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Original Research

Does chronic exposure to radiofrequency radiations from GSM base stations have health effects?

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Abstract
There is a general concern about the possible adverse health effect of Radio-frequency radiation [RFR] from mobile phone base stations [BS], due to the increase in the siting of these base stations close to residential houses, schools, etc. This study was conducted on randomly selected individuals [n = 61], mostly staying close to a base station for not less than 6months, using 6 selected base stations. The study included a self-administered questionnaire with measurement of RFR level from the sampled base stations, clinical examination and haematological analysis. The level of RFR emitted from the sampled base station was found to be much lower than the ICNIRP limits. The prevalence of symptoms was high for exhaustion/tiredness [62.3%], headache [54.1%], sleep disturbance & blurred vision [32.8%], while the result for both the clinical measurements [Blood Pressure & Pulse Rate] and haematological analysis were essentially within normal limits, except for the lymphocyte percentage which was slightly elevated. Although the study found no statistical significant relationship between RFR exposure and adverse health effect, the need for long term investigations of possible health impacts of non ionizing radiation associated with GSM base stations was recommended.

INTRODUCTION

The 1990s saw a boom in mobile telephony and its rapid expansion, first in the industrialized countries and then increasingly in the developing countries of Africa, Asia and Latin America. Since the introduction of this modern mobile telecommunication, exposure of the public to radiofrequency-high frequency electromagnetic fields [RF-EMF] has increased significantly. There is therefore a general concern about the possible health effects of exposure to Radio-frequency [RF] radiation emitted from mobile phone base station antennas. This concern is as a result of the increase in the use of cellular mobile communication which has led to citing of GSM base station antennas close to residential houses, schools, office, hospitals etc. especially in densely populated areas. Such concerns over electromagnetic fields or waves have triggered the emergence and growth of a multitude of citizens' initiatives in many countries especially in Europe. These initiatives are mostly directed against the installation of relay antenna stations, above or close to schools, nurseries, hospitals or other institutions caring for children or vulnerable individuals, and also increasingly challenge other aspects of wireless telecommunication such as Wi-Fi in schools [1]. Indeed, many people living near a mobile phone base station are concerned about the potential harmful effects of their radiation and often relate many unspecific symptoms like headache, restlessness, sleep disturbance, concentration and memory problems, absence of appetite, infertility, as well as tinnitus to the

presence of the base station in their immediate vicinity [2,3].

Although there is considerable public concern about possible effects of mobile telephone on health and wellbeing, exposure to the much lower but sustained emissions from mobile phone base stations antennae has been neglected. Recently the WHO recommended investigating the effect of exposure to emissions from mobile phones base station to address public concerns but the panel could not reach a consensus on the long-term effects of radiofrequency radiations [4]. The International Commission on Non-Ionizing Radiation Protection [ICNIRP] however declared such effects as not established [5]. The BioInitiative Report which is based on an international research and public policy initiative to give an overview of what is known of biological effects that occur at low-intensity electromagnetic fields [EMFs] exposure reported the following health endpoints to be associated with ELF and/or RF include childhood leukemia, brain tumor, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, breast cancer, miscarriage and some cardiovascular effects. The Bioinitiative Report concluded that a reasonable suspicion of risk exists based on clear evidence of bioeffect at environmentally relevant levels, which, with prolonged exposures may reasonably be presumed to result in health impacts [6].

A more recent report by the committee on the environment for the Council of Europe, recommends that member states should take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumors; reconsider the scientific basis for the present electromagnetic fields exposure standards set by the International Commission on Non-ionizing Radiation Protection, which have serious limitations and apply "as low as reasonably achievable" [ALARA] principles, covering both thermal effects and the athermic or biological effects of electromagnetic emissions or radiation; put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health, especially targeting children, teenagers and young people of reproductive age [1].

From a precautionary point of view, however, the potential long-term health effects is sufficient to warrant a thorough examination of possible effects on wellbeing and health from exposures to mobile telephone base stations. There are a number of studies that have been dedicated to exposures from mobile phones, which can cautiously be applied to emissions from base-stations as well, because exposure was in the far field. These investigations include a long-term animal study on lymphoma [7] and studies on sleep disturbance [8]. No human studies of long-term exposure have been reported so far, but there are numerous reports from physicians and action groups indicating that installation of mobile telephone base-stations is associated with a number of symptoms including sleep disturbances, headaches, palpitations, vertigo, and decrease of cognitive performance in those living in the vicinity of the facility. Due to their unsystematic nature of these reports, they cannot be taken as standard proof of adverse effects of these exposures. There is also the possibility that these symptoms are due to fear about potential negative effects and not necessarily due to the actual exposure.

