



Biological Effects of Global System of Mobile Communication- A Review

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Authors' contributions

This work was carried out in collaboration among all authors. Author MRA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript.

Authors MSS and OSO managed the analyses of the study and the literature searches.

All authors read and approved the final manuscript.

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ABSTRACT

In this study, a review of the biological effects of Global System of Mobile Communication handset was carried out using available literature and safety standards for radiofrequency of the National and International Agencies in conjunction with the International Committee for Non-Ionizing Radiation Protection (ICNIRP). The dose received by a biological tissue in time 0.5 minutes of dose as stated by the aforementioned agencies is equal to the microwave of 10mw/cm^2 SAR of 2 w/kg. The Specific Absorption Rate (SAR) limit of tissue for occupational workers for a whole body is 0.04 w/kg and for non-occupational workers is 0.08 w/kg. Additionally, GSM users exceeding the above SAR limits are likely to suffer from physiological effects of various forms such as alteration of calcium balance in the nerve tissues and inhibition of cells growth in the human amniotic, disruption of biorhythms due to the influence of electromagnetic field on the epiphysis resulting in dizziness, headaches and brain tumour.

Keywords: *Biological effect; GSM; radiation; global system; mobile communication.*

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1. INTRODUCTION

Global System for Mobile communication (GSM) is defined as a transmitter and a receiver of radiofrequency waves through a mobile station, i.e. it is a trans-receiver of microwaves. GSM handset through a mobile station, i.e. it is a trans-receiver of microwaves. GSM handset transmits signals with the frequency band between (800-900) MHz. this signals emits radiations of the electromagnetic energy into air, this emitted radiation from a point source (the mobile station) gets absorbed by human body tissues often the head of human beings is closer to the radiation source (GSM handsets). Radiations of this type are normally non-ionizing in nature. These radiations recur on a power of 2 watts per kilogram on the frequency of 900 MHz and 1.6 watts per kilogram on the frequency of 1800MHz as recommended by the international committee on non-ionizing protection (ICNIRP) [1,2].

Different forms of Electromagnetic energies are categorized by their wavelength and frequencies. For instance, the radio frequency part of the electromagnetic is general designed as when the part of spectrum where spectrum, where electromagnetic waves have frequencies within the range of 3KHz to 300GHz, is called microwave, which is a specific category of radio waves (GSM waves) that can be defined as radiofrequency energy frequency ranges from several hundred hertz (MHz) to several thousand hertz (GHz). Specifically, most mobile phones operate within the frequency range of (900-2200) MHz for the digital systems, while the analogue system operates on the frequency between (450-900) MHz.

According to Armstrong and K.R. Foster [3], exposure to GSM Frequency (Radio frequency) signals vary from occupational to non-occupational exposure. Non-occupational exposure is based on the distance of the population to the transmitter, while occupational exposure is based on the job transmitter [2,4].

It is possible that some jobs are adequate indicators of Radiofrequency exposure. That is, jobs that have more chances of exposing the worker to GSM frequency (Radio Frequency/Radiations which are more likely to be faced with the health hazards of electromagnetic radiation like heating of cells and tissues which might have adverse biological effects.

There is no means of communication that has revolutionized communication like the GSM

handset, the effects of GSM handset on the society and the country as a whole are too numerous to mention, to mention but a few is job creation, the formalism of capital influence indigenous skills acquisition and Bio-effects of GSM etc. GSM radiation is also known as microwaves, Body tissues react differently to this frequency wave depending on the electrical properties of the tissue.

The human head is mostly exposed to this radiation emitted at certain angles from the point source to the head [5,6]. These radiations cause a vibration of tissues and probably rise in temperature of the tissue causing bio-effects like fatigue, loss of mental attention etc.

