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Statistical Analysis of Electromagnetic Radiation Parameters and Specific Absorption Rate (SAR) in Selected Mobile Phones on Active Call within Sokoto Metropolis, Northwest, Nigeria

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Abstract: Mobile phone technology has brought important benefits to individuals, businesses, and society. The widespread use of mobile phones has raised public and scientific interest regarding exposure to electromagnetic radiation and its possible biological effects Like most technologies, there are negative effects that can arise as a result of using radiofrequency (RF) radiation source from mobile phones. Health effects can arise as a result of exposure to this radiation. In this study, power density and electromagnetic fields from mobile phones were measured using a handheld electromagnetic field meter GQ EMF 390. Measurements were obtained from some sources of electromagnetic field (EMF) from mobile phone users on active calls. The power density and electromagnetic field values were used to obtain the specific absorption rate of radiation in tissue (SAR).. This study statistically examined relationships among measured magnetic field strength, electric field strength, power density, and Specific Absorption Rate (SAR) in selected mobile phones. Data from 50 mobile phone samples were analyzed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics, Pearson correlation, and multiple regression analyses were performed. Results showed that electric field strength had a very strong positive correlation with SAR ($r = 0.979$, $p < 0.001$), while magnetic field strength showed a moderate positive correlation ($r = 0.358$, $p = 0.011$). Power density had no significant relationship with SAR ($r = -0.028$, $p = 0.849$). Multiple regression revealed that electric field strength was the only significant independent predictor of SAR ($p < 0.001$), and the model explained 95.8% of the variance in SAR ($R^2 = 0.958$). The study concludes that electric field strength is the most influential measurable radiation parameter associated with SAR among the sampled devices.

Keywords: *Mobile Phones, SAR, Electromagnetic Radiation, Electric Field, Magnetic Field, Power Density, SPSS.*

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I. INTRODUCTION

Mobile phones have become essential communication tools worldwide, especially in a developing country like Nigeria, where other forms of communication exist to a very limited extent. Nigeria is the largest mobile telecommunications market in Africa, largely based on rapid development following the successful auction of Digital Mobile Licenses (DML) in 2001 (NCC, 2019) (NNBP, 2020). According to the Nigerian Communication Commissions (NCC) annual report**,** mobile subscribers increased with a total of 27, 811,580, from 145,059,514 subscribers in 2017 to record high of 172,871,094 active voice subscriptions as at December 2018. By December 2019, the market served over 184 million Mobile lines, with 126 Million of those lines connected to Internet services (NCC, 2019). Today we are exposed to 100 million times more EMFs than our grandparents were (Girish, 2010). That's because most of the trappings of modern life – appliances, cell phones, wireless Internet, and more – emit artificial EMFs that disrupt the body's natural energy field and can cause many health problems. The more EMFs to which we are exposed, the more likely and serious your risk is. there were several reports that the electromagnetic radiation released by mobile telecommunications, which includes the use of cell phones, Wi-Fi and Bluetooth devices has now become the main man-made source of environmental radiation. The negative effects of non-ionizing radiation have been reported and the unwillingness of the cell phone companies to admit in public the results and to be responsible for the impacts this

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technology has in the human body is worrisome. The awareness of effects of radiofrequency emitted can educate the public on the consequences of using this RF sources for a long period of time. Their increasing use has generated concerns about user exposure to radiofrequency electromagnetic fields emitted during operation. These emissions are commonly characterized by measurable parameters such as electric field strength, magnetic field strength, and power density.

Owoh and his team carried out a study to examine the possible potential health risks that result from the use of some commonly available mobile phones in Nigeria. The mobile phones subjected to test were Tecno S1, Touching T1, Infinix hot 6 and Itel 1701. Their electric field strength, magnetic field strength and power density varied significantly per call engagement mode at various varied distances of measurement. Also, their computed head SAR values were observed to be below the limit set by the International Commission on Non-Ionizing Radiation Protection. From a potential health hazard point of view, Tecno S1 was found to be the safest for use (Owoh *et al*., 2020)

Khuzairi *et al* (2019) mentioned that the usage of mobile phone as a communication medium and information source are becoming ubiquitous in this era in Malaysia. It is to be understood that the radiation emitted from the antenna mounted on BTS is a type of non-ionizing radiation. There are invalid and insignificant evidence to support the claims that the radiation could cause adverse health effect to the human. The findings in his research were based on the indoor and outdoor measurement which shows that the level of E-field strength is very low. Furthermore, the finding in this research suggests that the usage of mobile phone from 2G, 3G, Wi-Fi for indoor and fourth generation mobile network (4G) and the BTS in Pulau Pinang will also be safe for the public, due to the radiation level at this particular location adheres to the permitted exposure limit. Bhat (2013) in his work titled - Effects of Electromagnetic Waves Emitted by Mobile Phones on Male Fertility. Reported that there are health effects that can occur when the human body is exposed to high levels of radio frequency (RF) energy, and Microwave radiation causes increase in tissue temperature. Riki *et al* (2015) in their work titled – Mobile Effect on Human Body. reported that the electromagnetic radiation emitted by mobile phones and towers are harmful, so people should keep away from the transmission towers and persons should use mobile phone as soon as low timing.

