ABOUT THE EFFECTS OF MICROWAVE EXPOSURE FROM CELLULAR PHONE BASE STATIONS: A FIRST APPROACH

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ABSTRACT

Low levels of microvawe power density are found around the GSM-DCS cellular phone Base Stations (BS), were antennas are usually located on the roofs or on the top of tall towers. After World War ll, a specific symptomatology was reported linked to the radar exposure of low levels of microwave power density. This was named "microwave syndrome". In the present work, results from a preliminary survey about the microvawe Syndrome are presented. This analysis tries to evaluate whether there is some statistical justification for complaints and related dysfunction that is associated to RF exposition in the neighborhood of GSM base stations. Statistical data and correlation between the severity/presence of the symptoms described in the RF Syndrome and the Power density found at home is reported with $P<0.05$. The present study may show evidence of some biological effects linked to this exposure even at very low intensity.

INTRODUCTION

The hypothesis that microwave exposure might produce health damage has been analyzed mainly from several epidemiological studies (1-6). Especially leukaemia in children and brain tumors were the clinical entities often described. The clinical consequences of radiofrecuency-microwave (RF-MW) exposure to radar was evaluated from military studies, in which an increase of lung cancer (7), and micronucleous (8) were observed.

"Microwave sickness" was the name given to the reported symptomatology related to low levels of exposure to RF-MW, (9). The Lilienfeld study, which reported elevated mutagenesis and carcinogenesis among the employees that were chronically exposed to a very low intensity radar signal at the U.S. embassy in Moscow in the 1950´s to 1970´s (10,11), was reviewed.

Several articles found biological dysfunction at very low density of radiation without perceptible temperature elevation, giving an indication of the existence of "non-thermal" effects below the actual standard of safety norms derived from ICNIRP (12-19).

Low levels of RF are found in cities and towns around and near cellular phone Base Stations (BS). Antennas are also located on tall towers. Digital cellular phones use pulsed microwaves, and these signals have a spectral similarity with the radar signal. Therefore, we have reached the conclusion that the above information could be important when considering its possible implication on public health.

Previously, a positive relationship between the degree of complaints and the distance from Base Stations were described (20-22) .

In the present work, results from a preliminary survey about the microwave syndrome are presented. Statistical data between the severity/presence of the symptoms described in the RF syndrome and the distance from the base station at home is reported. In the presented study, the significance of the results is evaluated, and results for two different groups are analyzed.

Nowadays, the electromagnetic-microwave power density is not a recognized environmental pollutant. The reported results are obtained from one of the first social surveys on the health of the population who live in the vicinity of a Base Station for GSM-DCS cellular phones.

MATERIALS AND METHOD

Measurements of the electromagnetic field were taken in the bedrooms of each home. The measurements were added to the report on the person who slept in that bedroom. A portable broadband electric field meter (EFM) was used.

The EFM was oriented by hand in order to measure the maximum strength of the electric field above the bed. The electric field in each room presented a standing wave pattern because of the reflection of the waves in the

nearest walls and building structures. Therefore, the Electromagnetic field meter was held around 1 meter from the walls, roughly 1.2 meters above the ground, and was moved in circles in order to get the maximum electric field strength.

The electromagnetic field meter contains a microwave diode with a logaritmic amplifier. The diode is a square law detector, which rectifies the microwave signal, and the DC signal is amplified giving a DC level of around 1-5 Volts. The ouput from the the amplifier is calibrated by introducing a known leveled power with the HP-8510C vectorial network analyzer. An antenna with known gain in the appropriate band, i.e. the GSM band 935-960MHz, and DCS-1805-1880MHz, permits the detection of the desired microwave band. The antenna gain was measured in the anechoic chamber at the University of Valencia. The measurement corrected with the antenna gain was converted to power density units in Watts/meter, or electric field units in Volts/meter, taking the wave plane approach into consideration. The measurement was shown in a display by using an ADC converter with a programmed chip. However, the power density units are better presented in microwatts/square centimeter units, because of their low levels.