The physiological effects of various forms are caused by GSM pulse-modulated radiation such effects include alteration of the calcium balance in nerve tissue and inhibition of cells grown in the human amniotic epithelium Disruption of biorhythms through the influence of Electromagnetic fields on the epiphysis, synthesis of melatonin in the epiphysis (pineal gland is inhibited [7]. Melatonin is a hormone that acts as ant-Oxidant and prevents the high level of estrogen foster cancer in dividing tissues. GSM frequency signals can cause a variety of other health effects like headache, dizziness etc. Due to the wide use of GSM handset it become necessary to alert GSM user in this research to be mindful of the time they spend on communication through on the phone to minimize the bio-effects of GSM handset frequency signals (Radiofrequency signals) or microwaves using the available materials as well as to advice on the safety measures on the use of GSM handsets. To this end, the review seeks to explore the biological effects of GSM.

2. RADIO FREQUENCY AND RELATED EFFECTS

2.1 Specific Absorption Rate (SAR) for Radio Frequency

Fritz and Stain [8] defined the specific absorption rate (SAR) as the rate at which radiofrequency energy is absorbed per unit mass of biological tissue. The dosimetry is the quantification of the magnitude and destruction of absorbed electromagnetic energy within human and biological objects that are exposed to electromagnetic radiation. The unit of specific absorption rate (SAR) is watts per kilogram (W/kg) or milliwatts per gram (Mw/g).

2.2 Absorbed Dose

The absorbed dose is the quantity or the amount of radiofrequency energy absorbed per unit kilogram of body tissue. It has the same unit of measurement as the specific absorption rate (SAR). The absorbed dose varies with the power density of the radiating sources. Under the normal circumstance, the interaction of body tissues with microwaves from the global system for mobile communication is very small at a particular time, but when accumulated over a long time. It becomes macroscopic (i.e. it can cause a macroscopic effect) e.g. brain and blood cancer.

Different human organs and tissues have different sensitivities to radio-frequency radiations. It has been found that microwaves cause a vibration of tissues and subsequently heat production.

The does limit for radiofrequency radiation varies from one country to another due to widespread public concern and differences in opinion between the experts from within the industry itself. It has become difficult due to these opinions to harmonize standard for specific absorption rate (SAR) limits.

However, ICNIRP set the general standard guideline for limiting exposure to electromagnetic radiation. These guidelines are generally accepted around the world except countries like USA and Canada that have more conservative of SAR limits.

2.3 Power Density

Power density is defined as the power per unit area. Power density can also be expressed in terms of milliwatts per square centimeter (MW/mm^2). Higher power density is usually used to express intensity.

2.4 Radio Frequency Field Dose

This is the dose received by a biological tissue in a time unit e.g. 0.5 minutes or 30 seconds of does

is equal to the microwave of $10mw/cm^2$ SAR OF $2w/kg$. For a minute will have a dose rate of $0.0002kg/m^2$

Maximum permissible dose simply means the amount of daily exposure to radio frequency (RF) field just to communicate from one point to another.

The international committee for Non-Ionizing Radiation Protection (ICNIRP) has specified certain volumes for the operation of our mobile phone and safe SAR limits recommendation were made by ICNIRP in collaboration with the World Health Organization (WHO) and other related agencies [9].

2.5 Safety Standard for Radio Frequency

The recent publication of specific absorption rate SAR measurement standard by institute of Electrical and Electronics Engineers (IEEE) 15228 has virtually harmonized (SAR) measurement methodology. These safety standards vary from one country to another as shown in the available standards for countries like Australia, USA, Japan, Europe, New Zealand etc. in conjunction with ICNIRP. Guidelines for SAR limits of some countries are shown below:

In Europe, the specific absorption rate (SAR) limit for mobile phone is $2w/kg$ and is measured as the average over 10 gram cube if tissue. A similar recommendation holds for Australia, while in USA and Canada, mobile telephone is $2w/kg$ and is measured as the average over 10 gram cube of tissue. As can be seen from the SAR limit table, it will not be possible to determine worldwide compliance by testing only one limit or one standard ISAR limit until international harmonization will occur.

In the meantime, manufactures ensure that Mobile Telephones (MTE) meet the SAR limits of each target Marketing and testing must be performed to the appropriate standard.

