ORIGINAL ARTICLE

CANCER PATIENT TRENDS AND EXCESS LIFETIME CANCER RISK: A COMPARATIVE STUDY OF JOS NORTH AND SOUTH AT JUTH ONCOLOGY CLINIC

Stephen D. Pam[1], Nandul N. Maurice[2], Anil I. Sirisena[1], Kyermang K. Dakok[3], Barnabas Dauda[4], Ishaya Habila[4]

1. Department of Radiology, Jos University Teaching Hospital, Jos, Nigeria.
2. Department of Radiation and Clinical Oncology, Jos University Teaching Hospital, Jos, Nigeria.
3. Department of Physics, Plateau State University, Bokkos, Nigeria.
4. Skane Radio-Diagnostic Centre & Hospital, Jos, Nigeria.

Corresponding Author:
Dr. Nandul N. Maurice, Department of Radiation and Clinical Oncology, Jos University Teaching Hospital, Jos, Nigeria, mnimark@yahoo.com, +2348068046988

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ABSTRACT

Background: The Oncology Clinic at Jos University Teaching Hospital has observed a significant influx of cancer patients residing in Jos North and Jos South Local Government Areas in Plateau State with a rich history of mining activities spanning several decades. This observation prompted this study.

Objective: The aim of this study was to assess the excess lifetime cancer risk (ELCR) for residents in these areas by measuring environmental background ionizing radiation levels.

Methods: Medical records from the Oncology Clinic were reviewed to extract data on cancer types, patients' residences, and gender. A radiation survey meter was employed to measure background ionizing radiation levels across 47 sample points in 11 selected locations within Jos North and 52 sample points in 10 selected locations within Jos South.

Results: The findings revealed alarmingly high ELCR values, significantly surpassing global averages. The minimum ELCR values were over 200% above the world standard, while the maximum values soared to 1200% above the global mean. Specifically, the mean absorbed dose rate for inhabitants in Jos North was 0.292 µSv/h, and that of Jos South was 0.285 µSv/h, both starkly higher than the global standard of 0.13 µSv/h.

Conclusion: This study underscores the pressing need to address the environmental and health ramifications of prolonged mining activities in Central Nigeria. The elevated radiation levels and associated cancer risks call for immediate policy interventions to mitigate these risks and safeguard community health.

Keywords: Excess Lifetime Cancer Risk, Cancer Patient Trend, Mining communities, Public Health concerns, Jos.

INTRODUCTION

Cancer rates are rising worldwide, fueled by a complex interplay of environmental, lifestyle, and socioeconomic factors.[1] In low-income and middle-income countries, where regulations around environmental and occupational health are often less stringent, hazardous industries pose heightened health risks to nearby communities.[2] The impact of industrial mining on cancer risk is well-documented. Mining releases harmful substances like heavy metals and radon gas, which seep into the soil, contaminate water sources, and pollute the air.[3] Prolonged exposure to these carcinogens can lead to chronic health issues, making those living in mining regions especially vulnerable. Residents working in or near these sites face daily environmental and occupational exposures that significantly elevate their excess lifetime cancer risk, a concerning trend that demands urgent attention.[4]

Adding to this risk are socioeconomic challenges that further complicate the picture. Economic hardships of communities surrounding the mining fields drive a substantial portion of the population to rely on mining for their livelihood despite the inherent health risks. This situation has increasingly drawn women into the workforce, often in roles that place them in direct contact with environmental hazards without adequate safety protections.[5] The unique vulnerabilities of women in mining have recently gained attention,[5] highlighting the intersection of gender and occupational health risks in hazardous environments.

A critical public health issue also lies in the lack of affordable healthcare access; limited availability of cancer screening and prevention programs leads to frequent late-stage diagnoses and lower survival rates.[6] Excess lifetime cancer risk assessments consistently show alarmingly high values in these mining areas compared to non-mining regions, underscoring the need for targeted healthcare interventions.[7] Current research emphasizes the importance of conducting thorough risk assessments and developing healthcare strategies for high-risk populations to curb the long-term impacts of these environmental exposures.

