Risks Associated with Low Level Radiofrequency Exposure at Close Proximities to Mobile Phone Base Stations.

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ABSTRACT

People, who live within 100 – 300 m radius of mobile phone telecommunication masts, are generally more concerned about the possibility of some health hazards that can be associated with living close to them. In this paper, a comparative assay of some selected epidemiological studies around the world, where some health symptoms observed from people living within close radius of some mobile base stations were associated with measured power density, was carried out. Their results indicate that common symptoms like headache, fatigue, irritability, sleep disorders, and nausea can be associated with exposures ranging from 20 $\mu W/m^2$ to 13.2 W/m^2 at distances less than 350 m. These studies shows that low level exposures which are less than most international guidelines should not be overlooked. Therefore, there is a need to conduct more exposure assessment and epidemiological studies, so as to prevent health hazard that might be associated with exposure to radiation from mobile phone devices.

(Keywords: radiofrequency, RF electromagnetic fields, power density, radiation exposure, health symptoms)

INTRODUCTION

There have been significant concerns raised about possible health effects from exposure to radiofrequency (RF) electromagnetic fields, especially after the rapid introduction of the mobile telecommunication systems (Wolf and wolf, 2004). People who live within 100 m – 300 m from the base of mobile phone telecommunication masts (when the mast is clearly visible) are generally more concerned about possible health effect associated with living close to them.

It is believed that radiation levels from the foot of the antenna to a distance of 50 m is due to any minor lobes and this is expected to be very small and therefore will not be a threat to the public health (Karunarathna and Dayawana, 2005). From real life assessments of RF intensity around base station antennas, the situation is quite different since the distribution of RF is influenced by nearby base station antennas and other structures.

Some studies (Hutter, et al., 2006; Santini, et al., 2002) have shown that there may be an association between some health effects and living very close to GSM base station antennas. In many of these studies carried out at different places around the world to assess the level of RF exposure to the populace, low power densities were measured around the base stations. But despite the low exposure obtained from these RF radiation sources, effects on well-being and performance cannot be ruled out as shown by recently obtained experimental results (Hutter, et al., 2006).

This paper aims at relating RF exposure at close proximities to mobile phone base stations to some health symptoms as assessed by some epidemiological studies. This is done by a comparative analysis of selected epidemiological studies around the world, where some health symptoms observed from people living within close radius of some mobile base stations were associated with measured power density.

RADIOFREQUENCY (RF) EXPOSURE ASSESSMENT

RF exposure measurements are done by using a broad band RF meter or by a frequency selective meter. For broad band measurements, the total contribution of RF sources over a designated

frequency band is obtained and this is often used in compliance assessment where the dominating source is known (Goiceanu and Dănulescu, 2006). A frequency selective measurement provides a single frequency radiation exposure characteristics, which is important in assessing of both the exposure level and effects attributed to a particular type of RF radiation.

RF meters can be a potable low cost, non-directional (isotropic) with digital tri-axial RF processing broad band meter or a sophisticated multifunctional spectrum analyzer with a directional or isotropic antenna used along with it. Both meters measures electric field strength *E* and converts it into magnetic field strength *H* and power density *S*. Power density is one of the commonly used quantities in RF exposure assessment. Both E and H are related to power density S expressed in W/m^2 as shown in the equation below (ICNIRP 1998):

$$S = EH = \frac{E^2}{377} = 377\Omega H^2 \qquad \textbf{(1)}$$

Where 377Ω = characteristic impedance of free space.

Another quantity is the specific absorption rate (SAR), which is a measure of the rate at which energy is absorbed by the human body when exposed to RF electromagnetic field. The unit of SAR is Watt per Kilogram (W/Kg). It can be calculated from *E* using the following equation, (ANSI/IEEE, 1999):

$$SAR = \frac{\sigma \left| E_{eq} \right|^2}{\rho_{md}} \qquad \textbf{(2)}$$

Where σ = conductivity of the material,
E_{eq} = electric is field strength
ρ_{md} = is the mass density of the material.

Assessments of RF exposure level are done by comparing the obtained results to standards or guidelines. Different organizations like the Institute of Electrical and Electronics Engineers (IEEE), International Commission on Non-Ionizing Radiation Protection (ICNIRP), National Radiation Protection Board (NRPB), and the Federal Communication Commission (FCC), set up guidelines to protect against known adverse effect of non-ionizing radiation (Karunarathna and Dayawana, 2005).

RF EXPOSURE AROUND BASE STATIONS

Exposure from mobile phone base stations (GSM) is basically divided into the near field exposure and the far field exposure, where far field exposure measurements are used for public exposure level assessment. The radiation from a mast depends on its antenna characteristics, like the antenna gain, emitted power, directivity, height and the tilt angle of the antenna. Also, it is known theoretically that at the far field of the antenna the radiation intensity reduces according to the inverse square law. Typically, radiation from the GSM antenna reaches the ground level at 50 to 300 meters (Mann et al., 2000). Thus it is expected that under the mast, low radiation levels can be found.

