Asian Journal of Advanced Research and Reports

Volume 17, Issue 4, Page 26-33, 2023; Article no.AJARR.97468
ISSN: 2582-3248

Evaluation of Excess Lifetime Cancer Risk in Some Selected X-Ray Diagnostic Centers in Port Harcourt, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJARR/2023/v17i4477

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97468

Original Research Article

Received: 09/01/2023
Accepted: 11/03/2023
Published: 03/04/2023

ABSTRACT

The evaluation of background ionizing radiation in some selected X-rays diagnostic centers in Port Harcourt has been carried out. This research was achieved with the used of Radex (RD 1212) radiation meter to measure the exposure rate due to ionizing radiation, and geographical coordinate system was employed to record the coordinates of the sampled locations. The exposure rate ranged from 0.14 to 0.22 μSv/h with a mean value of 0.18±0.03 μSv/h, this value was quite higher than the acceptable limit of 0.133μSv/h set by the international commission on radiological protection (ICRP). The computed annual equivalent dose ranged from 0.25 to 0.39 mSv/y with a mean value of 0.31±0.05 mSv/y, the annual effective dose equivalent (AEDE) dose varied from 0.17 to 0.27 mSv/y with a mean value of 0.22±0.35 mSv/y. This value is lesser than the safe limit of 1mSv/y as recommended by ICRP. The excess lifetime cancer risk (ELCR) ranged from 0.64×10^{-3}

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to $0.77x10^{-3}$ mSv/y with a mean value of $0.76\pm0.12x10^{-3}$ mSv/y which is quite higher than the safe limit of $0.29x10^{-3}$ (UNSEAR). Therefore, the diagnostic centers in Port Harcourt may not be radiologically safe to both occupational workers and patients who are radiologically diagnosed from the general public. Even though the signs of health risk issues are not physically pronounced the chances of contracting radiological health relative issues is still significant. Therefore, is it recommended that adequate steps should be taken to ensure that radiation leakage should be contained, if possible to the barest minimum.

Keywords: Radiation; exposure rate; annual effective dose equivalent; excess lifetime cancer risk.

1. INTRODUCTION

Ionizing radiation is a type of energy released by atoms in the form of electromagnetic wave or particles. Humans are exposed to natural and anthropogenic sources of ionizing radiation. Man is exposed to this radiation through, soil, water, consumption of food, as well as the used of technically enhanced machines such as X-rays and gamma-ray devices [1]. Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research. As the use of Ionizing radiation increases, so does the potential for health hazards when not property used or contained. Serious health effects such as skin burns, or cancer can occur when dose of ionizing radiation exceeds certain threshold limits. Low doses of ionizing radiation can increase the risk of longer-term effects such as cancer [2]. Ionizing radiation is mostly used daily in hospitals and clinics to perform diagnostic procedures. which are necessary for accurate diagnosis of disease and injury treatment. These procedures provide important information about our health to the medical practitioner and to ensure that we receive the appropriate treatment [3].

Nevertheless, certain procedures have the potential to expose large number of people to higher dose especially when the exposure rates are higher and exceeds the occupational dose limit of 20 mSv/y. When compared to the acceptable limit of the International Commission of Radiological Protection to the general public [4].

Radiographers and healthcare workers in X-ray diagnostic centers are concerned with the handling/operation of radiological materials/ procedures in medical facilities such as plain radiography, mammography, fluoroscopy, angiography, and computed axial tomography, which when operated exposes patients to low-dose ionizing radiation. Hematopoietic cells/tissues are highly sensitive to ionizing radiation and can be used to predict health impacts. Full blood counts and differentials, cellular morphologies, and other hematological indices are examples of basic hematological indicators. Ionizing radiation exposure at X-ray diagnostic facilities has been linked to the etiology of illnesses such as hematological cancers, sarcomas, and ocular defect/ malignancies, as well as embryological/ foetal abnormalities in exposed people's offspring [5-7].