High levels of ionizing radiation in the environment for long periods from both active and abandoned mining sites are a serious public health concern that needs urgent attention. Jos is the capital city of Plateau State in Central Nigeria and is also popularly known as the Tin City. It has a long history of mining activities for more than a century.[8] Mining of Tin and Columbite, among other minerals, is still going on today in Jos and its environs, especially in Jos North and Jos South Local Government Areas (LGAs) of Plateau State. However, unregulated and indiscriminate mineral mining and milling activities could lead to long-term ecological, health, and social degradation in these two areas. The presence of Naturally Occurring Radioactive Minerals (NORM) such as ^{238}U, ^{232}Th, and ^{40}K in these ores and processed waste during mining, milling, and processing of NORM-bearing minerals has been established.[7,9-10] This can enhance the distribution of NORM in the environment and consequently, an elevation in

the Background Ionizing Radiation (BIR) levels emanating from soil, water, and air around the mining fields.[11-13] Since these mining activities have made continuous radiological impact, risk assessment of the mining activities at present on the miners as well as the general public has become essential. A previous study done in the Barkin-Ladi Local Government area revealed that the mean radioactivity concentrations of ^{222}Ra and ^{232}Th were significantly higher in the ore samples than the world mean values.[8] Similarly, another study recently carried out in the Jos South Local Government Area concluded that Jos and its environs can be classified as a high background radiation area in Nigeria.[7] These intensive mining activities have left an indelible mark on the environment, exposing residents to potential carcinogens and elevating cancer risks in these communities.

The Oncology Clinic at Jos University Teaching Hospital has observed a high influx of patients from two specific Local Government Areas (LGAs) of Plateau State: Jos North and Jos South, from the hospital's medical records. This unusual concentration of cases prompted a closer investigation into potential environmental factors that might contribute to cancer rates among these communities. Since Jos is a city with a long history of tin mining, we hypothesized that prolonged exposure to background radiation might play a prominent role in the health risks faced by residents. Thus, this study was aimed at measuring the background ionizing radiation levels in these two LGAs and to calculate the Excess Lifetime Cancer Risk (ELCR) for inhabitants of these areas.

MATERIALS AND METHODS

Collection of data on cancer patients from medical records

The authors obtained ethical clearance from the Jos University Teaching Hospital with approval number NHREC/JUTH/05/10/22 prior to commencement of this study. The information required for this study was extracted from the medical records of the cancer patients attending the Oncology clinic of the hospital. These include the age, gender, residential location, and the type of cancer diagnosed.

Study Area for background radiation level survey

The Jos Metropolis, which consists of parts of Jos North and Jos South LGAs, is found to be the most densely populated area as well as the major mining area in Plateau State. The study areas for background radiation level survey were chosen based on these densely populated residential areas, which are situated around the major mining fields in both Jos North and Jos South LGAs. Therefore, we chose 11 sample locations in Jos North and 10 sample locations in Jos South LGA according to the above criteria for this research. However, according to a post in www.naijadetails.com/plateau-state-population titled 2025 population estimations in Plateau State, Jos North, which has an area of 291 km^2, has a population of 643,200, while Jos South, which has an area of 510 km^2, has a population of 458,100.

Background ionizing radiation measurements:

The in-situ radiation data were collected with a Geiger-Muller-based multipurpose radiation survey meter, Radiation Alert Inspector (Serial No. 29981, manufactured by S.E. International, Inc., USA), at 47 sample points

of the 11 sample locations in Jos North and 52 sample points of the 10 sample locations in Jos South. The survey meter is a battery-operated handheld portable unit made in the U.S.A. The calibration of the detector was verified at the National Institute of Radiation Protection and Research, which is a facility of the Nigerian Nuclear Regulatory Authority (NNRA). At each sample point, three in-situ measurements were taken with the handheld radiation meter at a standard distance of one meter (1.0 m) above the ground level, and the average was taken.[14] All measurements were carried out in the dry season (October and November 2022) between 11 hours and 17 hours daily. This is to minimize the effect of soil moisture attenuation of gamma-ray intensity and to avoid the random error that could be due to variations in atmospheric parameters. GPS coordinates of each sample point were recorded using a GPS Coordinates App from a smartphone.

To assess the Radiological risk due to the measured absorbed dose rate (ADR) (µSv/h), the annual effective dose rate (AEDR) and excess lifetime cancer risk (ELCR) were evaluated from the values of ADR measured at all the selected 21 sample locations in the Jos Metropolis which consists of some parts of Jos North and Jos South LGAs.

