

## Impact Assessment of Electromagnetic Radiation from Second and Fourth Generation Mobile Phones: Findings from GSM Village Kurudu, Abuja- Nigeria

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### ABSTRACT

Due to overall surge from the use of handset close to the body tissues and the widespread use of these devices has created an impending health crisis regarding their emissions. Twenty four (24) different models of commonly used mobile phones were selected for the study at Kurudu, Abuja municipal area comprising of twelve brands of 2G and twelve 4G phones for comparison on their mode of exposure. The handsets include: Alcatel XL 535, Philips D1311, Gigaset C430, AT& TCL 2940, VTech CS6114, Panasonic KX-TS500, Xenios ACD 010, Telematrix (9700 series), Nokia 2600, Sony Ericson j230i, Samsung SGH-X490, Bontel, Tecno spark 20, Samsung Galaxy (SN-A1157/B3), Infinix hot (X682B), Iphone MGFP34/A, Redmi A3X, Opo A57, Itel A80, Villoan, Poco C61, Vivo X300Pro, Huawei P60Pro and Xiaomi 14. Electromagnetic field levels of the mobile phones were measured using an electromagnetic field meter with measurements piloted at close proximity (0cm to 5cm) from each device to mimic real-world exposure. A diverse and realistic head model was used to estimate the effects of electromagnetic radiation coupling to the human head. The potential hazards posed by mobile phone handsets on the human head were also addressed by evaluating the specific absorption rate (SAR) in human tissue for 2G and 4G phones. The results showed the highest SAR value of  $1.66 \pm 0.05 \text{ Wkg}^{-1}$  obtained from 2G phone model type-Sony Ericson j230i and  $0.23 \pm 0.01 \text{ Wkg}^{-1}$  was obtained for Samsung Galaxy (A11-SN-A1157/B3) for 4G phone respectively. The lowest SAR for 2G and 4G phones were as well obtained from Sony Ericson j230i with a value of  $0.04 \pm 0.05 \text{ Wkg}^{-1}$  and  $0.04 \pm 0.01 \text{ Wkg}^{-1}$  for Iphone MGFP34/A. However, comparing the various results acquired, the 2G phone of Sony Ericson j230i had above the threshold boundary of  $1.6 \text{ Wkg}^{-1}$  set by the Federal Communications Commission (FCC) but falls below the  $2.0 \text{ Wkg}^{-1}$  value of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) limits.

**Keywords:** Specific absorption rate, Electromagnetic field exposure, Mobile phone, Human tissue, Electric field

### 1.0 INTRODUCTION

A mobile phone is a small electronic device that people carry with them to communicate easily. This device allows users to make voice calls, send messages, and share data with others, regardless of the distance. This communication works through a network of cell towers that connect the phone to the wider network, making long distance conversation possible (Mane, 2026). This technology has made everyday task humanly possible as it has afforded easy ways of getting in touch with families, friends and work. Some of the functions done by this devices are but not limited to: Bluetooth, infrared, packet switching, gaming, video recording, e-mail, camera, multimedia message service (MMS), general packet radio service (GPRS), moving picture experts group layer-3 (MP3) player, and radio (Algburi, 2025).

There has been a total estimation of about 18.2 billion as at 2025 of mobile devices, from an initial 15 billion in 2021 (Number of Mobile Devices Worldwide 2020-

2025). Nigeria, with a population estimate of about 215 million in 2022, according to United Nations (UN) estimates, has more than 200 million mobile phone (MP) subscribers as of 2020, according to the Nigerian Communications Commission (NCC) (Nigeria Population 2022 ; Onaleye 2022). It is nearly impossible to visualize daily living without handsets in today's globalized society (Hassan & Chaudhari, 2025). Suffice to say that in some countries, mobile phone practice has grown to the point that subscribers surpass the population (Yadav, 2025).

The communication of mobile phone is made possible with the radio frequency range of 100 to 2000 MHz (Fatokun & Boyejo, 2025). This has no ionization effect on the body and hence, not strong enough to directly damage deoxyribonucleic acid (DNA) or disrupt atomic structure; instead, it causes atoms to vibrate, which can make them to heat up. Furthermore, every MP has a specific absorption rate (SAR) rating with an upper limit of  $1.6 \text{ Wkg}^{-1}$ , which is equal to 6 minutes (360 seconds)

of daily MP usage for a person (Gyar, *et al.*,2022). According to SAR limit, an individual should not use a MP for more than 24 minutes (1440 seconds) per call. Sadly, the majority of MP users are ignorant of this information and engages in lengthy phone conversations without realizing the potential health hazards (Aysha & Dua, 2025). They are also uninformed that the radiofrequency energy absorbed by MP user is dependent on a variety of other related factors, such as the make, design specifications, network reception quality, and closeness to a base station mast (Boutouaba & Kerfati, 2025).