In view of the general uncertainty about the state of information in the scientific community, the committee on environment for the Council of Europe recommends the promotion of pluralist and contradictory debates between all stakeholders, as well as, formulate a human rights oriented definition of the precautionary and ALARA [as low as reasonably achievable] principles in order to evaluate the health risks associated with radiofrequency radiations associated with mobile telephony.

MATERIALS AND METHOD

Study Area: The study area was Akoka in Lagos Nigeria, an urban region which has a university [Univ. of Lagos] and some other institutions, in mainland LGA in Lagos state, south-west Nigeria. Six different base stations were used for this study, 4 within the campus and 2 outside the campus. These base stations belong to the different network in the country. The base stations were selected based on ease of accessibility, similarity in the socio-economic status of residents or workers and positive response of would-be participants to the study. All this was after some form of sensitization was done.

Sample period and Size: This study was conducted from May to December 2009 using participants working or living close to base stations. A total of 61 randomly selected exposed participants completed the study, this include both male and female of age between 18 and 65 years. Each individual was selected based on voluntary participation and stated exclusion criteria; which includes absence of chronic or acute infections, individuals exposed for less than 6months. Consent was obtained from each of them as indicated on the questionnaire. They were not informed about the exact purpose of the study, until they had completed the questionnaire; this was to reduce the element of bias

but were assured of the confidentiality of their responses.

Study Design

Determination of level of RF radiations at the sampling stations: The Radiofrequency level at the specific base station was also investigated, using a Radio-frequency strength meter. The electric fields strength [mV/m] and power density [W/m^2] were then obtained.

Self-Administered Questionnaire: This included a consent box, biodata, period of working/living close to the base station, number of hours spent close to the base station per day. Distance office/house from base station, subjective symptoms such as sleep-disturbance, depressive symptoms, headache tremor, irritability, blurred vision, tiredness/exhaustion, hotness, anxiety, excessive sweating and hotness after Abdel-Rassoul *et al.* [8].

Clinical Examination: A clinical examination which includes a general physical examination, blood pressure readings [mmHg] and pulse rate [bpm] measurement.

Haematological studies: 2mils of venous blood was obtained from the ante-cubital veins, and immediately transferred into an EDTA sample bottle, which had been pre-labelled with same serial number as that on the questionnaire for each participant. The samples were now placed in a cooling unit and sent to the laboratory for analysis within 6hrs of collection. The hematological parameters obtained were hemoglobin concentration [Hb], packed cell volume [PCV], white cell count [WBC], lymphocyte count, red blood cell count [RBC], platelet count, Mean Cell Volume [MCV], Mean Cell Haemoglobin [MCH], and Mean Cell Haemoglobin Concentration [MCHC], using the electronic coulter counter [ADVIA-TM 60].

Statistical analysis: Data were collected, tabulated and statistically analyzed [T-test and ANOVA] using SPSS 15 software package.

RESULTS

Radiofrequency Radiation Measurement

The level of RF radiation at the different sampling station varied and the mean value for the field strength measured in V/m was between 0.293 - 0.876. The values of the RF radiation detected at studied base station are several folds lower than the prescribed safe limits of 40-60 V/m, 6V/m, 2V/m and 4-5V/m by the International Commission on Non ionizing Radiation Protection [ICNIRP], Italian, Paris and Swiss regulators respectively as shown in [Table 1].