X-ray background ionizing radiation is a measure of the level of ionizing radiation present in x-ray diagnostic centers, hospitals or laboratories at a particular location Background radiation is defined by the International Atomic Energy Agency as " attributable to all sources of ionizing radiation both natural and anthropogenic present in the environment [8].

Consequently, there is a general lack of awareness and knowledge about the level of ionizing radiation to which patients and radiation workers in the radiological laboratories are exposed too. These ionizing radiations when they ionized living tissues, may probably be harmful to living cells, which may result to chromosomal aberrations and carcinogenic effects [9]. Ionizing radiation can randomly cause damage to all cellular components and induces a variety of DNA defects. So, X-rays are utilized in well-preventive and protective conditions [10]. The last two decades have witnessed a technological revolution in diagnostic and therapeutic medical imaging. However, minimizing the risk of ionizing radiation exposure in x-ray diagnostic and imaging centers is still a big challenge [11].

This study is therefore carried out to estimates the level of ionizing radiation in Ten (10) selected X -ray diagnostic centers in Port Harcourt local government area in Rivers State, Nigeria. X -ray diagnostic centers could pose serious health hazards to both staff and patients who receive radiological diagnosis. This is as a result of the fact that the environment is exposed to certain doses of x-ray radiation in the course of medical administration. However, the continual exposure to the background ionizing radiation in X -ray diagnostic laboratories over an extended period of time have the tendency to result in non-lethal mutation, which could increase the health risk of workers and patients even though it might not be pronounce. Based on stochastic effect, no matter how insignificant the dose may be, it has the potential to an induced cancer risks and other radiological health issues. The radiological Laboratory workers as well as the patients could not be radiological safe from the health hazard of ionizing radiation, hence the aim of this research was to estimates the level of ionizing radiation as well as its excess lifetime cancer risk (ELCR) health risk parameter in Ten (10) selected X -ray diagnostic centers in Port Harcourt, Rivers State, Nigeria.

2. MATERIALS AND METHODS

In-situ measurement of the background ionizing radiation (BIR) level was carried out using Radex (RD 1212) radiation meter which measured ionizing radiation level rate in micro-Sievert per hour (μSv/h). The meter is a handheld digital radiation detector which detects gamma radiation, X-ray radiation and beta radiations with a dose power range of 0.05 to 999μSv/hr and a linear energy response to gamma radiation between 0.1 to 1.25 MeV, readings were taken within the hours of 13:00 and 16:00 hours, because the radiation meter has a peak sensitivity to environmental radiation within these hours [12-14]. During operation the meter was maintained at a gonadal height of 1 m above the ground surface and at 2.5. meters away from the active x-ray machines in the surveyed diagnostic centers, three readings were recorded (at the entrance, center of the X-ray room, and X-ray scanning area) and the values were average to a single value and recorded [15]. In addition, Geographical positioning system (GPS) was employed to record the coordinates of the sampled locations.

2.1 Radiological Parameters

2.1.1 Annual Effective Dose Equivalent (AEDE)

UNSCEAR [16] recommended that the indoor occupancy factor of 0.8 is used to the time during which an individual is exposed to radiation ionizing radiation. To compute the exposure rate to annual equivalent dose (E_i) the equation below was used [17,18].

E_i(mSv/yr) = χ (μSv/hr) x μ x 8760hrs/yr days x 0.001 (1)

Where:

E_i represent the Annual equivalent dose,
χ (μsv/hr) is the mean indoor exposure rate
μ represents the indoor occupancy factor (0.8) represents (16/24)hrs spend in indoor environment daily.

The annual effective dose equivalent (AEDE) is obtained by multiplying the annual equivalent dose (E_i) by the conversion factor of 0.7Sv/yr [17].