Analog systems such as first –generation (1G) cellular networks-emit relatively high levels of radiofrequency (RF) radiation because they transmitted continuous carrier waves and often operated at higher power to maintain signal quality over larger distances (Onwuezobe, *et al.*, 2025). In contrast, modern digital mobile technologies (e.g. 2G through 5G) use advanced variation techniques that convert data into discrete binary signals, enabling more efficient use of the radio spectrum, reduced power consumption and increased data output (Raghavendra *et al.*,2024). The shift from analog to digital communication has also significantly altered the characteristics of electromagnetic emissions from mobile handsets and network infrastructure (Zontou, 2023).

Abuja, the Federal Capital Territory has witnessed a rapid increase in mobile phone ownership, due to the growing population and high level of phone patronage. This has made most users naive of the specific radiation levels emitted by different handset brands. This raises municipal health concerns, especially in an environment with partial regulatory enforcement regarding radiation safety standards and hence the need to assess the usage of MPS proximity to the human-body and the health concerns about exposure to radiation emitted from these devices. The objective of the work therefore, is to evaluate and compare the radiofrequency electromagnetic radiation (RF-EMR) levels emitted by 2G and 4G mobile phones in GSM Village Kurudu, Abuja, to determine compliance with ICNIRP safety standards.

## 2.0 MATERIALS AND METHODS

The electromagnetic field meter labelled Exttech instruments with serial number 480823 manufactured in Taiwan is a compact, handheld electromagnetic field meter designed to measure extremely low frequency (ELF) electromagnetic fields between the frequency of 30-300Hz and measurement range of 0.01 to 19.99μT with single axis sensor, designed for simple point and

use, sampling at approximately 2.5 times per second with user selectable readout in milliGauss (mG) or micro Tesla (μT) through switch. It has a power source of 9v battery with weight of 165g and operating conditions of 0-50°C with up to date annual recalibration. Twenty four (24) different models of commonly used GSM handsets were selected for the study. They were carefully selected at the Kurudu GSM village in Abuja which has existed for more than fifteen years. The phones were selected for different brands for 2G and 4G phones for comparison on their mode of exposure to electromagnetic field (EMF) radiation. The handsets include: Alcatel XL 535, Philips D1311, Gigaset C430, AT& TCL 2940, VTech CS6114, Panasonic KX-TS500, Xenios ACD 010, Telematrix (9700 series), Nokia 2600, Sony Ericson j230i, Samsung SGH-X490, Bontel, Tecno spark 20, Samsung Galaxy (SN-A1157/B3), Infinix hot (X682B), Iphone MGFP34/A, Redmi A3X, Opo A57, Itel A80, Villolan, Poco C61, Vivo X300Pro, Huawei P60Pro and Xiaomi 14.

The sensor head was positioned at different angles placed at close proximity (0cm to 5cm) to the mobile phone that was put on call mode to mimic real-world exposure to electromagnetic radiation. Five readings were taken for each phone measurement and the mean values of the magnetic field (B) recorded.

The mean values of velocities of EM waves in human head tissues were calculated using the relation:

$$V = \frac{C}{n} \quad 1$$

(Iortile, *et al.*, 2026)

where  $n$  are the refractive indices of tissues and  $C$  is the velocity of EM wave in vacuum ( $3 \times 10^8 \text{ms}^{-1}$ )

The values of the electric field intensity  $E$  were obtained using the measured values of magnetic field  $B$  and calculated values of velocity of EM waves  $V$ , using the relation:

$$E = VB \quad 2$$

The specific absorption rate (SAR) of the human tissues was evaluated using the relation:

$$SAR = \frac{\sigma E^2}{2\rho} \quad 3$$

$\sigma$ =Electrical conductivity of tissue,  $E$  = Electric field intensity and  $\rho$ = Density of tissue (Iortile, *et al.*, 2026).