The measurements were taken in two different days, however at a similar time both days. To check the number of working channels of the cellular phone base stations (BS), measurements of the spectral power density were carried out with a probe antenna and a portable spectrum analyzer.
The channels present dramatic differences in amplitude from channel to channel, some of them going "on" and "off" the air at random times.
The probe was mounted on a linen phenolic tripod about 1.2 meters above the ground on a hill next to the town, 20 meters from the BS. With the spectrum analyzer, we scanned the GSM and DSC band, at the beginning, taking the average for a period of 5 minutes. The measurement of the spectrum was similar on both days, having a difference in the peaks estimation (carriers of the channels) which were within the limits for error for the spectrum analyzer.
About the Questionnaire: The Santini questionnaire (20) was adapted to the Spanish language. This included demographic data (name, sex, ,age, address), time of exposure (days/week,; hours/day and years of living under exposure), distance and orientation to the antenna, presence of other EMF sources and use of computer (more than 2 hours/day) and cellular phones (more than 20 minutes/day), and measurements of several symptoms such as: depression, headache, fatigue, irritability, difficulty in concentrating, memory loss, dizziness, insomnia, loss of appetite, ocular and auditory dysfunctions, skin problems, gait difficulty, cardiovascular abnormalities and nausea. Respondents scored those symptoms between 0 to 3 depending on their severity. Up to the mean score of 1,5 was considered an uncomfortable symptom for the subject.
Finally, only 97 subjects were included in the study because of their absence of neurological and psychiatric records.

RESULTS

The exposure time, explained as the time spent in the vicinity of the BS was more than 6 hours per day, 7 days a week, in 95% of the respondents.
Concerning the frequency of use of cellular phones: 24% of the respondents declare themselves to be active users of mobile GSM-DCS phones for more than 20 minutes per day.
The mean value of the declared presence/severity of the symptom is presented in Table I, for people under exposure levels 0-0.5, 0.6-1.0, 1.1-1.5, 1.6-2.0 V/m. Table II shows mean values for groups by age and sex.

	0–0’5 V/m	0’5-1 V/m	1-1’5 V/m	1’5-2 V/m	Use of cellular phone	
					No	Yes
V_01	1	1	1	2	1	1
V_02	1	2	2	2	1	2
V_03	2	2	3	2	2	2
V_04	1	1	1	2	1	1
V_05	1	1	2	2	1	1
V_06	2	2	2	2	2	2
V_07	1	1	1	2	1	1
V_08	1	1	2	2	1	2
V_09	1	1	2	2	1	2
V_10	1	2	2	2	1	1
V_11	0	1	1	1	1	1
V_12	1	2	1	2	1	1
V_13	1	1	1	1	1	1
V_14	1	1	1	2	1	1
V_15	1	1	0	1	1	1
V_16	1	0	1	2	1	1
Number	76	8	8	5	74	23

Table I.a: *Average presence of the symptom related to the electric field, and the use of cellular phone (0-Never, 1-Sometimes, 2-Often, 3- Very Often)V_01 fatigue, V_02 irritability, V_03 headache, V_04 nausea, V_05 appetite loss, V_06 insomnia, V_07 depression, V_08 discomfort, V_09 difficulty in concentration, V_10 memory loss, V_11 skin problems, V_12 visual dysfunction, V_13 audibility dysfunction, V_14 dizziness, V_15 gait difficulty, V_16 cardiovascular abnormalities.*

