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ANALYSIS OF BACKGROUND RADIATION DOSES AND THEIR POTENTIAL RADIOLOGICAL EFFECTS IN HOSPITALS ACROSS SOUTHWESTERN NIGERIA

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Abstract

This study investigates the radiological impact of background ionizing radiation exposure levels in selected hospitals in Southwestern Nigeria. Ambient radiation measurements were conducted using a Geiger-Müller counter under non-operational conditions (X-ray machines turned off). Key radiological indices, including Absorbed Dose Rate (ADR), Annual Effective Dose Equivalent (AEDE), and Excess Lifetime Cancer Risk (ELCR), were computed to evaluate potential health risks. Indoor radiation levels recorded at PMH, GFH, OGH, and SSH averaged 0.012, 0.012, 0.013, and 0.010 mR/h, respectively. Outdoor levels at PMH, OGH, and SSH were 0.013, 0.012, and 0.011 mR/h, while GFH recorded the highest outdoor value at 0.014 mR/h. Although the absorbed dose rates exceeded the world average and recommended limits of 59.0 and 84.0 nGy/h, the calculated AEDE values remained below the public safety threshold of 1.0 mSv/y. The findings indicate that while short-term exposure remains within safe limits, prolonged exposure may increase the probability of cancer development for individuals regularly present in these environments. These results underscore the need for continuous environmental radiation monitoring and the enforcement of radiological safety practices in healthcare settings.

Keywords: Radiation, dosimetry, exposure, healthcare, risk.

Introduction

Background radiation refers to the ionizing radiation emitted in the environment at a specific location from both natural and artificial radionuclides present in the earth and atmosphere (ICRP, 2007). Natural sources primarily include terrestrial primordial radionuclides and cosmic rays, while artificial sources have increasingly contributed to environmental radiation levels through human activities. These artificial sources primarily stem from medical procedures using radionuclides for diagnostic imaging, routine operations of nuclear power and scientific research facilities, improper disposal or recycling of radioactive materials, and self-luminous dials and signs (Vukanac et al., 2012; Balogun et al., 2019).

Over time, background ionizing radiation in the environment has increased, especially due to industrial activities involving materials containing naturally occurring radioactive materials (NORMs) (Ilori et al., 2018; Sengupta et al., 2020). The processing and disposal of such materials release radionuclides into the environment, posing potential health risks to exposed populations if not adequately regulated.

The rapid growth in diagnostic radiology has also contributed to increased exposure to background radiation. Medical imaging technologies that use ionizing radiation, such as X-rays, are widely employed for body imaging, raising the radiation dose received by patients and healthcare workers (Vukanac et al., 2012; Adeyemi & Olowookere, 2024). Ionizing radiation is characterized by high-energy particles or waves capable of penetrating biological tissues and causing ionization at the cellular level, potentially resulting in cell damage. Exposure to high doses of gamma and X-ray radiation is associated with DNA mutations, cancer, and other health complications (Ugbede and Benson, 2018; Sengupta et al., 2020).

Excessive or repeated exposure to diagnostic X-rays is linked with various dose-dependent health problems, including somatic and genetic abnormalities (Taskin et al., 2009). Unfortunately, some diagnostic centers lack adequate radiation protection policies and do not meet radiological safety standards, increasing the risk of harmful exposures (Eze et al., 2013). The stochastic effects of diagnostic X-rays, primarily cancer induction and genetic impacts, pose significant concerns due to the potential for DNA damage (Eze et al., 2013).

Although several studies have examined radiological impact assessments of background ionizing radiation in Nigerian hospitals (Vukanac et al., 2012; Eze et al., 2013; Achuka et al., 2019; Adeiza et al., 2023), there remains limited data specifically focusing on background radiation exposure levels in selected hospitals in Southwestern Nigeria. This study aims to fill this gap by measuring background ionizing radiation exposure levels in chosen hospitals within this region to evaluate potential radiological health hazards to the local population.

Materials and Methods

Selection of Study Sites

Four hospitals providing X-ray services were selected as the study sites for this research. These include Pima Hospital (PMH), Gloryfield Hospital (GFH), General Hospital Ore (OGH), and State Specialist Hospital, Okitipupa (SSH). These hospitals are situated within the Ore and Okitipupa metropolitan areas of Southwestern Nigeria. They were chosen because they serve as the primary radiodiagnostic centers for a large population across more than one hundred towns, communities, and villages in the Southern Senatorial District of Ondo State.

Instrumentation

Background radiation measurements in these hospitals were conducted using the GQ GMC-500 digital Geiger-Müller counter, a portable and reliable device designed for detecting ionizing radiation. The instrument utilizes Geiger-Müller tubes to detect radiation events, providing real-time readings both audibly and visually. Measurements were initially recorded in counts per minute (CPM) and subsequently converted to standardized units of microsieverts per hour (μSv/h) and milliroentgens per hour (mR/h) for analysis. Prior to use, the device was calibrated according to the manufacturer's specifications using a certified reference source to ensure measurement accuracy and reliability.

Each measurement session was conducted over a minimum duration of 5 minutes per location, and the average of three repeated readings was taken to minimize random fluctuations and enhance data precision. Measurements were carried out during daytime under non-operational conditions, i.e., with all X-ray and other radiological equipment turned off, to reflect background radiation levels only. Environmental conditions, including ambient temperature, humidity, and atmospheric pressure, were monitored and kept stable to avoid their potential influence on radiation readings. All measurements were performed at approximately 1 meter above ground level to simulate human exposure height, and care was taken to avoid interference from metallic objects or electronic devices nearby. These methodological controls and calibration practices were essential to ensure the accuracy, consistency, and reproducibility of the collected data, thereby enhancing the reliability of the radiological risk assessment.