**Table 1: Refractive indices, Velocity of electromagnetic wave and tissue parameters**

Types of tissue	Refractive index	Velocity of EM waves ( $\text{ms}^{-1}$ )	Density ( $\text{Kgm}^{-3}$ )	Conductivity ( $\text{Sm}^{-1}$ )
Eye	1.336	$2.20 \times 10^8$	1000	1.90



geometric field focusing (Karunaratna, 2024). Whereas, the muscle and brain have low SAR as compared to the eye because they are water-rich, well-perfused, electrically conductive tissues that spread and dissipate energy efficiently instead of concentrating it (Lee *et al.*, 2022).

There were also variation in tissue parameters for 2G and 4G phones due to differences in composition of configuration and function (Onwuezobe, *et al.*, 2026). As illustrated in Figures 1-4.

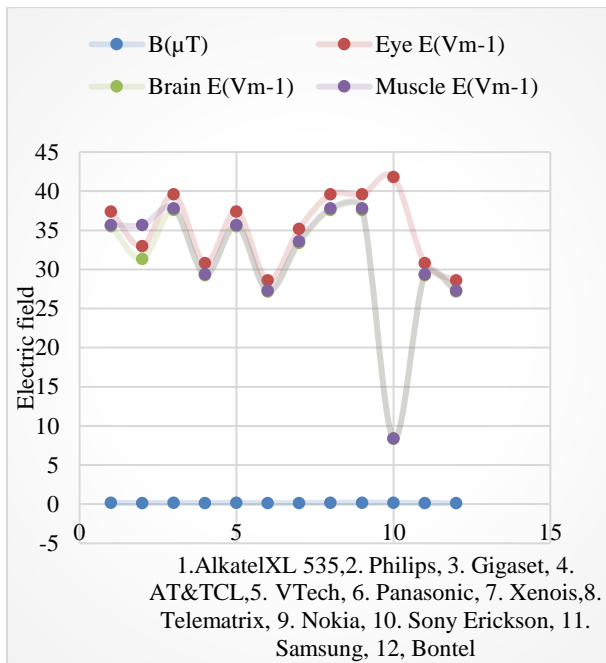


Figure 1: Comparing magnetic fields and electric fields for 2G mobile devices

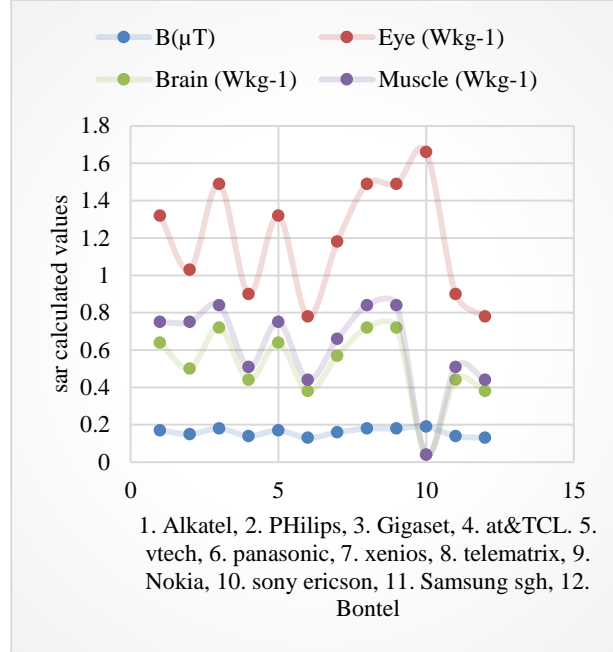
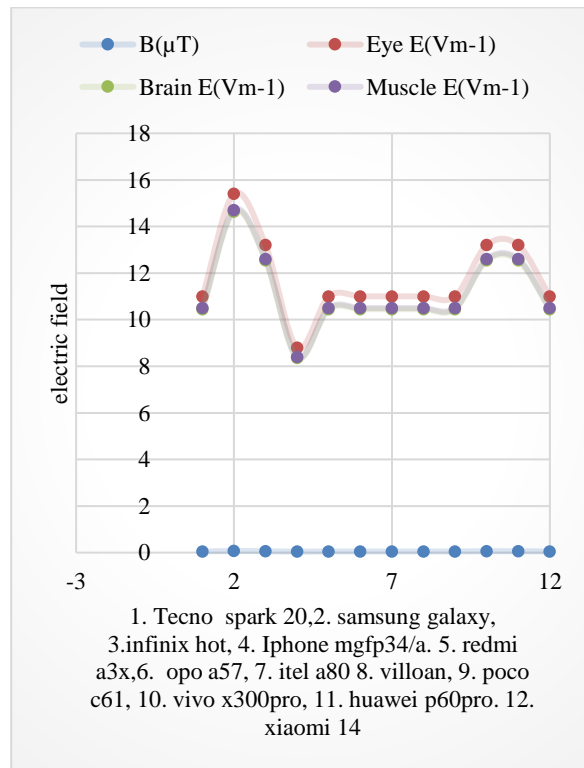
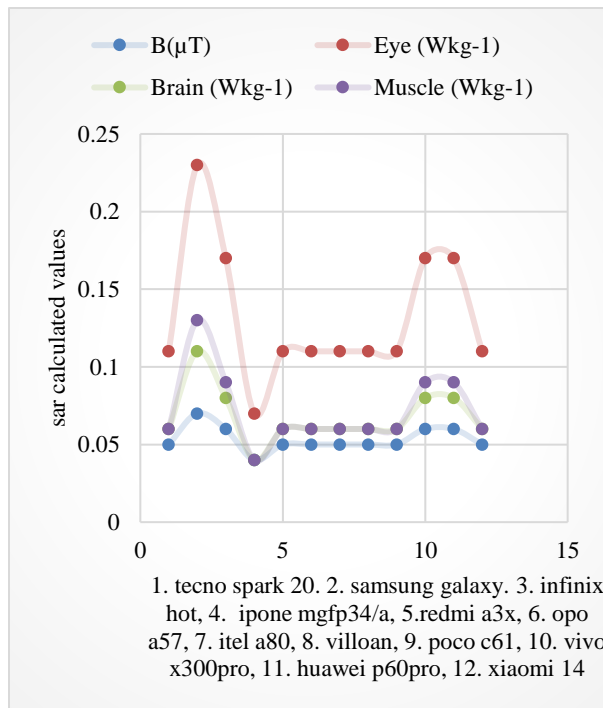