In real life situation, the variation of radiation exposure with distance can be very difficult to predict (Miclaus and Bechet, 2007). Factors like the number and position of buildings and vegetation, concentration of base station, and base station to bases station distance, can make the radiation level within 10 m to vary by a thousand fold.

Nevertheless, practical experience shows that exposure levels close to the feet of some base stations can be quite high. Radiation levels may have an increasing pattern within 30 to 150 meter radius of base stations in densely populated areas where many base stations are sited, but as one moves away from 200 meter radius of the base station the exposure may begin to have a reducing pattern.

ROLE OF EPIDEMIOLOGY IN RF HEALTH IMPACT ASSESSMENT

Epidemiology can be defined as the study of the distribution and the determinants of health-related state or events in specified population and the application this study to control of health problems (Last, 1995). It plays an important role in biological research, to assessing the causal and spread of diseases which is in turn serves an important tool in curbing further harm which such diseases may pose to the populace.

There is a proliferation and every day improvements on mobile phone technology. Epidemiology studies has since then played a critical role in trying to find a link between radiofrequency exposure and some health symptoms. The essential role of epidemiology in the Global Strategy for Health for All was recognized in a World Health Assembly resolution in May 1998 urging member of states to make use of epidemiological data, concept and method in the preparation, updating, motoring and evaluations of their work in this field (Beaglehole, et al., 1993).

One advantage of epidemiological research over others in disease control, is the assess to larger population sample at lower cost from which a lot of information can be obtained to link the various observed symptoms to the disease source and in turn find an end it. In electromagnetic field (EMF) and RF radiation exposure assessment, many epidemiological studies have been carried out (Santini, et al., 2003; Maskarinec, et al., 1994; Vena, et al., 1994; Eger, et al., 2004), with great progress being made especially in Global system of mobile communication (GSM) exposure risk assessment.

Some of these studies cut across occupational exposure, transmitter exposures, mobile phone exposures and public exposure assessments (Ahlbom, et al., 2004), using mostly case-control and cohort study designs especially in cancer related studies. For example, a cohort study of mortality of US Motorola employees in which 195,775 workers involved, many of whom were women shows that 6,296 died during the follow up period (Morgan, et al., 2000).

A prospective cohort study was carried in Denmark, using the computerized files of the two Danish cell phone companies, involving 420,095 cell phone subscribers with subscriptions starting since 1991, 58% using GSM system (Johansen, et al., 2001). In a case-control study of parental exposures to radio frequencies, information was obtained from 537 mothers of children with neuroblastoma and 503 control mothers in the US and Canada (De Roos, et al., 2001). Many more of these studies have been conducted around the world, but there is the need for better exposure assessment particularly in strong relation to transmitter studies, because the relation between distance and exposure is very low (Ahlbom, et al., 2004).

High RF radiation intensities are known to cause thermal effects in animals and humans and as adequately been taken care of by standards set by some internal bodies like the Internal Commission on Non-Ionizing Radiation (ICNIRP). At low intensities, some mechanisms via EMF might affect animal and human health have been proposed (Salford, et al., 2008), but full understanding of this mechanisms still remain to be determined (Khurana, 2008). Despite this, the accumulating epidemiological literature pertaining to the health effects of mobile phones, and their base stations suggests that previous exposure standards based on the thermal effects of EMF should no longer be regarded as tenable (Hardell, et al., 2008), since suspected health symptoms are being observed at lower intensities.

BASE STATION EXPOSURE LEVELS AND SOME SUSPECTED HEALTH SYMPTOMS

In the current effort to find a link between RF exposure and some health symptoms, many studies have been conducted with evidence of some association between them. A study conducted in Israel shows that there is an association between increased incidence of cancer and living in the proximity of a cell phone transmitter station (within 350 m radius), with the obtained power density far below 0.53 μW/cm^2 (5.3 mW/m^2) (Wolf and Wolf, 2004).

A study involving roughly 1,000 patients in Naila, Germany, concluded that the proportion of newly developing cancer case was significantly higher among those patients who lived up to 10 years at a distance within 400 m from cellular transmitter site, compared to those patients living farther away (Eger, et al., 2004). A similar study conducted in a remote part of a town in Westphalia, Germany involving 575 inhabitants, showed a statistically significant increase of the cancer incidence within a 400-metre radius of a mobile base station five years after it was sited there (Eger and Neppe, 2009).