Measurement Procedures and Data Analysis

Measurements were taken in various hospital locations, including departments, wards, and offices, with the X-ray machines powered off to avoid interference with background radiation readings. The Geiger counter was held at a height of one meter above the ground to maintain consistency. At each measurement point, four readings were obtained and averaged to ensure accuracy. Coordinates of the measurement points were recorded using a GPS device for spatial reference.

The radiation levels recorded on the Geiger counters display in milliroentgens per hour (mR/h) were used to calculate several radiological health hazard indices. These included the absorbed dose rate in air, the annual effective dose equivalent (AEDE), and the excess lifetime cancer risk (ELCR). These indices were employed to evaluate the radiation safety levels within the hospital environments under investigation.

Results and Discussions

The values for the measured Background Ionizing Radiation Exposure Levels (Indoor and Outdoor) and the related radiological health hazard indices in the selected hospitals were shown in Tables 1-8.

Table 1: Background ionizing radiation (BIR) for indoor radiation exposure levels and related radiological health hazard indices in PMH.

S/N	Sample ID	Location	BIR (mR/h)	D (nGy/h)	AEDE (mSv/y)	ELCR X 10^{-3}
1	Labour Room	6° 44' 23.32'' N, 4° 52' 34.59'' E	0.014	121.80	0.598	2.091
2	X-ray room	6° 44' 23.37'' N, 4° 52' 34.49'' E	0.017	147.90	0.726	2.539
3	Theatre unit	6° 44' 23.42'' N, 4° 52' 34.57'' E	0.010	87.00	0.427	1.494
4	Staircase	6° 44' 23.21'' N, 4° 52' 34.53'' E	0.013	113.10	0.555	1.942
5	Mortician	6° 44' 23.13'' N, 4° 52' 34.56'' E	0.011	95.70	0.469	1.643
6	Ward 2	6° 44' 22.97'' N, 4° 52' 34.52'' E	0.008	69.60	0.341	1.195
7	Ward 3	6° 44' 23.03'' N, 4° 52' 34.37'' E	0.007	60.90	0.299	1.046
8	Ward 4	6° 44' 22.99'' N, 4° 52' 34.49'' E	0.015	130.50	0.640	2.241
9	Ward 1	6° 44' 22.99'' N, 4° 52' 34.34'' E	0.010	87.00	0.427	1.494

10	RTA	6° 44' 22.92'' N, 4° 52' 34.53'' E	0.016	139.20	0.683	2.390
11	Reception	6° 44' 22.83'' N, 4° 52' 34.40'' E	0.014	121.80	0.598	2.091
12	Secretary	6° 44' 22.83'' N, 4° 52' 34.54'' E	0.015	130.50	0.640	2.241
13	CMD's office	6° 44' 22.75'' N, 4° 52' 34.49'' E	0.008	69.60	0.341	1.195
14	Lobby	6° 44' 23.00'' N, 4° 52' 34.44'' E	0.007	60.90	0.299	1.046
	Mean		**0.012**	**105.74**	**0.519**	**1.815**

Table 2: Background ionizing radiation (BIR) for outdoor exposure levels and related radiological health indices in PMH.

S/N	Sample ID	Location	BIR (mR/h)	D (nGy/h)	AEDE (mSv/y)	ELCR X 10^{-3}
1	Power house	6° 44' 23.43'' N, 4° 52' 34.22'' E	0.012	104.40	0.128	0.448
2	Car Park	6° 44' 23.06'' N, 4° 52' 34.10'' E	0.012	104.40	0.128	0.448
3	Hallway	6° 44' 22.61'' N, 4° 52' 34.36'' E	0.014	121.80	0.149	0.523
	Mean		**0.013**	**110.20**	**0.135**	**0.473**

Table 3: Background ionizing radiation (BIR) for indoor exposure levels and related radiological health indices in GFH.

S/N	Sample ID	Location	BIR (mR/h)	D (nGy/h)	AEDE (mSv/y)	ELCR X 10^{-3}
1	Consulting Room	6° 45' 30.85'' N 4° 52' 32.71'' E	0.013	113.10	0.555	1.942
2	Ward 3	6° 45' 30.68'' N 4° 52' 32.17'' E	0.011	95.70	0.469	1.643
3	Ward 2	6° 45' 30.86'' N 4° 52' 32.16'' E	0.008	69.60	0.341	1.195
4	Ward 1	6° 45' 30.87'' N 4° 52' 32.09'' E	0.008	69.60	0.341	1.195
5	Theatre (Prep Room)	6° 45' 30.63'' N 4° 52' 32.63'' E	0.011	95.70	0.469	1.643
6	Theatre	6° 45' 30.61'' N 4° 52' 32.74'' E	0.008	69.60	0.341	1.195
7	Pharmacy	6° 45' 30.63'' N 4° 52' 32.17'' E	0.012	104.40	0.512	1.793
8	X-ray Room	6° 45' 30.59'' N 4° 52' 32.01'' E	0.016	139.20	0.683	2.390
9	Reception	6° 45' 30.88'' N 4° 52' 31.95'' E	0.012	104.40	0.512	1.793

10	Staircase	6° 45' 30.88" N 4° 52' 32.57" E	0.016	139.20	0.683	2.390
11	Hallway	6° 45' 30.74" N 4° 52' 32.47" E	0.016	139.20	0.683	2.390
12	Ward 4	6° 45' 30.68" N 4° 52' 32.17" E	0.016	139.20	0.683	2.390
	Mean		**0.012**	**106.58**	**0.523**	**1.830**

Table 4: Background ionizing radiation (BIR) for outdoor exposure levels and related radiological health indices in GFH.