Figure 2: Comparing magnetic fields and SAR for 2G mobile devices



**Figure 3: Comparing magnetic fields and electric fields for 4G mobile devices****Figure 4: Comparing magnetic fields and SAR for 4G mobile devices**

Our study shows that the SAR values obtained are within safe limits  $2.0 \text{ Wkg}^{-1}$  but higher than the work conducted by Iortile *et al.*, 2026, with SAR value range of  $(0.04 \pm 0.01 \text{ to } 0.17 \pm 0.02) \text{ Wkg}^{-1}$ . Although the results corroborated well with the study piloted by Turgut and Engiz, (2023) at approximately  $0.5 \text{ to } 1.4 \text{ Wkg}^{-1}$ , Chen and Zhang, (2026) at the range of  $0.2 \text{ to } 1.6 \text{ Wkg}^{-1}$ , Tian *et al.*, 2023 at  $1.0 \text{ to } 1.6 \text{ Wkg}^{-1}$  and Abdul-Al *et al.*, 2022 with a SAR value of  $0.2 \text{ to } 1.5 \text{ Wkg}^{-1}$  respectively. These findings strengthen the importance of continued monitoring and transparent reporting of EMF emissions by manufacturers, as well as public education on safe handset usage. Further research, particularly long-term and large-scale human studies, is needed to fully understand the consequences of developing mobile technologies on human health.

#### 4.0 CONCLUSION

Our study carefully investigated the second-generation mobile devices alongside the fourth generation of various brands of mobile phones that are actively utilized by residents of GSM village located in Kurudu, Abuja. The investigations brought to light the significant finding that there is no threat posed to the population based on the examination of the brands of phones that were scrutinized during the findings. However, it is imperative to

emphasize that this study highlights the importance of maintaining constant vigilance when it comes to monitoring the levels of electromagnetic radiation (EMR) emissions emitted by GSM phones. The findings also necessitate strict adherence to established regulatory guidelines and the implementation of proactive policy measures that are essential for effectively mitigating the risks that have been associated with prolonged exposure to EMR. It is important to mention that mobile phone users should actively seek to reduce both the duration and frequency of their mobile phone conversations as a means to minimize their exposure to electromagnetic fields (EMF), and they should also promote the utilization of speaker mode in order to ensure that mobile phones are kept at a safe distance from both the head and the body. It is advisable to discourage the practice of keeping mobile phones stored in pockets, under pillows, or in close proximity to the body for extended periods of time, as this may increase exposure to EMF. Finally, there exists the need for ongoing advocacy directed at the public regarding the safe usage of mobile phones, as well as the potential risks associated with EMF, with a continuous monitoring system of EMF levels to ascertain whether there may be any long-term health effects that could arise from such exposure.

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