2.1.2 Excess lifetime Cancer Risk (ELCR)

The excess lifetime cancer risk (ELCR) is based on the chances of cancer-induced incidence in a population, in order words is state the possible carcinogenic consequence due to exposure to ionizing radiation for a given period of lifetime. In other words, the ELCR computes the possibility of developing cancer after receiving dose of ionizing radiation for a specific period of lifetime. The excess lives cancer risk (ELCR) was computed using by Equation 2, [13,17].

$$\text{ELCR (mSv/yr)} = \text{AED} \times \text{DL} \times \text{RF} \quad (2)$$

Where: DL= Is the average life exposition expectancy = 70 yrs.
RF= Is the fatal cancer risk factor per Sievert = 0.05.

3. RESULTS AND DISCUSSION

The result of the field measurement of the *in-situ* exposure rate as well as the radiological parameters of the selected X-ray diagnostic centers in Port Harcourt, Rivers state is presented in Table 1, The exposure rate ranged from 0.14 to 0.22 μSv/h with a mean value of 0.18±0.03 μSv/h, this value is quite higher than the acceptable standard of 0.133 μSv/h of ICRP as illustrated in Fig. 1. However, the values measured in this research in the Ten (10) X-rays diagnostics centers are all higher than the ICRP safe limit of 0.133 μSv/hr. This result of this research in agrees with the previously reported work on background radiation dose in selected X-ray facilities in southwest Nigeria [19], and the evaluation of background ionizing radiation levels in some X-ray centers in Owerri, Imo State, Nigeria [20]. This indicate that the diagnostic centers within Port Harcourt local government areas may not be safe for both occupational workers and patients of the general public who receive radiological diagnosis evaluation. However, there is presently no reported case of any radiological hazards within these areas.

The contour map of the study location shows that the sampled locations surveyed indicates that the Nouth-East direction approaching towards the central of the study location tends to have the highest level of exposure rate, and decreased uniformly towards the North-East direction, but as one approaches towards the South-East there seems to be a decrease in the level of the exposure rate. While other cardinal points of the location show a significant decrease in level of the exposure rate, as it extends towards the Noth-East, South-East, and significantly towards the North-East cardinal locations of Port Harcourt local government area respectively. The high levels of the exposure rate is predominantly significantly as you approach from the North-East toward the central, this might have been attributed to the fact that most of the X-ray diagnostic centers are located towards within these areas as a result of urban development thereby increasing the need of more X-rays diagnostics center to satisfy the need of the rising urban populations.

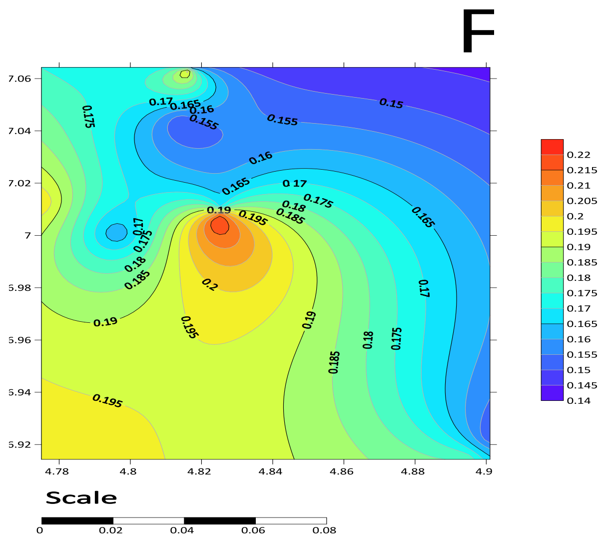

Fig. 1. Contour map of background Ionization radiation of the sampled X-ray diagnostics centers