S/N	Sample ID	Location	BIR (mR/h)	D(nGy/h)	AEDE(mSv/y)	ELCR X 10 $^{-3}$
1	Front /car park	6° 45' 30.68" N 4° 52' 32.32" E	0.014	121.80	0.149	0.523

Table 5: Background ionizing radiation (BIR) for indoor exposure levels and related radiological health indices in OGH.

S/N	Sample ID	Location	BIR (mR/h)	D(nGy/h)	AEDE(mSv/y)	ELCR X 10 $^{-3}$
1	Hallway (Accident & Emergency)	6° 45' 2.60" N 4° 52' 40.73" E	0.012	104.40	0.512	1.793
2	Consulting Room 4	6° 45' 2.81" N 4° 52' 40.91" E	0.012	104.40	0.512	1.793
3	Consulting Room 4 (office)	6° 45' 2.89" N 4° 52' 40.87" E	0.011	95.70	0.469	1.643
4	Consulting Room 4 (2nd office)	6° 45' 2.87" N 4° 52' 0.86" E	0.011	95.70	0.469	1.643
5	Lobby (accident and emergency)	6° 45' 2.75" N 4° 52' 40.99" E	0.014	121.80	0.598	2.091
6	Ward (accident and emergency)	6° 45' 2.67" N 4° 52' 41.13" E	0.014	121.80	0.598	2.091
7	Male ward (accident and emergency)	6° 45' 2.80" N 4° 52' 41.35" E	0.012	104.40	0.512	1.793
8	Male ward (accident and emergency)	6° 45' 2.82" N 4° 52' 41.49" E	0.012	104.40	0.512	1.793
9	Male ward (accident and emergency)	6° 45' 2.76" N 4° 52' 41.48" E	0.010	87.00	0.427	1.494
10	Paediatric (Female ward)	6° 45' 3.28" N 4° 52' 41.65" E	0.013	113.10	0.555	1.942
11	Records (Office 1)	6° 45' 3.23" N 4° 52' 41.53" E	0.012	104.40	0.512	1.793
12	Records (Office 2)	6° 45' 3.04" N 4° 52' 41.71" E	0.014	121.80	0.598	2.091

13	Records (Lobby)	6° 45' 3.24'' N 4° 52' 41.82'' E	0.014	121.80	0.598	2.091
14	Chest department	6° 45' 3.15'' N 4° 52' 41.92'' E	0.010	87.00	0.427	1.494
15	Maternity (lobby)	6° 45' 4.36'' N 4° 52' 42.50'' E	0.016	139.20	0.683	2.390
16	Maternity (waiting room)	6° 45' 4.11'' N 4° 52' 42.49'' E	0.014	121.80	0.598	2.091
17	Maternity (family planning)	6° 45' 4.14'' N 4° 52' 42.30'' E	0.014	121.80	0.598	2.091
18	Maternity (ward)	6° 45' 3.92'' N 4° 52' 42.16'' E	0.016	139.20	0.683	2.390
19	Maternity (office)	6° 45' 3.77'' N 4° 52' 42.26'' E	0.015	130.50	0.640	2.241
20	Maternity (Paediatric)	6° 45' 4.71'' N 4° 52' 42.73'' E	0.017	147.90	0.726	2.539
21	X-ray Room	6° 45' 4.86'' N 4° 52' 42.81'' E	0.017	147.90	0.726	2.539
22	Laboratory (lobby)	6° 45' 5.35'' N 4° 52' 42.46'' E	0.007	60.90	0.299	1.046
23	Laboratory (lab)	6° 45' 5.26'' N 4° 52' 42.73'' E	0.015	130.50	0.640	2.241
24	Laboratory (office)	6° 45' 5.41'' N 4° 52' 42.41'' E	0.016	139.20	0.683	2.390
25	Accounts	6° 45' 4.72'' N 4° 52' 41.60'' E	0.016	139.20	0.683	2.390
26	Accounts(office)	6° 45' 4.76'' N 4° 52' 41.48'' E	0.014	121.80	0.598	2.091
27	Accounts(lobb y)	6° 45' 4.76'' N 4° 52' 41.52'' E	0.013	113.10	0.555	1.942
28	Admin building (MD's secretary)	6° 45' 3.43'' N 4° 52' 40.23'' E	0.010	87.00	0.427	1.494
29	Admin building (MD's office)	6° 45' 3.38'' N 4° 52' 40.392'' E	0.012	104.40	0.512	1.793
	Mean		**0.013**	**114.90**	**0.564**	**1.973**

Table 6: Background ionizing radiation (BIR) for outdoor exposure levels and related radiological health indices in OGH.

S/N	Sample ID	Location	BIR (mR/h)	D(nGy/h)	AEDE(mSv/y)	ELCR X 10 $^{-3}$
1	Outside (Accident & Emergency)	6° 45' 2.57'' N 4° 52' 40.49'' E	0.018	156.60	0.192	0.672
2	Male ward hallway	6° 45' 3.02'' N 4° 52' 41.55'' E	0.013	113.10	0.139	0.485
3	Maternity (outside)	6° 45' 4.22'' N 4° 52' 42.31'' E	0.007	60.90	0.075	0.261