The AEDR (mSv/y) at 1m above ground level in the air for external exposure was estimated according to the equation.[9]

$$AEDR\left(\frac{mSv}{y}\right) = ADR\ x\ 8760\ x\ 0.2\ x\ 10^{-3}$$

Where 8760 is the number of hours in a year, 0.2 is the outdoor occupancy factor, and 10-3 is the conversion factor from µSv to mSv.

The ELCR for outdoor exposure was evaluated from AEDR computed by equation 1.

$$ELCR = AEDR\ x\ L\ x\ RF$$

Where L is the life expectancy (taken as 56 years) for people of Plateau State (Nigeria Life Expectancy, 2023), and RF is the risk factor taken as (0.05/Sv).[15]

The percentage increase of Excess Lifetime Cancer Risk over the world mean value 0.29 x 10-3 from [9] is computed by the following formula: Percentage increase = [(ELCR at the sample point – world mean value)/world mean value] x 100%

RESULTS

Figure 1 shows the distribution of cancer patients attending the Oncology clinic of Jos University Teaching Hospital, Jos. From our survey, it was found that out of 401 cancer patients seen at the Oncology clinic, 138, representing 34% are residing in Jos North LGA, and 119, representing 30% are residing in Jos South LGA. Remaining 34% are residing in other LGAs of Plateau State and other states of Nigeria. This shows 64% of cancer patients who attended the Oncology Clinic of JUTH are residing in Jos North and Jos South alone. However, the cancer patient statistics from these two LGAs of other hospitals are not readily available for comparison. Since JUTH is the main referral hospital in Jos, we believe that most of the patients from all LGAs of Plateau State are among the patients seen at our Oncology clinic. Due to a lack of readily available and verified information, we are unable to ascertain that our findings in Jos North and Jos South are higher than those of other Nigerian cities of

similar population sizes and access to cancer care.

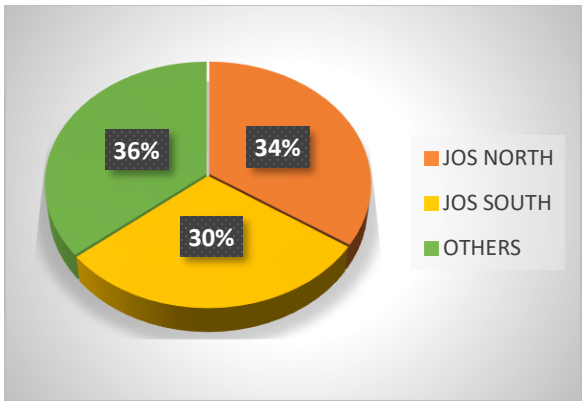

Figure 1: Distribution of cancer patients attending Oncology clinic at JUTH

The distribution of types of cancer patients residing in Jos North, Jos South, and others is shown in Figure 2. The Total number of patients from Jos North, Jos South, and others was 138, 119, and 144, respectively. This means that Jos North and Jos South accounted for 257 cancer patients out of the total number of 401 data retrieved from the medical records. This shows that 64% of cancer patients who attended the Oncology clinic of JUTH were from Jos North and Jos South LGAs. The most prevalent cancer types in Jos North and Jos South were found to be cervical and breast cancers. A significant number of head and neck cancers were also identified. Altogether, 16 different cancer types of patients were recorded by the Oncology clinic.