	0–0'5 V/m	0'5-1 V/m	1-1'5 V/m	1'5-2 V/m	Use of cellular phone	
					No	Yes
V_01	N-39'2% S-17'5% O-13'4% VO-8'2%	N-4'1% S-2'1% O-1% VO-1%	N-3'1% S-2'1% O-1% VO-2'1%	N-0% S-1% O-1% VO-3'1%	N-36'1% S-19'6% O-10'3% VO-10'3%	N-10'3% S-3'1% O-6'2% VO-4'1%
V_02	N-24'7% S-22'7% O-22'7% VO-8'2%	N-2'1% S-0% O-6'2% VO-0%	N-1% S-1% O-0% VO-6'2%	N-0% S-1% O-2'1% VO-2'1%	N-23'7% S-20'6% O-22'7% VO-9'3%	N-4'1% S-4'1% O-8'2% VO-7'2%
V_03	N-7'2% S-22'7% O-23'7% VO-24'7%	N-0% S-2'1% O-3'1% VO-3'1%	N-0% S-0% O-4'1% VO-4'1%	N-0% S-2'1% O-2'1% VO-1%	N-7'2% S-21'6% O-23'7% VO-23'7%	N-0% S-5'2% O-9'3% VO-9'3%
V_04	N-43'3% S-21'6% O-9'3% VO-4'1%	N-3'1% S-5'2% O-0% VO-0%	N-2'1% S-3'1% O-2'1% VO-1%	N-0% S-3'1% O-1% VO-1%	N-42'3% S-20'6% O-8'2% VO-5'2%	N-6'2% S-12'4% O-4'1% VO-1%
V_05	N-47'4% S-19'6% O-8'2% VO-3'1%	N-4'1% S-2'1% O-1% VO-1%	N-1% S-3'1% O-2'1% VO-2'1%	N-0% S-2'1% O-1% VO-2'1%	N-43'3% S-22'7% O-7'2% VO-3'1%	N-9'3% S-4'1% O-5'2% VO-5'2%
V_06	N-16'5% S-20'6% O-23'7% VO-17'5%	N-1% S-0% O-5'2% VO-2'1%	N-0% S-1% O-5'2% VO-2'1%	N-0% S-3'1% O-0% VO-2'1%	N-14'4% S-16'5% O-25'8% VO-19'6%	N-3'1% S-8'2% O-8'2% VO-4'1%
V_07	N-35'1% S-16'5% O-16'5% VO-10'3%	N-4'1% S-2'1% O-1% VO-1%	N-4'1% S-1% O-1% VO-2'1%	N-0% S-2'1% O-1% VO-2'1%	N-35'1% S-15'5% O-16'5% VO-9'3%	N-8'2% S-6'2% O-3'1% VO-6'2%
V_08	N-29'9% S-20'6% O-21'6% VO-6'2%	N-3'1% S-1% O-2'1% VO-2'1%	N-0% S-1% O-4'1% VO-3'1%	N-0% S-2'1% O-1% VO-2'1%	N-30'9% S-16'5% O-21'6% VO-7'2%	N-5'2% S-3'1% O-9'3% VO-6'2%
V_09	N-27'8% S-19'6% O-17'5% VO-13'4%	N-3'1% S-1% O-3'1% VO-1%	N-0% S-2'1% O-3'1% VO-3'1%	N-0% S-2'1% O-1% VO-2'1%	N-25'8% S-21'6% O-15'5% VO-13'4%	N-5'2% S-3'1% O-9'3% VO-6'2%
V_10	N-26'8% S-24'7% O-15'5% VO-11'3%	N-1% S-2'1% O-2'1% VO-3'1%	N-1% S-2'1% O-5'1% VO-0%	N-0% S-3'1% O-1% VO-1%	N-23'7% S-24'7% O-14'4% VO-13'4%	N-5'2% S-7'2% O-9'3% VO-2'1%
V_11	N-55'7% S-10'3% O-9'3% VO-3'1%	N-4'1% S-2'1% O-1% VO-1%	N-4'1% S-2'1% O-2'1% VO-0%	N-0% S-4'1% O-0% VO-1%	N-52'6% S-9'3% O-9'3% VO-5'2%	N-11'3% S-9'3% O-3'1% VO-0%
V_12	N-37'1% S-15'5% O-18'6% VO-7'2%	N-2'1% S-2'1% O-2'1% VO-2'1%	N-3'1% S-1% O-3'1% VO-1%	N-0% S-3'1% O-1% VO-1%	N-36'1% S-15'5% O-15'5% VO-9'3%	N-6'2% S-6'2% O-9'3% VO-2'1%
V_13	N-40'2% S-14'4% O-10'3% VO-13'4%	N-3'1% S-3'1% O-2'1% VO-0%	N-3'1% S-5'2% O-0% VO-0%	N-0% S-4'1% O-0% VO-1%	N-39'2% S-14'4% O-9'3% VO-13'4%	N-7'2% S-12'4% O-3'1% VO-1%
V_14	N-36'1% S-18'6% O-10'3% VO-13'4%	N-4'1% S-3'1% O-1% VO-0%	N-4'1% S-1% O-1% VO-2'1%	N-0% S-3'1% O-0% VO-2'1%	N-37'1% S-20'6% O-6'2% VO-12'4%	N-7'2% S-5'2% O-6'2% VO-5'2%
V_15	N-43'3% S-15'5% O-14'4% VO-5'2%	N-4'1% S-2'1% O-1% VO-1%	N-5'2% S-3'1% O-0% VO-0%	N-0% S-4'1% O-0% VO-1%	N-42'3% S-14'4% O-14'4% VO-5'2%	N-10'3% S-10'3% O-1% VO-2'1%
V_16	N-54'6% S-10'3% O-7'2% VO-6'2%	N-7'2% S-1% O-0% VO-0%	N-6'2% S-0% O-1% VO-1%	N-2'1% S-1% O-2'1% VO-5'2%	N-55'7% S-9'3% O-5'2% VO-6'2%	N-12'4% S-4'1% O-4'1% VO-3'1%
Number	76	8	8	5	74	23