4	Female ward (outside)	6° 45' 4.93'' N 4° 52' 42.60'' E	0.013	113.10	0.139	0.485
5	Laboratory (hallway)	6° 45' 5.14'' N 4° 52' 42.62'' E	0.014	121.80	0.149	0.523
6	Laboratory (hallway)	6° 45' 5.28'' N 4° 52' 42.42'' E	0.017	147.90	0.181	0.635
7	Accounts (Outside)	6° 45' 4.08'' N 4° 52' 41.44'' E	0.010	87.00	0.107	0.373
8	Outside	6° 45' 3.75'' N 4° 52' 41.26'' E	0.012	104.40	0.128	0.448
9	Outside	6° 45' 3.57'' N 4° 52' 40.97'' E	0.011	95.70	0.117	0.411
10	Generator house	6° 45' 4.02'' N 4° 52' 40.94'' E	0.010	87.00	0.107	0.373
11	Car Park	6° 45' 3.79'' N 4° 52' 40.55'' E	0.011	95.70	0.117	0.411
12	Admin building(outside)	6° 45' 3.29'' N 4° 52' 40.46'' E	0.012	104.40	0.128	0.448
13	Admin building (lobby)	6° 45' 3.30'' N 4° 52' 40.40'' E	0.011	95.70	0.117	0.411
	Mean		**0.012**	**106.41**	**0.130**	**0.457**

Table 7: Background ionizing radiation (BIR) indoor exposure levels and related radiological health indices in SSH.

S/N	Sample ID	Location	BIR (mR/h)	D (nGy/h)	AEDE (mSv/y)	ELCR X 10^{-3}
1	X-ray Room	6° 30' 3.94'' N 4° 47' 11.36'' E	0.012	104.40	0.512	1.793
2	Radiographer's Office	6° 30' 3.97'' N 4° 47' 11.37'' E	0.013	113.10	0.555	1.942
3	Dark Room	6° 30' 4.08'' N 4° 47' 11.30'' E	0.014	121.80	0.598	2.091
4	Theatre Department	6° 30' 3.62'' N 4° 47' 10.69'' E	0.010	87.00	0.427	1.494
5	Dental Centre (Hallway)	6° 30' 4.13'' N 4° 47' 14.40'' E	0.010	87.00	0.427	1.494
6	Dental Centre (Doctor's room)	6° 30' 4.20'' N 4° 47' 14.33'' E	0.007	60.90	0.299	1.046
7	Dental Centre (Therapy)	6° 30' 4.11'' N 4° 47' 14.47'' E	0.008	69.60	0.341	1.195
8	Dental Centre (Surgery 2)	6° 30' 4.29'' N 4° 47' 14.48'' E	0.010	87.00	0.427	1.494

9	Dental Centre (Consulting room)	6° 30' 4.20'' N 4° 47' 14.67'' E	0.010	87.00	0.427	1.494
10	Dental Centre (lobby)	6° 30' 4.35'' N 4° 47' 14.86'' E	0.009	78.30	0.384	1.344
11	Dental Centre (technologist)	6° 30' 4.56'' N 4° 47' 14.96'' E	0.012	104.40	0.512	1.793
12	Dental Centre (polishing room)	6° 30' 4.62'' N 4° 47' 15.05'' E	0.012	104.40	0.512	1.793
13	Dental Centre (store)	6° 30' 4.76'' N 4° 47' 15.25'' E	0.011	95.70	0.469	1.643
14	Dental Centre (Doctor's office)	6° 30' 4.40'' N 4° 47' 15.03'' E	0.014	121.80	0.598	2.091
15	Dental Centre (Admin)	6° 30' 4.45'' N 4° 47' 15.14'' E	0.016	139.20	0.683	2.390
16	Dental Centre (Hallway)	6° 30' 4.64'' N 4° 47' 15.23'' E	0.014	121.80	0.598	2.091
17	NHIS (lobby)	6° 30' 3.80'' N 4° 47' 13.46'' E	0.012	104.40	0.512	1.793
18	NHIS (HOD)	6° 30' 3.66'' N 4° 47' 13.40'' E	0.010	87.00	0.427	1.494
19	Accident & Emergency (waiting room)	6° 30' 3.01'' N 4° 47' 13.09'' E	0.012	104.40	0.512	1.793
20	Accident & Emergency (office)	6° 30' 3.04'' N 4° 47' 13.01'' E	0.006	52.20	0.256	0.896
21	Accident & Emergency (consulting room 1)	6° 30' 3.05'' N 4° 47' 13.02'' E	0.008	69.60	0.341	1.195
22	Accident & Emergency (consulting room 2)	6° 30' 3.05'' N 4° 47' 13.03'' E	0.009	78.30	0.384	1.344
23	Accident & Emergency (emergency room)	6° 30' 2.79'' N 4° 47' 12.52'' E	0.006	52.20	0.256	0.896