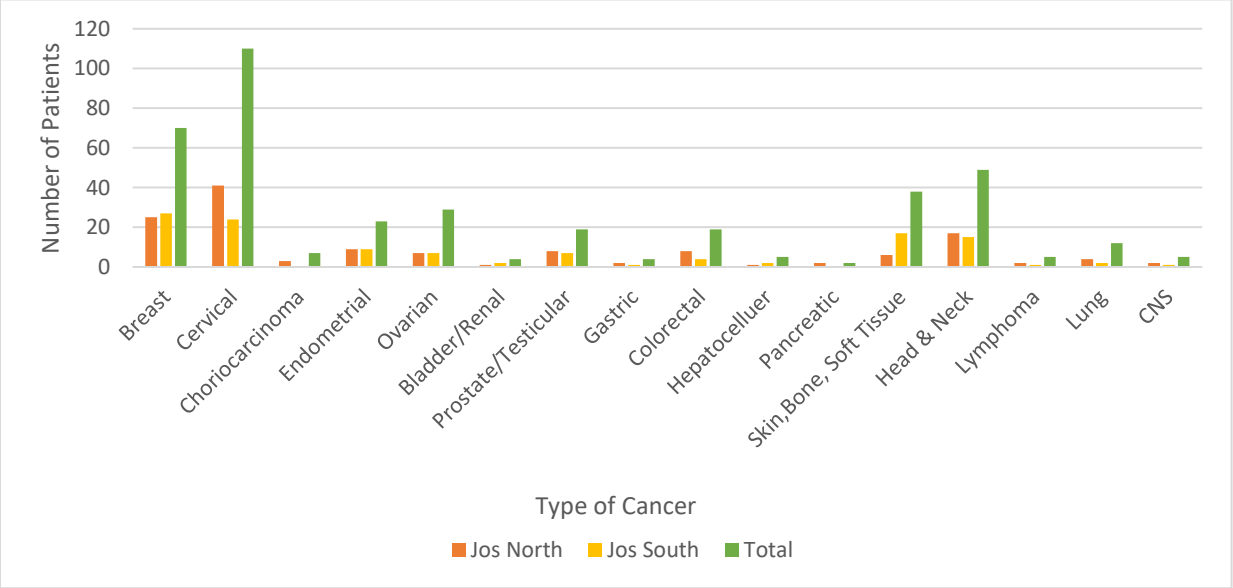

Figure 2: Distribution of Type of Cancer Patents in Jos North, Jos South, with Overall Total

From the environmental survey, we found that the elevations of the sample points in Jos North LGA ranged from 1116-1342 m with a mean ± SD value of 1222 ± 57m, while in Jos South LGA, they ranged from 1210 -1329 m with a mean value of 1274 ± 29 m. The overall mean elevation of the entire study area was 1248 ± 51 m. The summary of outdoor mean values of ADR, AEDR, and ELCR for the 11 sample locations, which consist of 47 sample points of Jos North, is shown in Table 1 while Table 2 shows the summary of outdoor mean values of ADR, AEDR, and ELCR for the 10 sample locations which consist 52 sample points of Jos South

Table 1: Summary of Mean values of ADR, AEDR, and ELCR for Jos North sample locations.

S/N	Sample Location Code	Minimum BIR (μSv/h)	Maximum BIR (μSv/h)	ADR (μSv/h) Mean ± S.D.	AEDR (Outdoor) Mean ± S.D. (mSv/y)	ELCR x 10^{-3} Mean ±S.D.
1	GRA	0.26	0.52	0.350±0.047	0.612±0.083	1.72±0.23
2	BRRS	0.17	0.36	0.255±0.035	0.446±0.061	1.25±0.17
3	SHS	0.14	0.35	0.261±0.028	0.456±0.048	1.28±0.14
4	BRR	0.17	0.32	0.254±0.021	0.445±0.037	1.24±0.11
5	UJSQ	0.18	0.31	0.252±0.014	0.441±0.025	1.23±0.07
6	LRR	0.17	0.35	0.263±0.024	0.461±0.041	1.29±0.12
7	JGRR	0.17	0.46	0.305±0.054	0.535±0.094	1.50±0.26
8	TRR	0.12	0.51	0.293±0.080	0.513±0.140	1.44±0.39
9	RRR	0.17	0.40	0.283±0.029	0.495±0.051	1.39±0.15
10	SRR	0.16	0.72	0.359±0.135	0.628±0.237	1.76±0.66
11	RR	0.16	0.62	0.333±0.120	0.584±0.211	1.64±0.59
	Jos North Mean	0.17	0.45	0.292±0.040	0.511±0.070	1.43±0.20

GRA- Gwarandok Residential Area, BRRS- Bauchi Ring Road Settlement, SHS- Shere Hills Settlement, BRR- Bauchi Road Residential, UJSQ- University of Jos Staff Quarters, LRR- Lamingo Road Residential, JGRR- Joseph Gomwalk Road Residential, TRR- Tudun Wada Ring Road, RRR- Rukuba Road Residential, SRR- Secretariat Road Residential, RR- Rusau Residential

Table 2: Summary of Mean values of ADR, AEDR, and ELCR for Jos South sample locations.