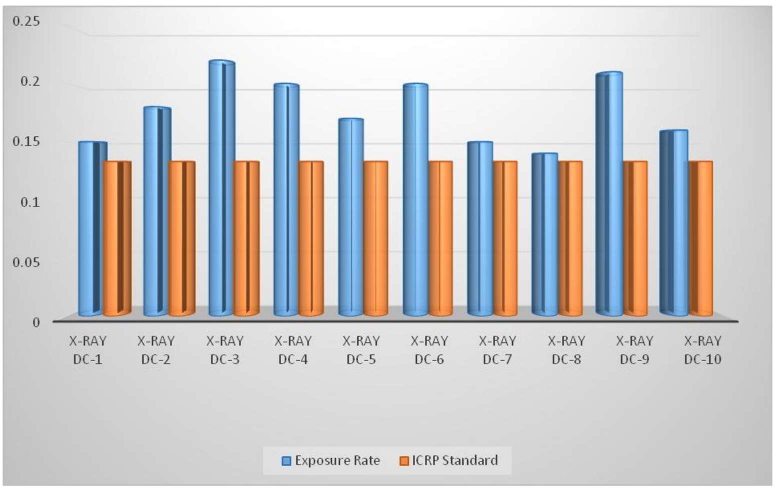

Fig. 2. Exposure rate of the sampled X-ray diagnostic centers with ICRP, 2003

Table 1. Mean values (BIR), Annual Equivalent Dose and Annual Effective Dose the sampled X-ray diagnostic centers

SN	Location	GPS reading		Mean Exposure Rate	Annual Equivalent Dose	Annual Effective Dose Equivalent	Excess lifetime Cancer Risk (ELCR)
		Latitude (N)	**Longitude (E)**	χ **(μSv/h)**	E_i **(mSv/y)**	**AEDE (mSv/y)**	**ELCR × 10^{-3}**
1	X-Ray DC-1	4.81394	7.04371	0.15	0.26	0.18	0.64
2	X-Ray DC-2	4.89436	6.91432	0.18	0.32	0.22	0.77
3	X-Ray DC-3	4.82416	7.00517	0.22	0.39	0.27	0.94
4	X-Ray DC-4	4.77502	7.01262	0.20	0.35	0.25	0.86
5	X-Ray DC-5	4.82550	7.00979	0.17	0.30	0.21	0.73
6	X-Ray DC-6	4.81640	7.06424	0.20	0.35	0.25	0.86
7	X-Ray DC-7	4.90106	6.92281	0.15	0.26	0.18	0.64
8	X-Ray DC-8	4.81641	7.06427	0.14	0.25	0.17	0.60
9	X-Ray DC-9	4.82550	7.00971	0.21	0.37	0.26	0.90
10	X-Ray DC-10	4.79623	7.00046	0.16	0.28	0.20	0.69
			Average	**0.18±0.03**	**0.31±0.05**	**0.22±0.35**	$\mathbf{0.76 \pm 0.12}$

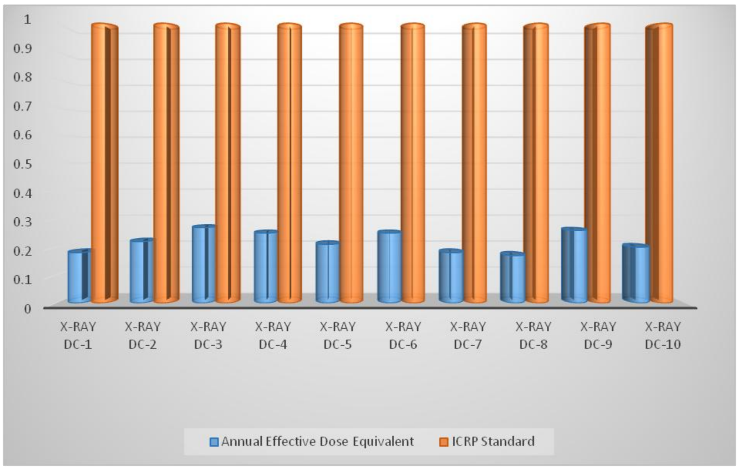

Fig. 3. Annual Effective Dose Equivalent of the sampled X-ray diagnostic centers with ICRP, 2003