24	Accident & Emergency (store)	6° 30' 2.74'' N 4° 47' 12.68'' E	0.008	69.60	0.341	1.195
25	Pharmacy (reception)	6° 30' 2.36'' N 4° 47' 11.88'' E	0.008	69.60	0.341	1.195
26	Pharmacy (office)	6° 30' 2.45'' N 4° 47' 11.93'' E	0.012	104.40	0.512	1.793
27	Pharmacy (store)	6° 30' 2.36'' N 4° 47' 11.88'' E	0.012	104.40	0.512	1.793
28	Pharmacy (room)	6° 30' 2.36'' N 4° 47' 11.88'' E	0.008	69.60	0.341	1.195
29	Laboratory (reception)	6° 30' 2.26'' N 4° 47' 11.32'' E	0.006	52.20	0.256	0.896
30	Laboratory (clinical chem)	6° 30' 2.22'' N 4° 47' 11.26'' E	0.010	87.00	0.427	1.494
31	Laboratory (medical microbiology)	6° 30' 2.20'' N 4° 47' 11.10'' E	0.007	60.90	0.299	1.046
32	CMD (secretary)	6° 30' 1.86'' N 4° 47' 10.56'' E	0.010	87.00	0.427	1.494
33	CMD	6° 30' 1.84'' N 4° 47' 10.40'' E	0.008	69.60	0.341	1.195
34	Admin	6° 30' 1.74'' N 4° 47' 10.30'' E	0.012	104.40	0.512	1.793
35	Admin (hospital secretary)	6° 30' 1.83'' N 4° 47' 10.10'' E	0.009	78.30	0.384	1.344
36	Central Store	6° 30' 1.67'' N 4° 47' 10.04'' E	0.008	69.60	0.341	1.195
37	HNS (office)	6° 30' 1.58'' N 4° 47' 9.93'' E	0.009	78.30	0.384	1.344
38	HNS (records)	6° 30' 1.57'' N 4° 47' 9.80'' E	0.014	121.80	0.598	2.091
39	Eye (hallway)	6° 30' 0.20'' N 4° 47' 9.39'' E	0.008	69.60	0.341	1.195
40	Eye (waiting)	6° 30' 0.26'' N 4° 47' 9.43'' E	0.016	139.20	0.683	2.390
41	Eye (office)	6° 30' 0.13'' N 4° 47' 9.32'' E	0.009	78.30	0.384	1.344
42	Eye (lobby)	6° 30' 0.04'' N 4° 47' 9.46'' E	0.012	104.40	0.512	1.793
43	Eye (doctors' room)	6° 30' 0.00'' N 4° 47' 9.56'' E	0.008	69.60	0.341	1.195
44	Eye (consulting room)	6° 29' 59.91'' N 4° 47' 9.59'' E	0.016	139.20	0.683	2.390
45	Eye (test)	6° 29' 59.83'' N 4° 47' 9.37'' E	0.014	121.80	0.598	2.091
	Mean		**0.010**	**90.67**	**0.445**	**1.557**

Table 8: Background ionizing radiation (BIR) Outdoor exposure levels and related radiological health indices in SSH.

S/N	Sample ID	Location	BIR (mR/h)	D(nGy/h)	AEDE (mSv/y)	ELCR X 10^{-3}
1	X-ray hallway	6° 30' 3.79'' N 4° 47' 11.29'' E	0.010	87.00	0.107	0.373
2	Dental Centre (outside)	6° 30' 3.87'' N 4° 47' 14.04'' E	0.012	104.40	0.128	0.448
3	Dental Centre (out lobby)	6° 30' 4.24'' N 4° 47' 14.95'' E	0.012	104.40	0.128	0.448
4	NHIS (outside)	6° 30' 3.84'' N 4° 47' 13.65'' E	0.010	87.00	0.107	0.373
5	Hallways (Admin office)	6° 30' 1.60'' N 4° 47' 10.28'' E	0.010	87.00	0.107	0.373
6	Hallways (CMD)	6° 30' 1.64'' N 4° 47' 10.47'' E	0.009	78.30	0.096	0.336
7	Hallways (Accidents/ Emergency)	6° 30' 2.79'' N 4° 47' 13.11'' E	0.012	104.40	0.128	0.448
8	Hallways (Laboratories)	6° 30' 2.65'' N 4° 47' 12.61'' E	0.013	113.10	0.139	0.485
9	Walkway (Maternity and Theatre)	6° 30' 2.04'' N 4° 47' 10.77'' E	0.012	104.40	0.128	0.448
10	Hallways (Central Store)	6° 30' 1.49'' N 4° 47' 9.91'' E	0.014	121.80	0.149	0.523
11	Accident & Emergency (outside)	6° 30' 3.04'' N 4° 47' 13.37'' E	0.009	78.30	0.096	0.336
12	Eye (outside)	6° 30' 0.46'' N 4° 47' 9.28'' E	0.010	87.00	0.107	0.373
	Mean		**0.011**	**96.43**	**0.118**	**0.414**

Background Ionizing Radiation Exposure Levels

The Indoor Background Ionizing Radiation Exposure levels measured in the selected hospitals, Pima Hospital (PMH), Gloryfield Hospital (GFH), General Hospital Ore (OGH), and State Specialist Hospital (SSH), ranged approximately from 0.006 to 0.017 mR/h, with mean values of about 0.010 to 0.013 mR/h for each hospital. Outdoor exposure levels for PMH, OGH, and SSH ranged roughly from 0.007 to 0.018 mR/h, with mean values near 0.011 to 0.013 mR/h, while GFH's outdoor level was measured at 0.014 mR/h.

These values are generally consistent with typical background radiation exposure rates reported in Nigerian hospitals and other similar environments. Studies indicate that outdoor natural background radiation in populated areas usually falls around 0.013 mR/h, which aligns with international exposure safety thresholds commonly near or below this level. Environmental studies in Nigerian regions have reported average background exposure rates close to 0.012–0.014 mR/h (James et al., 2015; Nwokeoji & Avwiri, 2017; Ezemba et al., 2025), which are considered safe for public health according to ICRP (2007) guidelines, suggesting an annual effective dose limit of 1 mSv/year for the general public, and such exposure levels correspond to doses below this limit.

Therefore, the reported indoor and outdoor background radiation levels in the selected Southwestern Nigerian hospitals fall within accepted safety limits and do not indicate unusually elevated radiation that would pose immediate radiological health hazards. However, continual monitoring and assessment of radiological health indices, such as absorbed dose rates, annual effective dose equivalents, and excess lifetime cancer risks, are essential to ensure environmental safety and public health protection over time.