In Austria a study involving Self-declared base station neighbors (DBS ≤ 100 meters) shows that people who rated the distance from their home to the next base station as 100 meters or less had higher scores in psychological strain scales, with significantly higher concentrations of alpha-amylase in their saliva, obsessive-compulsive, anxiety and so on. The mean power density measurement taken in rooms of persons rating

DBS 100 meters or less, for GSM-900 MHz and GSM-1800 MHz in the mean was 856.75 μW/m^2 for DBS less than 100 meters it was 223.80 μW/m^2 (Augner and Hacker, 2009). According to Hutter, et al. (2006), with confounding variables, including the fear of adverse effects from exposure to high RF radiation from GSM base stations, there was a significant relationship between some observed symptoms to measured power density, of which an average of 0.05 mW/m^2 was obtained in rural areas within 24 – 60 m and an average of 0.02 mW/m^2 in urban areas within 20-250 m from cellular transmitter site (Hutter, et al., 2006).

In Nigeria, a study shows that proximity and duration of mast radiation is directly proportional to hazard effect. From this study, most respondent stayed closest to mast in the range of 1–50 m accounting for 31.5 % of the respondent, 24 % were in the range of 50 – 100 m and 18% were in the range of 100 – 1000 m; and average power density within 200 m radius was 1.32 ± 0.075 mW/cm^2 (13.2 W/m^2) (Akintonwa, et al., 2009). The exposure of male mice to radiofrequency radiations from GSM base stations at a workplace complex and residential quarters in some locations in Nigeria caused 39.78 and 46.03%, respectively, of the mean sperm head abnormalities compared to 2.13% in control group of the study population. Both the residential quarter and the office block complex were found to be close to a base station, while the control station was located within 300 m radius of a base station. Power density measurements at these locations were found to be 59 mV/m (9.2 μW/m^2) in the control station, 489 mV/m (634.3 μW/m^2) in the workplace complex, and 625 mV/m (1036.1 μW/m^2) in the residential quarters (Otitiloju, et al., 2010).

Enrique, et al. (2003) estimated the level power density within 150 m radius of the base stations to be 1100 μW/m^2 and reported some symptoms like fatigue, irritability, headache, and nausea, observed in the study population (Enrique, et al., 2003). Viel, et al. (2009) reported higher concentrations of alpha-amylase in their saliva, obsessive-compulsive, anxiety within 280 m radius of the base station measuring a power density of 1,613.8 μW/m^2 (Viel, et al., 2009). Santini, et al. (2002) conducted such a study in France, and shows that there is an association between irritability, depression, dizziness, tiredness and living within 100 – 300 m radius of a cell phone transmitter station (Santini, et al., 2002). Therefore, they suggested that a minimal distance of people from cellular phone base stations should not be less than 300 m. The summary of some studies referenced in this study is presented in Table 1.

Table 1: Epidemiological Studies Reporting some Health Symptoms Associated with Power Density and Distance of Studied Population to Base Station.

Reference	Distance from Antenna	Estimated Power Density	Some Reported Symptoms
Enrique et al. (2003)	< 150 m 250 m	1100 μW/m^2 100 μW/m^2	Fatigue, irritability, headache, nausea, appetite loss, discomfort, gait difficulty
Wolf and Wolf (2004)	350 m	5.3 mW/m^2	Incidence of cancer
Hutter et al. (2006)	24 – 60 m 20 – 250 m	50 μW/m^2 20 μW/m^2	Headaches, exhaustion tiredness, difficulties to concentrate, feeling strained, urge for sleep.
Viel et al. (2009)	280 m	1613.8 μW/m^2	Higher concentrations of alpha-amylase in their saliva, obsessive-compulsive, anxiety.
Augner et al. (2009)	100 m < 100 m	856.75 μW/m^2 223.80	High concentrations of alpha-amylase in saliva, obsessive-compulsive, anxiety, phobic anxiety.
Akintonwa et al. (2009)	200 m	13.2 W/m^2	Headache, skin irritation, anxiety, sleep disorder, weight loss.
Otitoloju et al. (2010) (Animal study)	300 m (residential quarters)	1036.1 μW/m^2	Sperm head abnormalities.

There is a clear indication that there is a possibility of observing some health effects that are associated with living in close proximity to GSM base stations. From close observations, most mobile base stations in most cities in a country like Nigerian are close to residential buildings.

This is a real environmental concern in many developing countries, since the non-discriminatory manner in which these base stations are sited in close proximity to residential homes, offices, hospitals and schools increases the exposure level in such environment (Otitoloju, et al., 2010).

CONCLUSION

Efforts to find the link between radiofrequency exposure and some health symptoms has prompted many studies in experimental, cellular, animal, and epidemiological research to be carried out in recent times. Epidemiological studies have played vital in this aspect and substantial progress has been made. Some selected epidemiological studies across the world in which measured power density at close proximity to mobile phone transmitters are associated with some health symptoms in a population group has been assessed. Their results indicate that common symptoms like headache, fatigue, irritability, sleep disorders, and nausea can be associated with exposures ranging from 20 $\mu W/m^2$ to 13.2 W/m^2 at distances less than 350 m.

These studies obtained low level exposures most of which are less than international guidelines. Therefore, there is a need to conduct more exposure assessment and epidemiological studies, so as to prevent health hazard that might be associated with exposure to radiation from mobile phone devices.

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