Table I.b: *Percentage of the declared symptom related to the electric field measurement and the use of the cellular phone (N-Never, S-Sometimes, O-Often, VO- Very Often)*

	15-25 yr	26-35 yr	36-45 yr	46-55 yr	56-65 yr	More than 65 yr
V_01	1	1	1	1	1	1
V_02	1	2	1	1	1	1
V_03	2	2	2	2	2	1
V_04	1	1	1	1	1	0
V_05	1	1	0	1	1	0
V_06	1	2	1	2	2	2
V_07	1	1	1	1	2	1
V_08	2	2	1	1	1	1
V_09	1	1	1	2	2	1
V_10	1	1	1	2	2	1
V_11	0	1	0	1	1	0
V_12	1	1	1	2	1	1
V_13	1	1	1	2	1	1
V_14	1	1	1	1	2	1
V_15	1	1	1	1	1	1
V_16	1	1	0	1	1	1
Number	21	21	18	11	13	13

Table II: *Average presence of the symptom related to the age of those surveyed (0-Never, 1-Sometimes, 2-Often, 3- Very Often)*

Table I.a contains mean values that are rounded off to the nearest category, giving a first glance at the reported symptoms at different electric fields. Table I.b is an enlargement of Table I.a showing the percentage of respondents reporting levels 0-1-2-3.
Table II shows the average presence of the symptom related to the age of those surveyed. The reported severity is distributed throughout all the age groups and is not exclusive of the elder.
The overall health level of the people interviewed was obtained by the addition and normalization of all reported symptoms. The health indicator was categorized in four levels: Good health, Healthy, Regular, Bad Health. The health indicator is presented in Table III for people subjected to exposure levels 0-0.5, 0.6-1.0, 1.1-1.5, 1.6-2.0 V/m, and Table IV shows mean values in groups of age and sex. Tables I and III shows a high number of respondents under low levels of electric field, however it is not statistically conclusive because of the low number of respondents subjected to 0.6-2.0V/m. This is a characteristic of the present study: The low levels of the RF exposure. Table IV demonstrates a uniform health distribution by age groups.