Absorbed Dose Rate (D)

To calculate the absorbed dose rate (nGy/h), the Background Ionizing Radiation Exposure levels data gotten in milli-Roentgen per hour (mR/h) were converted to Absorbed Dose Rate in the air using equation (1) according to Omogunloye et al. (2021):

$$1\ mR/h = 8.7 nGY/h * 10^3 = 8700\ nGy/h \quad (1)$$

The calculated indoor absorbed dose rates in the selected hospitals PMH, GFH, OGH, and SSH, ranged as follows: PMH from 60.90 to 147.90 nGy/h with a mean of 105.74 nGy/h, GFH from 69.60 to 139.20 nGy/h with a mean of 106.58 nGy/h, OGH from 60.90 to 147.90 nGy/h with a mean of 114.90 nGy/h, and SSH from 52.20 to 139.20 nGy/h with a mean of 90.67 nGy/h. Outdoor absorbed dose rates for PMH ranged from 104.40 to 121.80 nGy/h (mean 110.20 nGy/h), OGH from 60.90 to 156.60 nGy/h (mean 106.41 nGy/h), SSH from 78.30 to 121.80 nGy/h (mean 96.43 nGy/h), and GFH had a mean outdoor absorbed dose rate of 121.80 nGy/h. These mean dose rates exceed both the world weighted average of 59 nGy/h and the recommended safe limit of 84 nGy/h as specified by UNSCEAR in their 2008 report. The UNSCEAR recommended limit of 84 nGy/h refers typically to outdoor absorbed dose rates from natural background radiation to ensure minimal radiological health risk to the general public. Values above this limit suggest a higher level of external gamma radiation exposure, which may increase radiological risk (UNSCEAR 2008).

Annual Effective Dose Equivalent (AEDE)

A dose conversion factor of 0.7 Sv/Gy and occupancy factors of 0.2 (5/24) and 0.8 (19/24) for outdoor and indoor, respectively, are used to calculate the Annual Effective Dose Equivalent received by a person. The following equations 2 and 3 are used to calculate AEDE (ICRP, 1999; Jojo et al., 2016):

$$AEDE\ (mSv/y) = D\ (nGy/h) \times 8760\ (h) \times 0.7\ (Sv/Gy) \times 0.8 \times 10^{-6} \quad (2)$$

$$AEDE\ (mSv/y) = D\ (nGy/h) \times 8760\ (h) \times 0.7\ (Sv/Gy) \times 0.2 \times 10^{-6} \quad (3)$$

Equations (2) and (3) represent the indoor and outdoor Annual Effective Dose Equivalent (AEDE), respectively. According to the ICRP, the maximum permissible dose for public exposure is 1 mSv/y, averaged over five years, while for occupational exposure it is 20 mSv/y (UNSCEAR, 2008). The calculated indoor AEDE values for the selected hospitals were as follows: PMH ranged from 0.299 to 0.726 mSv/y (average 0.519 mSv/y), GFH from 0.341 to 0.683 mSv/y (average 0.523 mSv/y), OGH from 0.299 to 0.726 mSv/y (average 0.564 mSv/y), and SSH from 0.256

to 0.683 mSv/y (average 0.445 mSv/y). For outdoor AEDE, the values were: PMH ranged from 0.128 to 0.149 mSv/y (average 0.135 mSv/y), OGH from 0.075 to 0.192 mSv/y (average 0.130 mSv/y), and SSH from 0.096 to 0.149 mSv/y (average 0.118 mSv/y), while GFH had a value of 0.149 mSv/y. All the calculated indoor and outdoor AEDE values across the selected hospitals are below the recommended public exposure limit of 1.0 mSv/y set by ICRP and UNSCEAR (Omogunloye et al., 2021).

Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk is an increase in the likelihood of an individual developing cancer over a lifetime due to exposure to a certain level of radiation doses, which is linked to an increase in breast and prostate cancer and blood cancer (Sengupta et al., 2020). Equation (4) is used in the calculation of ELCR (ICRP, 1999):

$$ELCR = AEDE \times DL \times RF \quad (4)$$

DL is the average duration of life (estimated to be 70 years), and RF is the Risk Factor (Sv^{-1}) that is fatal cancer risk per Sievert. For stochastic effects, ICRP uses RF as 0.05 for the public. The global average value for ELCR is 0.29×10^{-3} (Ugbede and Benson, 2018; Naqvi et al., 2019).

The calculated indoor Excess Lifetime Cancer Risk (ELCR) in the selected hospitals ranged as follows: PMH, 1.046×10^{-3} to 2.539×10^{-3} (average: 1.815×10^{-3}); GFH, 1.195×10^{-3} to 2.390×10^{-3} (average: 1.830×10^{-3}); OGH, 1.046×10^{-3} to 2.539×10^{-3} (average: 1.973 10^{-3}); and SSH, 0.896×10^{-3} to 2.390×10^{-3} (average: 1.557×10^{-3}). For outdoor ELCR, the values were: PMH, 0.448×10^{-3} to 0.523×10^{-3} (average: 0.473×10^{-3}); OGH, 0.261×10^{-3} to 0.672×10^{-3} (average: 0.457×10^{-3}); and SSH, 0.336×10^{-3} to 0.523×10^{-3} (average: 0.414×10^{-3}). At GFH, the outdoor ELCR was 0.523×10^{-3}) In all cases, the mean indoor and outdoor ELCR values across the hospitals exceeded the global average ELCR of 0.29×10^{-3} (ICRP, 2007).