Table 1. Specific absorption rate (SAR) measured in log cube of tissue

SAR limits	Occupational worker	Non-Occupational worker
Whole body	0.04w/kg	0.08w/kg
Localized Exposure	10w/kg	2w/kg
Head and Trunk	20w/kg	4w/kg
Head and Feet		

Source [9]

Table 2. Specific absorption rate (SAR) limits for occupation

	Australia ACA	USA ANSIC 93.1	Europe ENV 50/66	Japan TT/MPT	New Zealand NZ52772
Whole Body	0.04w/kg	0.8 w.kg	0.8 w.kg	0.04 w.kg	0.08 w.kg
Spatial peak	2w/kg	1.6w/kg	2w/kg	2w/kg	2w/kg
Averaging time	6 min	6 min	6 min	6 min	6 min
Averaging mass	10 g	10 g	10 g	10 g	10 g
Shape	Cube	Cube	Cube	Cube	Cube

Source [9]

Table 3. Specific absorption rate (sar) limits for non occupation

	Australia ACA	USA ANSIC 93.1	Europe ENV 50/66	Japan TT/MPT	New Zealand NZ52772
Whole Body	0.04w/kg	0.04 w.kg	0.04 w.kg	0.04 w.kg	0.04 w.kg
Spatial peak	10w/kg	8w/kg	10w/kg	0.8w/kg	10w/kg
Averaging time	6 min	6 min	6 min	6 min	6 min
Averaging mass	10 g	10 g	10 g	10 g	10 g
Shape	Cube	Cube	Cube	Cube	Cube

Source [9]

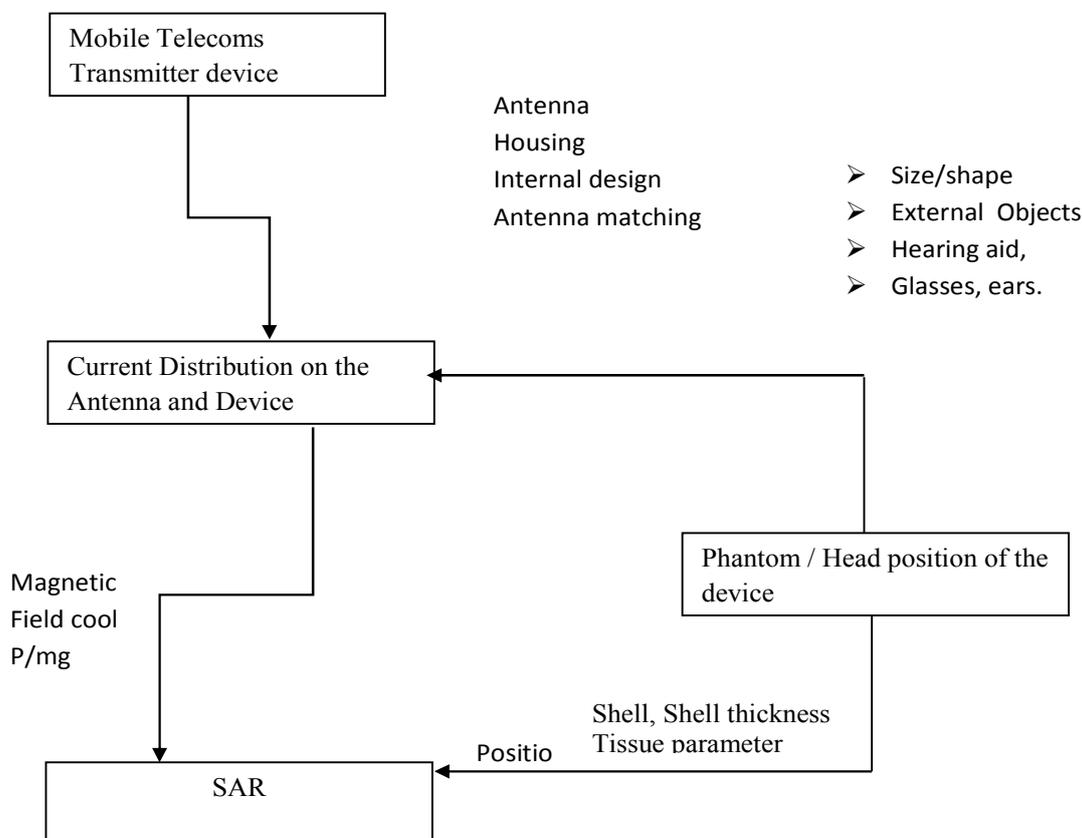


Fig. 1. Factor affecting specific absorption rate SAR [9]