S/N	Sample Location Code	Minimum BIR (μSv/h)	Maximum BIR (μSv/h)	ADR (μSv/h) Mean ± S.D.	AEDR (Outdoor) Mean ± S.D. (mSv/y)	ELCR x 10^{-3} Mean ±S.D.
1	KZS	0.23	0.38	0.304±0.067	0.533±0.118	1.49±0.33
2	KS	0.21	0.26	0.242±0.025	0.424±0.044	1.19±0.12
3	SBS	0.28	0.38	0.322±0.042	0.563±0.074	1.58±0.21
4	KRA	0.27	0.33	0.300±0.027	0.525±0.047	1.47±0.13
5	FLS	0.22	0.27	0.246±0.021	0.431±0.037	1.21±0.10
6	DS	0.24	0.30	0.271±0.030	0.475±0.053	1.33±0.15
7	ZS	0.23	0.25	0.238±0.012	0.418±0.020	1.17±0.06
8	RRA	0.20	0.34	0.270±0.069	0.472±0.121	1.32±0.34
9	SDSA	0.28	0.33	0.302±0.024	0.529±0.043	1.48±0.12
10	NH	0.32	0.39	0.353±0.031	0.619±0.054	1.73±0.15
	Jos South Mean	0.25	0.32	0.285±0.038	0.499±0.066	1.40±0.18

KZS- Kwata Zawan Settlement, KS- Kuru Settlement, SBS- Sabon Barki Settlement
KRA- Kwang Residential Area, FLS- Farin Lamba Settlement, DS- Du Settlement, ZS- Zawan Settlement, RRA- Rayfield Resort Area, SDSA- Skane Diagnostic Services Area, NH- Nungyel Hill

Using the data provided in Tables 1 and 2, paired sample significance tests were carried out with IBM SPSS Version 22 statistical package for ADR, AEDR, and ELCR, and the results are shown in Table 3 below.

Table 3: Paired Sample Tests of Significance of ADR, AEDR, and ELCR for Jos North and Jos South LGAs

Paired Samples Test

		Paired Differences					T	df	P-VALUE
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ADR (µSv/h) Mean ± S.D. JOS NORTH - ADR (µSv/h) Mean ± S.D JOS SOUTH	.003091	.036852	.011111	-.021667	.027849	.278	10	**.787**
Pair 2	AEDR (Outdoor) Mean ± S.D. (mSv/y) JOS NORTH - AEDR (Outdoor) Mean ± S.D. (mSv/y) JOS SOUTH	.005000	.064301	.019387	-.038198	.048198	.258	10	**.802**
Pair 3	ELCR x 10-3 Mean ±S.D JOS NORTH - ELCR x 10-3 Mean ±S.D JOS SOUTH	.014545	.1822AEDR83	.054961	-.107914	.137005	.265	10	**.797**

This showed that there is no significance between all the study parameters (ADR, AEDR, and ELCR) between Jos North and Jos South LGAs. (Significance value is placed at $p < 0.05$.).

The distribution of the percentage increase of ELCR over the world means value in Jos North and Jos South is shown in Figures 3, and 4, respectively.

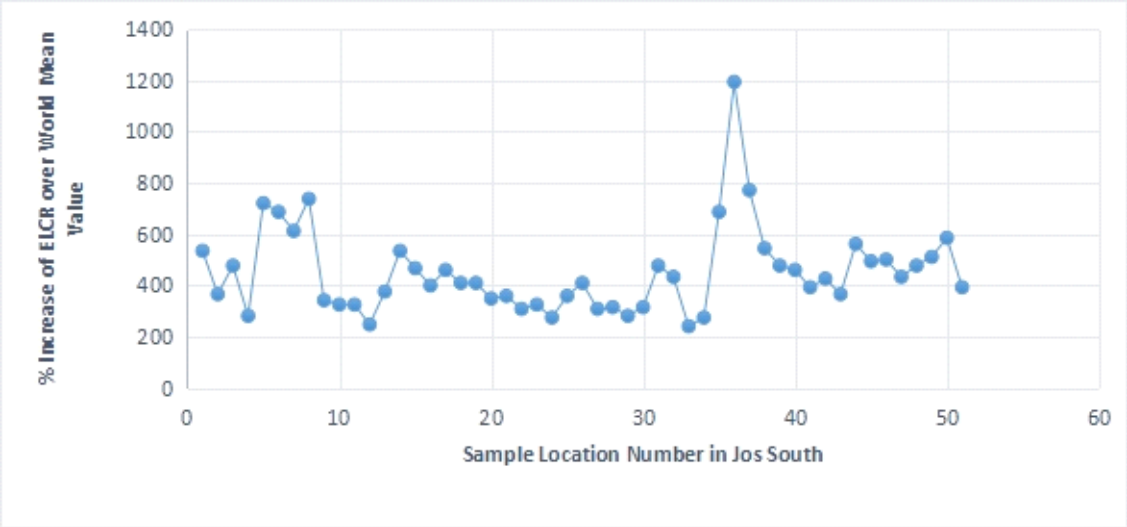

Figure 3: Distribution of Percentage Increase of ELCR over World Mean Value (Global standard) in Jos North LGA

