-compliance rate. Conclusively, x-ray machine should have their leakage radiation check at interval at least annually to maintain consistency in which unnecessary and unwanted exposures are checked and corrected.

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