The fact that ELCR values in these healthcare environments surpass the global benchmark suggests a heightened long-term cancer risk for hospital staff, patients, and frequent visitors. Although individual annual exposures may fall within accepted safety limits, cumulative radiation doses over time, especially for healthcare workers with prolonged occupational exposure, could pose significant public health concerns. This finding underscores the importance of implementing routine radiation surveillance and exposure mitigation strategies, such as improved shielding, controlled access to high-radiation areas, and regular maintenance of diagnostic equipment. Additionally, raising awareness about radiological risks and enforcing compliance with international radiological protection standards (ICRP and UNSCEAR guidelines) are critical steps to safeguard the health of those regularly present in these facilities.

The highest level of indoor background ionizing radiation exposure was reported for all hospitals' X-ray rooms. This could be attributed to the presence of radiation sources (x-ray machines and other equipment) except for the SSH, which can be attributed to the fact that the walls of the X-ray room were plastered with Barium Plaster which acts as an excellent shield for ionizing radiation. This shows that patients and personnel are frequently exposed to higher radiation levels during x-ray examinations due to a lack of sufficient shielding materials. In the selected hospitals (PMH, GFH, OGH, and SSH), about 57%, 67%, 45%, and 82% of the measured indoor background ionizing radiation exposure rate levels are lower than the recommended permissible limit of 0.013 mR/h (Omogunloye, 2021). The high background ionizing radiation exposure recorded for the hospitals under study suggests radiological contamination and enhancement. As a result, probably, it's not radiologically safe or healthy for the general public in the study area. Figures 1-4 depict the background ionizing radiation for indoor and outdoor radiation exposure levels and related radiological health indices (Annual Effective Dose Equivalent, Excess Lifetime Cancer Risk, and Absorbed Dose Rate) from the study areas. The higher results for the indoor and outdoor excess lifetime cancer risk for all hospitals show that residents who plan to dwell in the area for the rest of their lives are at risk of developing cancer.

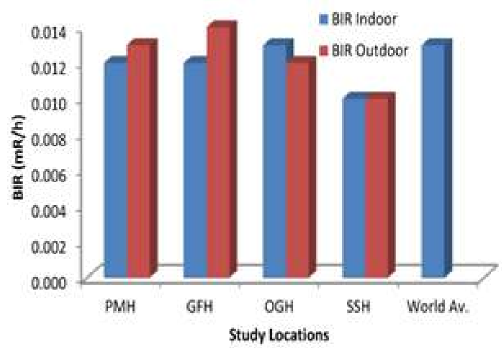

Figure 1: Background Ionizing Radiation (BIR) for indoor and outdoor background radiation exposure levels within the study areas.

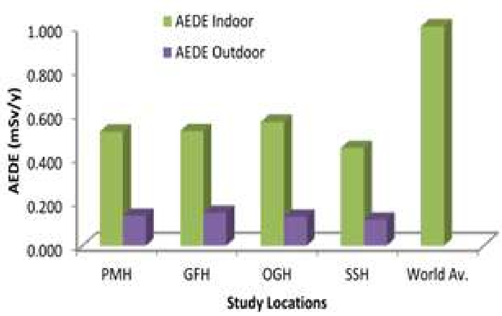

Figure 2: Annual Effective Dose Equivalent (AEDE) for indoor and outdoor background radiation exposure levels within the study areas.

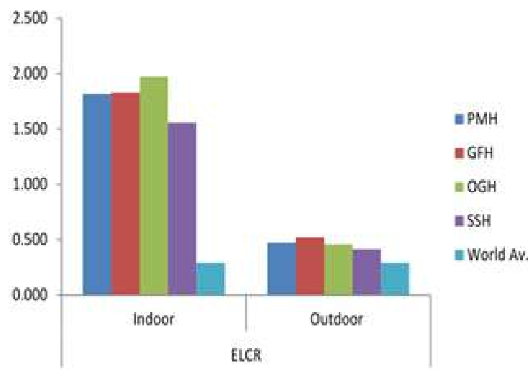

Figure 3: Excess Lifetime Cancer Risk (ELCR) for indoor and outdoor background radiation exposure levels within the study areas.

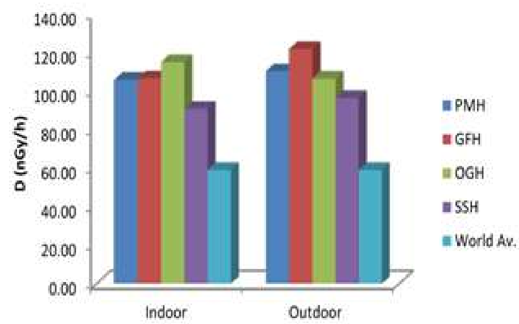

Figure 4: Absorbed Dose Rate (D) for indoor and outdoor background radiation exposure levels within the study areas.

Conclusion

This research was conducted to determine the radiological risk associated with the background radiation levels within selected hospitals with X-ray facilities in Southwestern Nigeria. The study was carried out in four hospitals with a GQ GMC-500 digital Geiger Muller Counter, a measuring tape, and a Geographical Positioning System (GPS) device. The results showed that in the selected hospitals (PMH, GFH, OGH, and SSH), about 57%, 67%, 45%, and 82% of the measured indoor background ionizing radiation exposure rate levels are lower than the recommended permissible limit of 0.013 mR/h. The mean background ionizing radiation dose rates in the studied areas are higher than the world weighted average of 59.00 nGy/h and the recommended safe limit of 84.0 nGy/h. The calculated indoor and outdoor annual effective dose equivalent in all the selected hospitals is lower than the ICRP, and UNSCEAR recommended permissible limits of 1.00 mSv/y for the general public. All of the selected hospitals' mean ELCR (indoor and outdoor) values are higher than the world average value of 0.29 x 10^{-3}, indicating the probability of cancer development among people who choose to live their entire lives in the study location.