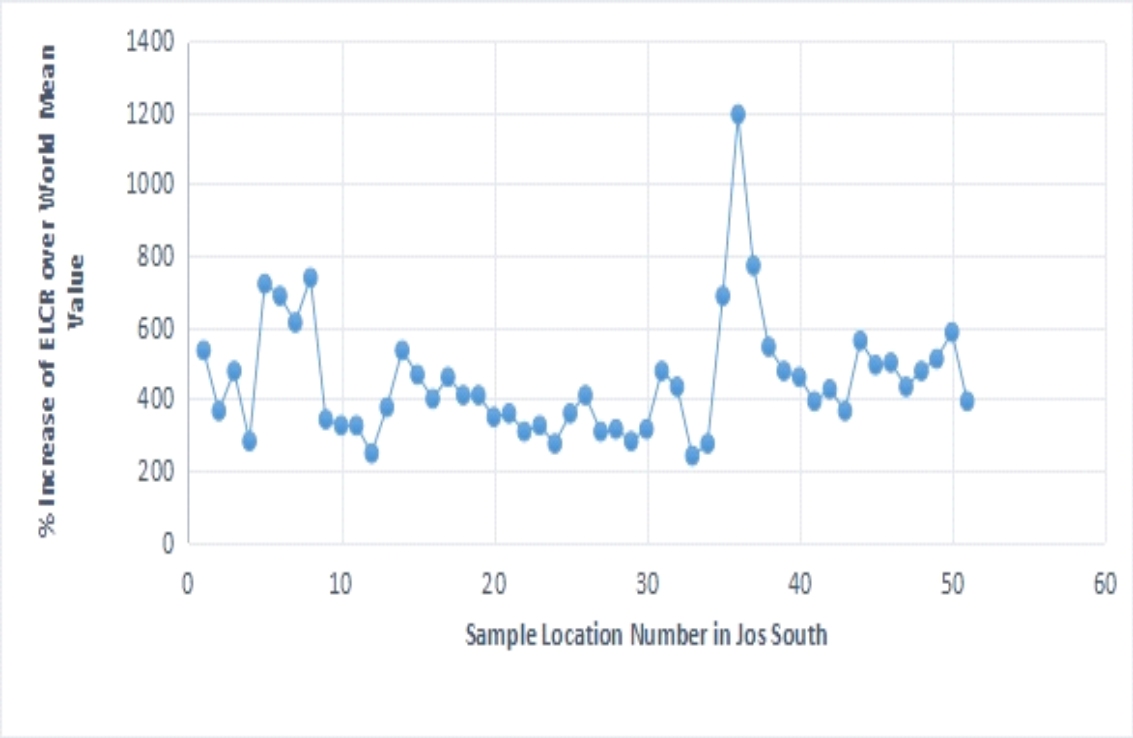

Figure 4: Distribution of Percentage Increase of ELCR over World Mean Value (Global standard) in Jos South LGA

DISCUSSION

Table 1 summarizes the mean values of ADR, AEDR, and ELCR of locations in the Jos North LGA. From these measured values, it could be seen that the least mean minimum BIR was found in the Tudun Wada area, 0.12µSv/h, and the mean maximum BIR value was 0.72µSv/h found in the Secretariat Road residential area. Table 2 gives the mean minimum and maximum BIR dose rates of the selected sample locations in the Jos South area. The measured mean minimum value was found in the Rayfield resort area at 0.20µSv/h, while the mean maximum BIR in Jos South was 0.39µSv/h, found in Nungyel Hill settlement.