	0–0'5 V/m	0'6-1 V/m	1.1-1'5 V/m	1'6-2 V/m	Use of cellular phone	
					No	Yes
0-V. Good health	19 (25%)	1 (12'5%)	0	0	18 (24'3%)	2 (8'7%)
1- Healthy	38 (50%)	4 (50%)	4 (50%)	2 (40%)	38 (51'4%)	10 (43'5%)
2-Poor health	17 (22'4%)	3 (37'5%)	4 (50%)	2 (40%)	15 (20'3%)	11 (47'8%)
3- Bad Health	2 (2'6%)	0	0	1 (20%)	3 (4'1%)	0
N	76	8	8	5	74	23

Table III: *Health state related to the electric field measurements and the use of the cellular phone. In grey colour is the average state of health.*

	15-25 yr	26-35 yr	36-45 yr	46-55 yr	56-65 yr	More than 65 yr
0-V. Good health	5 (23'8%)	3 (14'3%)	4 (22'2%)	2 (18'2%)	3 (23'1%)	3 (23'1%)
1- Healthy	10 (47'6%)	9 (42'9%)	13 (72'2%)	5 (45'5%)	3 (23'1%)	8 (61'5%)
2- Poor Health	6 (28'6%)	9 (42'9%)	1 (5'6%)	4 (36'4%)	4 (30'8%)	2 (15'4%)
3- Bad Health	0	0	0	0	3 (23'1%)	0
Number	21	21	18	11	13	13

Table IV: *State of health related to the age of those surveyed. In grey colour is the average state of health.*

DISCUSSION

We find that the loss of appetite is the most relevant symptom that increases with exposure intensity. Others symptoms: irritability, discomfort, fainting, difficulty in concentrating and fatigue also show a significant increment with exposure intensity. However, others such as insomnia or severe headache do not present any increment.

The results could be interpreted as follows: despite the fact that some correlation could exist, the dose (power density) or the exposure time is not sufficient to produce any effects on health.

However, an interesting observation is that symptoms such as headache and irritability have the largest gradient between low radiation and high radiation and the highest values on the clinical scale, 2.17 and 1.56 respectively.

As there is a significant difference in terms of the irradiated power density, a hypothetical relationship between the GSM emission and the severity of both symptoms could exist. Moreover, the symptomatic response could be influenced by personal or human idiosyncrasy, even a non-linear relationship between each of these symptoms and the emission dose measured, could be inferred. .

In order to find some similarities between our study and previous studies, we could claim that there is a strong coincidence with the Lilienfeld Study (Lilienfeldet al. (1978)), that showed a dose-response relationship between various neurological symptoms as a function of years of service, these symptoms were grouped under the name "Microwave Syndrome" of the "Radiofrequency Radiation Sickness", Johnson-Liakouris (1998), that was also reported in the earlier Russian and Polish literature (Baranski and Czerski, 1976). There is a large and coherent body of evidence of biological mechanisms that support the conclusion of a plausible, logical and causal relationship between EMR exposure and neurological disease. Hence, it is probable that cell sites are causing many adverse health effects. Public health surveys of people living in the vicinity of cell site BSs should continue being carried out now and progressively over the next two decades as the sudden appearance of effects such as miscarriage, cardiac disruption, sleep disturbance and chronic fatigue could well be early indicators of adverse health effects.

REFERENCES

1.- Altpeter, E.S., Krebs, Th., Pfluger, D.H., von Kanel, J., Blattmann, R.(1995) "Study of health effects of Shortwave Transmitter Station of Schwarzenburg, Berne, Switzerland". University of Berne, Institute for Social and Preventative Medicine.

2.- Abelin, T., (1999): "Sleep disruption and melatonin reduction from exposure to a shortwave radio signal". Seminar at Canterbury Regional Council, New Zealand. August 1999.

3.- Maskarinec, G. Cooper, J., Swygert, L., (1994): "Investigation of increased incidence in childhood leukemia near radio towers in Hawai: Preliminary observations"J. Environ Pathol Toxicol and Oncol 13: 33-37.

4.- Hocking, B., Gordon, I.R., Grain, H.L., Hatfield, G.E., (1996): "Cancer incidence and mortality and proximity to TV towers". Medical Journal of Australia, Vol 165, 2/16 December, pp 601-605.