Self-Administered Questionnaire

The outcome of administered questionnaire on the well-being of respondents was based on subjective symptoms and clinical examinations revealed the major symptoms complained of by the respondents are as follow: Exhaustion and Tiredness [62.30%], Headache [54.1%], Sleep Disturbances [32.8%], Blurred Vision [32.8%], Dizziness [27.9%] and Depression [17%] [Table 2] as shown in [Table 2]

Clinical Examination:

The result for the clinical measurements of the respondents surveyed for blood pressure and pulse rate was 112.1/67.2mmHg and 73.1bpm respectively and these falls within normal range as shown in [Table3]

Haematological Indices

The haematological analysis of the respondents surveyed were RBC, WBC, PCV, PLT ,MCV, MCH, MCHC, LYM and NEUT., and the mean value of the haematological parameters were 4.22-5.18×10^6 µL, 5.11-4.25×10^3 µL, 35.85-41.5[%], 225.6-116 x10^9 , 80.1-87.2fL, 24.7-27.7pg, 30.8-33.18g/dL, 2.8.7-53.0[%] and 35.14-71.3[%] respectively. All the results were essentially within normal range, except for the lymphocyte percentage which had a mean values that are slightly elevated as shown in [Table 4].

Table 1. Level of RF radiation in the vicinity of the different base stations and the international limits.

Base stations [BS]	Field strength [V/m]	ICNIRP limit [V/m]	Italian Exposure Limit [V/m]	"Paris Charter": [V/m]	"Swiss Regulation" [V/m]
A	0.876	40- 60	6.0	2.0	4.0- 5.0
B	0.698	40- 60	6.0	2.0	4.0-5.0
C	0.431	40- 60	6.0	2.0	4.0-5.0
D	0.293	40- 60	6.0	2.0	4.0-5.0
N	0.564	40- 60	6.0	2.0	4.0-5.0
F	0.364	40- 60	6.0	2.0	4.0-5.0

Table.2. Percentage of symptoms experienced by respondents

SYMPTOMS	TOTAL NO OF RESPONDENTS	% OF YES	% OF NO	X^2
Sleep disturbance	61	32.8[20]	67.2[41]	0.08
Tiredness	61	62.3[38]*	23[37.7]	0.86
Depression	61	27.9[17]	72.1[44]	6.14
Anxiety	61	26.2[16]	73.8[45]	0.28
Hotness	61	24.6[15]	75.4[46]	0.26
Excess sweating	61	24.6[15]	75.4[46]	4.27
Headache	61	54.1[33]*	45.9[28]	0.18
Dizziness	61	27.9[17]	72.1[44]	0.39
Tremor	61	11.5[7]	88.5[54]	2.08
Irritability	61	9.8[6]	90.2[55]	1.38
Blurred vision	61	32.8[20]	67.2[41]	1.63

*= 50% significance

Table 3. Comparing the mean values of the clinical findings on examination with the normal value

	MEAN VALUE ALL RESPONDENTS	Normal Range	REMARK
Blood pressure	112.1 / 67.2mmHg	90/60-120/80mmHg	Within Normal Range
Pulse rate	73.1bpm	60- 90bpm	Within Normal Range

Table 4. Showing the mean haematological indices of respondents at the different base stations and the normal / expected range.

BS	RF level [V/m]	Mean RBC x10^6	Mean WBC x10^3	Mean PCV [%]	Mean PLT x10^3	Mean MCV [fL]	Mean MCH [pg]	Mean MCHC [g/dL]	Mean LYM [%]	Mean NEUT [%]
A	0.876	5.18	5.0	41.5	116*	80.1	24.7*	30.8	28.7	71.3
B	0.698	4.34	5.11	36.4	214.3	84.2	26.7	31.65	47.36*	43.29
N	0.564	4.22	4.25	35.85*	225.6	85.8	26.2	31.3	47.75*	35.14*
C	0.431	4.49	4.71	37.92	193.8	84.5	27.2	32.09	47.59*	40.49
F	0.364	4.93	4.74	40.94	217.5	83.5	27.7	33.18	44.4	47.26
D	0.293	4.25	4.52	37.07	207.0	87.2	26.4	31.3	53.0*	45.62
Normal Range	40-60	3.9-6.5	4-11	37-54	150-400	76-96	27-32	30-36	20-45	40-75

*= Not within Normal Range

DISCUSSION

Sixty-one exposed participants were used in this study, [62.3% males and 37.7% females] the mean age for participants was 40.5 ± 21.5years. Of the total participants, 62.3% had tertiary education, while 27.9% and 6.6% had secondary and primary education respectively, while the remaining 3.3% had no formal education. At the end of the study, about 90.2% of participants agreed to have their blood sampled for haematological analysis.