Overall, the total mean values of the minimum and maximum BIR in the selected 11 sample locations in Jos North were found to be 0.17 µSv/h and 0.45 µSv/h, respectively, while the mean minimum and maximum BIR dose rates in the 10 selected sample locations in the Jos South area were 0.25 µSv/h and 0.32 µSv/h, respectively. Also, we found that Jos North generally has a higher overall mean Absorbed Dose Rate (ADR) of 0.292 µSv/h compared to 0.285 µSv/h of Jos South. The higher ADR value in Jos North could be because most of these locations, which were abandoned mining sites but have now become residential areas due to urbanization, and the emitted BIR could

be a result of previous mining activities and other human activities. The mining sites in Jos South are still active, and most of these locations have fewer residential areas and fewer human activities contributing to the background ionizing radiation. From the average of these two, the ADR for people in Jos Metropolis is found to be 0.289 µSv/h. This was about 6 times greater than the world average value of 0.05 µSv/h given by the UNSCEAR.[9] Likewise, the mean Annual Effective Dose Rate (AEDR) for the inhabitants of 11 sample locations in Jos North was 0.511 mSv/y compared to 0.499 mSv/y in Jos South. This gives the mean AEDR for people living in Jos Metropolis as 0.505 mSv/y, which is about 7 times greater than the outdoor world average value of 0.07 mSv/y given by UNSCEAR.[9] From this, we found that both the mean ADR and mean AEDR in the Jos North area are slightly higher than those of the Jos South area. Incidentally, Jos North has a larger population compared to Jos South LGA. From our computations, the mean Excess Lifetime Cancer Risk (ELCR) for the inhabitants of selected 11 sample locations in Jos North was found to be in the range between 1.23×10^{-3}- 1.76×10^{-3} and that of 10 sample locations in Jos South between 1.17×10^{-3} - 1.73×10^{-3}. The average ELCR for Jos North and Jos South was found to be $1.43 \pm 0.20 \times 10^{-3}$ and $1.40 \pm 0.18 \times 10^{-3}$, respectively. Therefore, the ELCR for the people living in Jos Metropolis can be taken as the mean of these two values to be 1.42×10^{-3}.

When compared with the world mean value of $0.29 \times 10^{-3,}$ this is about 400% higher than the world mean value. The maximum permissible limit of ELCR is 2.4×10^{-3}, as stated by ICRP.[15,16] However, the greatest individual ELCR at a single sample point in Jos North out of the 47 sample points was found to be 2.90 x 10-3 at the sample point located at longitude N 9^0 54' 9.7" and latitude E 8^0 52' 31.8" (about 900% higher than the world mean value as shown in Figure 3) and out of 52 sample points in Jos South was found to be 3.75 x 10-3 in the sample point located at longitude N 9^0 50' 18.2" and latitude E 8^0 55' 5.9" (about 1200% higher than the world mean value as shown in Figure 4) which was close to an active mining field. In all the selected sample points of both Jos North and Jos South LGAs, the minimum ELCR was found to be well over 200% above the world mean value, which is the global standard, and the maximum ELCR was found to be 1200% more than the global standard. This is reflected in the high percentages of patients attending the Oncology clinic from Jos North and Jos South Local Government Areas of Plateau State. The Oncology clinic in JUTH is observing an increasing incidence of lung cancer in people who have never smoked. Most of these patients reside within Jos metropolis, with ELCR found to be above 200%. This could be contributory to the etiological factors responsible for this epidemiological trend of lung cancer on the plateau. Radon has been implicated as the leading cause of lung cancer in non-smokers.[17] The association of residential radon with lung cancer is a dose-response relationship, with an increment of 100Bq/M3 said to increase lung cancer by about 7% in a study.[18]

CONCLUSION

In conclusion, this study highlights a concerning public health issue in Jos North and Jos South LGAs, where prolonged exposure to high-background radiation levels from tin mining has resulted in Excess Lifetime Cancer Risk (ELCR) values that significantly exceed global safety standards. The elevated ELCR levels observed across all sample points lead to a high cancer risk for local populations,

especially in areas where values surpass the maximum permissible limit. This risk is further underscored by data from the Oncology Clinic at Jos University Teaching Hospital (JUTH), where over 60% of cancer patients attended, residing in these areas, with a notable prevalence among women, likely due to socioeconomic pressures leading to increased female involvement in mining.

The study's findings emphasize the urgent need for targeted interventions to address the health risks associated with radiation exposure in these communities. Remediation efforts, public health awareness campaigns, and stricter regulatory measures are necessary to protect current and future generations. Additionally, the data underscores the importance of monitoring and mitigating environmental radiation in mining regions to reduce the long-term health impacts. Overall, this research provides critical insights into the environmental and health ramifications of tin mining in Sub-Saharan Africa, advocating for comprehensive policies to safeguard public health and promote sustainable development in mining communities.

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