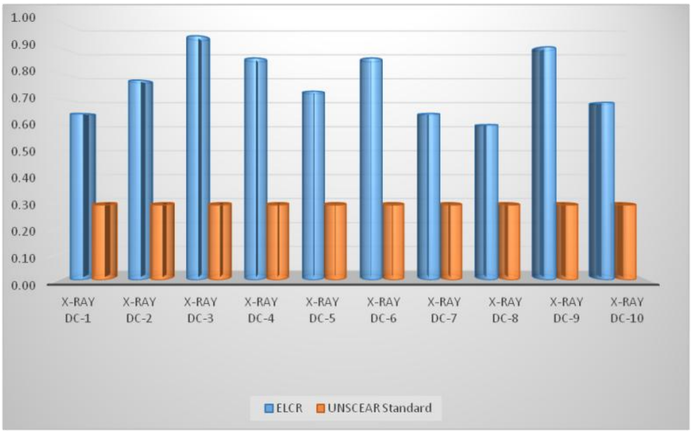

Fig. 4. Excess Lifetime Cancer Risk of the sampled X-ray diagnostic centers with UNSCEAR, 2008

The estimated annual equivalent dose ranges from 0.25 to 0.39 mSv/y with a mean value of 0.31 ± 0.05 mSv/y, the annual effective dose equivalent (AEDE) as depicted in Fig. 3, ranged from 0.17 to 0.27 with a mean value of 0.22 ± 0.35mSv/y. This value is lesser than the safe limit of ICRP [4]. All the values the X-ray diagnostic centers are lower than the ICRP recommended value for public exposure of 1.0 mSv/y. This interprets that occupational workers and patients exposed to the facilities of X-ray machines are safe from the threat from radiological health related issues. The findings from this work is in harmony with the work previously report by [18], on the estimation of indoor and outdoor background ionizing radiation levels of Kwali general hospital in Abuja.

The excess lifetime cancer risk ranged from 0.64 $\times 10^{-3}$ to 0.77 $\times 10^{-3}$ mSv/y with a mean value of 0.76 ± 0.12 mSv/y which is quite higher than the safe limit of [17], as demonstrated in Fig. 4. This result indicates that even though visible signs are not pronounced the chances of contracting radiological health issues relating to cancer is significant according to UNSCEAR [17].

This means, occupational workers, and patients from the general public in these particular X-ray diagnostics centers may be at a risk of developing cancers, hence extreme care and caution should be employed. Studies have demonstrated that ionizing radiation has acute or chronic adverse effects on human beings. Based on Stochastic concepts no threshold level exists below which harmful effects do not occur. The result from this study were similar to the research carried out in Saudi Arabia., Palestine, and Kenya [21-23].

Exposures to low level of radiation could potentially cause lethal effects, which could progress silently and undetected. The knowledge, awareness and practice of radiographers in X-ray diagnostic centers should be taken seriously in X-ray diagnostic centers. In addition, the use of personal protecting equipment is efficient to avoid health issues that may arise from radiation dose exposure [24,25].

4. CONCLUSION

Conclusively, this study successfully estimates the level of Ionizing radiation in Ten (10) selected X-ray diagnostic center in Port Harcourt, Nigeria as well as the mean exposure rate, annual equivalent dose, annual effective dose equivalent, and excess lifetime cancer risk of the sampled locations. Results have shown that all obtained mean values are higher than the safe limit except for the annual effective dose equivalent as recommended by the International Commission of Radiological Protection (ICRP). Even though there is no visible effect of radiological health related incidence, but the chances of induces cancer risk is significant. Therefore, it is highly recommended to contain the leaks of radiation exposure to the barest minimum from the used of these X-rays machines or and the used of personal protection equipment should be adopted as this play a significant role in the long run. It is recommended based on this research that Regular assessment of background ionizing radiation in X-ray diagnostic centers should be done for the safety of both the radiographers, workers and patients of the general public who received radiological diagnosis, by reducing the exposure rate to the barest minimum.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97468