The level of RF radiation at the different sampling station varied. The mean value for the field strength measured in V/m was between 0.293 - 0.876 [Table 1]. The values of the RF radiation detected at studied base station are several folds lower than the prescribed safe

limits of 40-60 V/m, 6V/m, 2V/m and 4-5V/m by the International Commission on Non ionizing Radiation Protection [ICNIRP], Italian, Paris and Swiss regulators respectively [Table 1]. In Nigeria, there is however no currently established safe limit of RF radiation from GSM phones and base stations. The fact that the level of RF detected at all the base stations are below all the other regulatory agencies' safe limits suggest that exposure of the people living around base stations to RF radiations are low and should not be a major cause for concern. However, the wide variation [2V/m to 60V/m] in the set guidelines from different countries is a reflection of the state of information and risk perception of the potential health effect of the RF radiations. It is also an indication that at present the effect of long term exposure that would be experienced

by people living near these mobile phone base stations is not well established [8,9].

The outcome of administered questionnaire on the well-being of respondents based on subjective symptoms and clinical examinations revealed that the major symptoms complained of by the respondents are as follow: Exhaustion and Tiredness [62.30%], Headache [54.1%], Sleep Disturbances [32.8%], Blurred Vision [32.8%], Dizziness [27.9%] and Depression [17%] [Table 2]. This result agrees with Abdel-Rassoul *et. al.* [8] who reported that this group of symptoms are more frequent among individuals staying close to telecommunication base stations. Statistical evaluation of the respondents' responses showed that there is no significant [P>0.05] differences in the affirmative and negative responses of the respondents to the subjective symptoms. Furthermore, on the basis of a 50% mark of biological significance, Exhaustion and Tiredness [62.30%] and Headache [54.1%] represent the main significant symptoms complained of by the respondents. However, symptoms of this nature may not be easily separated from stress imposed on urban dwellers commuting to work daily in heavy traffic, and also symptoms of the holo-endemic malaria infection in the Nigerian environment. There may also be individuals expressing some level of anxiety about the health implication of staying close to a base station, although during the survey exercise, the respondents were not aware of the purpose of collating the data and no suggestive questions were asked in order not to mask their responses.

The result for both the clinical measurements [blood pressure and pulse rate] and haematological analysis indicate that the parameters for the respondents surveyed were essentially within normal range, except for the lymphocyte percentage which had a mean values that are slightly elevated [Table 3 and 4]. The result of the clinical measurements is in contrast to findings by Hamburger et. al., [10], whose study showed a positive correlation between cardiovascular diseases and RF radiation. The increase in lymphocyte counts though not statistically significant, may be related to the induction of a protective mechanism in the sampled respondents to the effect of the RF radiation and other activities around the GSM base stations. Bastide *et al,* [11] reported from their study on mice exposed to GSM radiation that there was 50% decrease in immunoglobulin levels and a further 50% decrease in serum levels of corticosterone. Hence, the authors deduced that exposure to radiofrequency radiations induces stress in exposed organisms and increase susceptibility to infections, which may also lead to the synthesis of abnormal levels of white blood cell. Several studies including [Pocock *et. al.*, [12]; Hoffman *et* al., [13]; Jee *et. al.,* [14] and Otitoloju *et al.,* [15]] have identified the white blood cell or lymphocyte count as an integrated indicator of inflammatory stimuli on both acute and chronic time frames; and it is elevated acutely by infection and other stresses or toxic exposures.

Due to the important roles of mobile telephony plays in our modern lives, the possible health effects of radiofrequency radiations emitted from the devices will continue to be a public health issue. Therefore, there is need to have continuous monitoring of the RF radiation emitted from these devices including GSM base stations, determine long term impacts on public health, control the locations where base stations can be sited and revise the regulatory exposure limits or standards of RF radiations until acceptable and more definite information are available.

CONCLUSION

The outcomes of this study show that there is no statistically significant relationship between RF radiation exposure and adverse health effects [subjective symptoms, clinical examinations and haematological parameters] under the given exposure conditions. The complaints from the unsuspecting respondents living in close proximity to the GSM base stations can therefore be related to general stress associated with urban dwelling. It is however important to note that lack of statistical significance is not a complete proof of lack of biological significance and therefore, further investigations, involving a larger population group should therefore be carried out to further allay the fears of the people of the potential negative effects of RF radiations from the base stations.