Report in [10] recommended that any exposure to radiation (radio frequency) above the recommendation for SAR limits should be kept as low as reasonable achievable. The recommended dose limits is modified across the whole world by the recommended agencies such as WHO & ICNIRP etc, except for countries like Australia, USA, Europe and Japan etc. who have their specific SAR limits.

The latest recommended SAR limits were specific in 2000. They are not compulsory but in many countries, they have been enacted as legally binding regularities.

2.6 Time Limit for Specific Absorption Rate (SAR)

It has been established by some researchers that the more one spend has/her time talking on the phone (GSM handsets) the more exposure to microwave radiation is enhanced. Therefore, users of global system for mobile communication should be mindful of the time they use in communicating through GSM handset to minimize the bio-effects of GSM handsets.

2.7 Radio Frequency Field Exposure Distance

The distance to which exposure from a small source of radiation (GSM handsets) is inversely proportional to the square of the distance from the source (i.e. inverse Square Law).

$$\text{Intensity} = \frac{c}{x^2} \quad (1)$$

Where c is the proportionality constant and X is the distance from the source to the tissue

Equation (1) implies that at very far distance X , the intensity of radiation is reduced positioning the handset at a distance from the body organs.

3. SOME BIOLOGICAL EFFECTS GSM HANDSETS

The author in [11] applied some physical principles and engineering methods to optimize the design and the performance of a microwave antenna structured for use in cancer therapy. The arrays of thus micro strip patch antenna were constructed from thin and flexible printed circuited board materials for heating large areas of superficial tissues for application in hypothermic treatment of chest wall recurrence of breast carcinoma.

The quantitative knowledge of the close of radio frequency radiation, absorbed in an exposed biological tissue is essential in understanding the bio effects of radio frequency exposure.

Dostimetric information must be estimated form the measurements made outside the tissue by the use of mechanical or mathematical models. This estimation is extremely complex depending on the following:

- i. Parameter of tissues (i.e. dielectric values. Shape division and orientation as well as stability respects to the fields).
- ii. The radiofrequency parameter (frequency, intensity, pulse parameter, time rate energy deposition and near vs. far fields).
- iii. The environmental (e.g. reflection or conductive agents in the fields).

These methods can also be used in obtaining biological effects of radiation from the Global system for mobile communication. These are resistive and dielectric losses from an applied electromagnetic field. Frictional losses from molecular oscillations due to the absorbed energy pressure wave and simple thermal conduction from areas of high temperature to areas of low temperature. The recent work relied primarily on an applied electromagnetic field to induced heating of superficial tissue at a depth of up to (1cm) and thermal conduction to heat slightly deeper and smoother temperature profile. Additionally, the measurement of electric field strength in the extreme near field of the radiating antenna is however very difficult to measurement and these difficulties are further compounded by the interaction of the radiating source with the human tissues. SAR results depend on various parameters such as the position of radio Frequency energy source near the human body, posture size anatomy and many other factors. The absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the body with respect to the field vector the electrical prospects of the complexity of the field distribution places great demands on the measurement probes with respect to spherical isotropy linear response, spatial resolution, minimum field disturbances and boundary effects. These dielectric properties are summarized in the table below. The parameters are equivalent to human brain tissues, which can be used for SAR calculation.