Specific Absorption Rate (SAR) is widely used to quantify the rate at which radiofrequency energy is absorbed by biological tissues. Regulatory agencies establish SAR limits to ensure device safety. Understanding the relationship between environmental radiation parameters and SAR is important for public health awareness, device assessment, and scientific research.

This study applies statistical analysis to determine the association between selected electromagnetic radiation parameters and SAR values of mobile phones.

➢ *Aim and Objectives*

- *Aim*

To analyze the relationship between electromagnetic radiation parameters and SAR in selected mobile phones.

- *Objectives*

✓ To determine descriptive statistics of measured radiation parameters and SAR.
✓ To examine correlations between magnetic field, electric field, power density, and SAR.
✓ To identify significant predictors of SAR using multiple regression analysis.
✓ To interpret the implications of the findings for radiation exposure assessment.

II. MATERIALS AND METHODS

➢ *Research Design*

This study employed a quantitative experimental design using radiation measurements obtained from Fifty (50) different mobile phones selected from different active users within a higher institution of learning. Measurements were obtained when phone was on active call engagement. Measurements were taken using GQ EMF 390 V-2 capable of measuring power density, electric field and magnetic field in different units. EMF has Zero Calibration. The data were obtained by pointing the EMF meter in front of each mobile phone. The measurements were obtained at 0 cm distance from the phone at one second interval for a period of one minute from each of the mobile phone used in the study. The EMF meter was placed directly on the phone for direct contact with the skin since most of the time the phone is either held on the hand or place on the ear thereby having direct contact with skin. Each mobile phone was placed on a laboratory stand as shown in

➢ *Sample Size*

A total of 50 mobile phone samples were included in the study.

➢ *Variables Measured*

- Magnetic Field (mG)
- Electric Field (V/m)
- Power Density (mW/m^2)
- Specific Absorption Rate (SAR) (W/kg)

➢ *Data Analysis*

Data were entered and analyzed using IBM SPSS Statistics. The following statistical procedures were applied:

- Descriptive statistics (mean, standard deviation, minimum, maximum)
- Pearson correlation analysis
- Multiple linear regression

Statistical significance was considered at $p < 0.05$.

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III. RESULTS

➢ *Descriptive Statistics*

Table 1 Descriptive Statistics

Variable	N	Mean	Std. Dev	Min	Max
Magnetic Field (mG)	50	0.820	0.129	0.600	1.400
Electric Field (V/m)	50	1.156	0.235	0.400	1.900
Power Density (mW/m²)	50	0.155	0.580	0.001	3.585
SAR (W/kg)	50	0.00110	0.00044	0.00013	0.00286

- *Interpretation*

The mean SAR value of the mobile phones was 0.00110 W/kg. All recorded values were substantially lower than common international exposure limits for mobile devices.

➢ *Correlation Analysis*

Table 2 Correlation Analysis

Variables	r	p-value	Remark
Magnetic Field vs SAR	0.358	0.011	Significant
Electric Field vs SAR	0.979	<0.001	Highly Significant
Power Density vs SAR	-0.028	0.849	Not Significant

- *Interpretation*

Electric field strength had the strongest relationship with SAR. As electric field values increased, SAR also increased. Magnetic field showed a weaker but significant association, while power density did not show statistical significance.

➢ *Multiple Regression Analysis*

- *Model Summary*

✓ $R = 0.979$
✓ $R^2 = 0.958$
✓ Adjusted $R^2 = 0.955$
✓ $F(3,46) = 347.8$
✓ $p < 0.001$

- *Coefficients*

Table 3 Coefficients

Predictor	B	p-value	Interpretation
Magnetic Field	~0.000001	0.991	Not Significant
Electric Field	0.0018	<0.001	Significant
Power Density	-0.000006	0.792	Not Significant

- *Interpretation*

Electric field strength was the only significant independent predictor of SAR when all predictors were considered simultaneously.

IV. DISCUSSION

The findings demonstrate that electric field strength is strongly associated with SAR in the sampled mobile phones. This is expected because SAR depends on the interaction of electromagnetic fields with biological materials. The strong predictive ability of electric field measurements suggests that it may serve as a practical indicator during rapid radiation assessment.

Although magnetic field strength showed a significant correlation with SAR, it lost significance in the regression model. This indicates that its effect may overlap with electric field variation. Power density showed no meaningful predictive effect in this dataset.

The relatively low SAR values observed suggest compliance with widely accepted safety thresholds, although actual exposure can vary depending on network conditions, distance from base stations, device usage patterns, and measurement conditions.

V. CONCLUSION

This study evaluated electromagnetic radiation parameters and SAR in selected mobile phones using statistical analysis. The study concludes that:

➢ Average SAR values of sampled devices were low.
➢ Electric field strength had the strongest positive relationship with SAR.
➢ Magnetic field showed limited influence after adjustment.
➢ Power density was not a significant predictor.

Electric field measurement may therefore be a useful parameter in estimating radiation absorption trends in mobile phones.

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RECOMMENDATIONS

- Further studies should include larger sample sizes and more phone brands.
- Frequency bands and network modes (2G/3G/4G/5G) should be compared.
- Real-life usage conditions should be incorporated into future measurements.
- Public awareness on safe phone usage practices should be encouraged.

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