5.- Dolk, H., Shaddick, G., Walls, P., Grundy, C., Thakrar, B., Kleinschmidt, I.,Elliott, P., (1997): "Cancer incidence near radio and television transmitters in Great Britain, I - Sutton-Colfield transmitter". American J. of Epidemiology, 145(1):1-9.

6.- Selvin, S., Schulman, J., Merrill, D.W.,(1992): "Distance and risk measures for the analysis of spatial data: a study of childhood cancers". Soc. Sci. Med., 34: 769-777.

7.- Robinette, C.D., Silverman, C. and Jablon, S.,(1980): "Effects upon health of occupational exposure to microwave radiation (radar)". American Journal of Epidemiology, 112: 39-53, 1980.

8.- Garaj-Vrhovac V, Horvat D and Koren Z (1990). Comparison of chromosome aberration and micronucleus induction in human lymphocytes after occupational exposure to vinyl chloride monomer and microwave radiation. Periodicum Biologorium, 92, 411.

9.- Johnson-Liakouris, A.J. (1998) "Radiofrequency Sickness in the Lilienfeld Study: an effect of modulated microwaves". Arch Environ Heath 53(3):236-238.

10.- Goldsmith, J.R.,(1997): "Epidemiologic evidence relevant to radar (microwave) effects". Environmental Health Perspectives, 105 (Suppl 6): 1579-1587.

11.- Lilienfeld, A.M., Tonascia, J., and Tonascia S., Libauer, C.A., and Cauthen, G.M., (1978): "Foreign Service health status study - evaluation of health status of foreign service and other employees from selected eastern European posts". Final Report

12.- Frey, A.H., Feld, S.R., Frey, B.,(1975) Neural function and behavior: defining the relationship. Ann N Y Acad Sci 247: 433-439.

13.- D'Inzeo, G., Bernardi, P., Eusebi, F., Grassi, F., Tamburello, C., Zani, B.M., (1988).Microwave effects on acetylcholine-induced channels in cultured chick myotubes, Bioelectromagnetics 9: 363-372.

14.- de Pomerai, D., Daniells, C., David, H., Allan, J., Duce, I., Mutwakil, M., Thomas, D., Sewell, P., Tattersall, J., Jones, D., and Candido, P., (2000), Non-thermal heat-shock response to microwaves, Nature 405: 417-418.
15.- Persson B.R.R., Salford L.G., Brun, A., (1997) Blood-brain barrier permeability in rats exposed to electromagnetic fields used in
wireless communication. Wireless Network 3: 455-461.
16.- Dutta, S.K., Ghosh, B., and Blackman, C.F., (1989). Radiofrequency radiation-induced calcium ion efflux enhancement from human and other neuroblastoma cells in culture. Bioelectromagnetics 10: 197-202.
17.- Byus CV, Kartun K, Pieper S, Adey WR (1988). Increased ornithine decarboxylase activity in cultured cells exposed to low energy modulated microwave fields and phorbol ester tumor promoters. Cancer Res, 48, 4222.
18.- Lai H and Singh N P (1996). Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. Int J Radiat Biol, 69, 513.
19.- Malyapa R S, Ahern E W, Bi C, Straube W L, LaRegina M, Pickard W F and Roti Roti J L (1998). DNA damage in rat brain cells after in vivo exposure to 2450 MHz electromagnetic radiation and various methods of euthanasia. Radiat Res, 149, 637.
20.- Santini R. Santini P, Seigne M, Danze JM : Symptoms expressed by people living near cell phone relay stations ; La Presse Médicale ;2001,30 (32): 1594 .
21.- R.Santini R, Le Ruz P, Danze JM, Santini P, Seigne M : Preliminarystudy on symptoms experienced by people living in vicinity of cellularphone base stations . Bioelectromagnetics 24th Meeting Abstract Book .June 2002 . Québec Canada .
22.- Santini R, Santini P, Danze JM, Le Ruz P, Seigne M : Symptoms experienced by people in vicinity of base station : I/ Incidences of distances and sex. Pathol. Biol. 2002 (In Press)