Table 4. Data on dielectric parameters of tissues and tissue equivalent

Brain tissues	Frequency		Range	
	900MHz		1800MHz	
	ϵ_r	σ	ϵ_r	σ
Grey Brain matter	51.4	1.06	49.5	1.44
White Brain matter	34.0	0.59	32.6	0.84
Homogenous medium				

Source [9]

Federal communication committee [12] and QET Bulletin (65) recommended that unit “volt per meter” (V/M) be used to measure the electric field strength and the unit and “Ampere per meter” (AIM) be used to measure the strength of a magnetic field.

Alternatively, the electromagnetic field can be measure in the unit called “power density” i.e. power per unit area ($w/kg/m^2$) or ($wkg^{-1}m^{-2}$).

The author in [13] researched on the effects of GSM radio frequency fields to cage a rat for one hour, 2 hour etc on brain tissues showed that for the specific absorption rate (SAR) of 4w/kg there was no significant difference in the album leakage from blood vessels in marine brains to those of unexposed groups. However when exposed to the radiofrequency radiations of 900MHz for hours at SAR ranging from (0.3-7.5) w/kg. Serum album extravasations were significant in the group exposed to the highest SAR i.e. 7.5 with minimum leakage found in freely moving and sham-exposed control groups.

He also examined the effects of GSM microwaves exposed on genomic expose of the brain by measuring the changes in the RNAs of hap 70 (i.e. the available specie of rate for the research). The transcription factor genes c-fos and c-juns and the glial structural gene glial fibrillary acidic protein. They found that some minor stress response could be induced as the result. It could not result in long lasting or reactive changes in the brain.

However significant albumin leakage was found in the rat brain exposed for 2 hours to both continuous and pulsed of 915 MHz microwaves at SARs between 0.016 w/kg and 5w/kg. similarly, increased pincytonio uptake of traces (rhodamine ferritin complex) by cerebral capillary endothelia cells were found in rate exposed for (30-120) minutes to 2450 MHz microwaves at relatively low levels ($10mw/cm^2$) SAR= $2wa/kg$ pulse with 10ms at 100 pulses.

Federal Communication Committee (ECC) QUT Bulletin (56) reports that biological effects can results from animals or humans exposed to radio frequency energy. Biological effects to result from heating of tissues by RF energy are often referred to as thermal effects.

It has been shown for some years that exposure to very high level of radio frequency radiation can be very harmfully due to the ability of RF energy to heat biological tissues rapidly. This is the principle by which microwave ovens cook food.

4. CONCLUSION

The word radio frequency in physics is that part of the electromagnetic spectrum where electromagnetic waves have frequencies within the range of 3 KH z to 300GHz. When this radio frequency range from several hundreds of Hertz (MHz) to several thousands of Hertz (GHz) then it is called microwave which is a specific category of radio wave that can be defined the frequency energy. Specifically, most mobile phone operate within the frequency range of (1900-2000) MHz for the digital system, while the analog system operate on the frequency range of (450-900).

This review has shown that by using the available literature, radio frequency (RF) or microwaves of GSM handsets can cause the heating of tissues which significantly result in some biophysical effects such as leukemia (blood cancer), headaches, dizziness, eye defects, brain tumor level of radio frequency radiation can be very harmful due to the ability of the radio frequency energy to heat biological tissues rapidly. Exposure to high radio frequency intensity result to the heating of biological tissues and a rise in body temperature, human tissues that are most affected due to the temperature rise is particularly the eye because of its relative lack of available blood flow to dissipate the excessive heat level. Certain recognized bodies like the international committee on Non-ionizing Radiation protection (ICNIRP). Institute of Electrical and Electronics Engineers (IEEE) and

World Health Organization (WHO) have been charged with the duty of regulating appropriate safety standards / limits for the use of GSM handsets, who publish appropriate dose and exposure limits for the general use as reviewed inside the projects. This review concludes by recommending that GSM handset users should know that radiations emitted by GSM handsets cause biological effects to animals including human beings. Therefore users should use only those handsets with SAR (specified absorption rate) specifications of between 1.6 w/kg to 2.0w/kg for occupational and 0.04w/wkg to 0.08w/kg for Non-occupational.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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