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References

Achuka, J. A., Usikalu, M. R., Aweda, M. A., Onumejor, C. A., & Babarimisa, I. O. (2019). Background radiation dose in selected X-ray facilities in Southwest Nigeria. *J. Phys. Conf. Ser.*, 1299(1), 012103. https://doi.org/10.1088/1742-6596/1299/1/012103

Adeiza, S. A., Olarinoye, O. I., Kolo, M., & Kasim, I. (2023). Assessment of environmental background gamma radiation variation in Minna area of Nigeria. *Environ. Forensics*, 25(5), 275–286. https://doi.org/10.1080/15275922.2023.2297424

Adeyemi, F. O., & Olowookere, C. J. (2024). Real-time radiological practice: Dose descriptors and fatal risk of cancer estimates in adult patients from most frequent radiological procedures in Ondo State, Nigeria. *Int. J. Res. Sci. Innov.*, 10(12), 220–233. https://doi.org/10.51244/ijrsi.2023.1012018

Balogun, F. A., Adeyemi, F. O., Balogun, B. O., Oketayo, O. O., Olowookere, C. J., & Fasan-Odunsi, A. O. (2019). Effective dose and risk estimates in adult patients from four radiological procedures extrapolated over two populations at selected centers in Lagos State, Nigeria. *Radiat. Prot. Dosim.*, 187(3), 327–337. https://doi.org/10.1093/rpd/ncz171

Eze, C., Irurhe, N., Njoku, J., Olowu, O., & Abonyi, L. (2013). Assessment of radiation protection practices among radiographers in Lagos, Nigeria. *Niger. Med. J.*, 54(6), 386. https://doi.org/10.4103/0300-1652.126290

Ezemba, V. C., Amakom, C. M., Ononugbo, C. P., Avwiri, G. O., & Ugwoke, R. E. (2025). Assessment of environmental radiation levels in Anambra South Senatorial District, Anambra State, Nigeria. *Environ. Health Insights*, 19, 1–12. https://doi.org/10.1177/11786302251350781

ICRP (1991). 1990 Recommendations of the International Commission on Radiological Protection. *ICRP Publ. 60*. Ann. ICRP, 21(1–3).

ICRP (2007). 2007 Recommendations of the International Commission on Radiological Protection. *ICRP Publ. 103*. Ann. ICRP, 37(2–4).

Ilori, A. O., Ibitola, G., Ajanaku, O., & Utomewore, R. D. (2018). Entrance skin dose (radiation) measurement and evaluation (for all age groups) at the State Specialist Hospital, Okitipupa, Nigeria. *Open Sci. J.*, 3(2). https://doi.org/10.23954/osj.v3i2.1658

James, I., Moses, I., Vandi, J., & Ikoh, U. (2015). Measurement of indoor and outdoor background ionising radiation levels of Kwali General

Hospital, Abuja. *J. Appl. Sci. Environ. Manage.*, 19(1), 89. https://doi.org/10.4314/jasem.v19i1.12

Jojo, P., Monica, S., Visnu Prasad, A., & Soniya, S. (2016). Estimation of indoor and outdoor effective doses and lifetime cancer risk from gamma dose rates along the coastal regions of Kollam district, Kerala. *Radiat. Prot. Environ.*, 39(1), 38. https://doi.org/10.4103/0972-0464.185180

Naqvi, S. T. S., Batool, S. W., Rizvi, S. A. H., & Farhan, K. (2019). Awareness of hazards of X-ray imaging and perception regarding necessary safety measures during X-ray imaging procedures among patients in public tertiary hospitals of Karachi, Pakistan. *Cureus*, 11(5). https://doi.org/10.7759/cureus.4756

Nwokeoji, I., & Avwiri, G. (2017). Radiological risk estimates due to background exposures in selected hospitals in South-East Nigeria. *Arch. Curr. Res. Int.*, 8(1), 1–12. https://doi.org/10.9734/acri/2017/34244

Omogunloye, O. Y., Adepoju, A. T., & Kururimam, P. (2021). Assessment of radiation risk from background radiation exposures in selected hospitals within Makurdi Metropolis, North-Central, Nigeria. *Eur. J. Appl. Phys.*, 3(4), 43–47. https://doi.org/10.24018/ejphysics.2021.3.4.91

Sengupta, S., Roy, U., Chowdhary, S., & Das, P. (2020). New bioremediation technologies to remove heavy metals and radionuclides. In *Springer Ebooks*, 23–45. https://doi.org/10.1007/978-981-15-5901-3_2

Taskin, H., Karavus, M., Ay, P., Topuzoglu, A., Hidiroglu, S., & Karahan, G. (2009). Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. *J. Environ. Radioact.*, 100(1), 49–53. https://doi.org/10.1016/j.jenvrad.2008.10.012

Ugbede, F. O., & Benson, I. D. (2018). Assessment of outdoor radiation levels and radiological health hazards in Emene Industrial Layout of Enugu State, Nigeria. *Int. J. Phys. Sci.*, 13(20), 265–272. https://doi.org/10.5897/ijps2018.4763

UNSCEAR (2008). Sources and effects of ionizing radiation. Report to the General Assembly with Scientific Annexes, Volume I. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), United Nations, New York.

Vukanac, I., Kandic, A., Đurašević, M., & Šešlak, B. (2012). Human exposure to artificial radionuclides in the environment. *J. Hum. Res. Rehabil.*, 2(2), 15–19. https://doi.org/10.21554/hrr.091202