LIMITATIONS OF THE STUDY

One of the problems faced during the course of this study was movement. Humans are constantly on the move either away or towards the intensity of radiation. Unlike in animal studies where distance and dose of radiation received by the animals per unit time can be accurately obtained and quantified, this was almost impossible for this study. Also in the urban setting, where the use of the mobile phone and siting of base stations is high, it is difficult to get unexposed control groups, as most individuals are exposed at home, at work, and even market places. There were also challenges of multiple base stations serving different GSM networks at the same place, and also the issue of extreme fluctuation in radiation level. Other issues such as socio-economic status may play significant role and possibly confound the outcomes of this research.

REFERENCES

1. Council of Europe. *The potential dangers of electromagnetic fields and their effect on the environment.* Doc. 12608. Report of the Committee on the Environment, Agriculture and Local and Regional Affairs. 2011; 12pp

2. Mimoza IP, Luan A, Enver H. Human eposure assessment in the vicinity of 900MHz base station antenna. *International Journal of Communication.* 2007; 1 [2]: 122-127

3. Otitoloju AA, Obe LA, Adewale OA, Otubanjo OA, Osunkalu VO. Preliminary Study on the induction of sperm head abnormality in mice *Mus musculus*, exposed to radiofrequency radiation from global system for mobile communication base station. *Bull Environ Contam Toxicol.* 2010a; 84: 51-54

4. Valberg PA, Deventer EV, Repacholi MH. Workgroup Report: Base Stations and Wireless Networks—Radiofrequency [RF] Exposures and Health Consequences. *Environ. Health Perspect.* 2007;115 [3]: 416-424

5. International Commission on Non-Ionizing Radiation Protection [ICNIRP]. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields [up to 300GHz]. *Health Phys.* 1998; 74: 494-522

6. Hardell L, Sage C. Biological effect from EMF exposure and public exposure standard. *Biomed pharmacotherapy.* 2007; 62 [2]: 104-109

7. Repacholi MH, Basten A, Gebski V, Noonan D, Finnie J, Harris AW. Lymphomas in Em-Pim1 Transgenic Mice Exposed to Pulsed 900MHz Electromagnetic Fields. *Radiation Res.* 1997;147: 631-640

8. Abdel-Rassoul G, Abou El-Fateh O, Abou Salem M, Michael A, Farahat F, El-Batanouny M *et al.*Neurobehavioral effects among inhabitants around mobile phone base stations. *Neurotoxicology.*2007;28: 434–440

9. Bortkiewicz A, Zmyslony M, Szyjkowska A, Gadzicka E. Subjective symptoms reported by people living in the vicinity of cellular phone base stations. *Rev. Med. Pr.* 2004; 55: 345-351

10. Hamburger S, Logue JN, Silverman PM. Occupational Exposure to non-ionizing radiation and an association with heart Disease; An exploratory study. *J. Chronic Dis.* 1983; 36 [11]: 791-802

11. Bastide M, Youbicier-Simo BJ, Lebecq JC, Giaimis J. Toxicological study of electromagnetic radiation emitted by television and video display screens and cellular telephones on chickens and mice. *Indoor Built Environ.* 2001; 10: 291–298

12. Pocock SJ, Ashby D, Shaper AG. Diurnal variations in serum biochemical and hematological measurements. *J. Clin. Pathol.* 1989; 42: 172–179.

13. Hoffman M, Blum A, Baruch R. Leukocytes and Coronary Heart Disease. *Atherosclerosis.* 2004; 172: 1–6.

14. Jee SH, Park JY, Kim HS, Lee TY, Samet JM. White blood cell count and risk for all-cause, cardiovascular, and cancer mortality in a cohort of Koreans. *American J Epidemiol* 2005; 162: 1062-1069

15. Otitoloju, AA., Osunkalu, VO., Akogun MM., Obe, IA., Adewale, OA., Akinde, OR. Stimulation of Haemopoetic Activity in Bone Marrow and Deformation of Red Blood Cells in Albino Mice, *Mus musculus* Exposed to Radiations from GSM Base Stations. *SL J Biomedical Res.* 2010b*;* [2]:127-134