ELECTROMAGNETIC BIOLOGY AND MEDICINE
Vol. 22, No. 1, pp. 41–49, 2003

Survey Study of People Living in the Vicinity of Cellular Phone Base Stations

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ABSTRACT

A survey study was conducted, using a questionnaire, on 530 people (270 men, 260 women) living or not in proximity to cellular phone base stations. Eighteen different symptoms (Non Specific Health Symptoms–NSHS), described as radiofrequency sickness, were studied by means of the chi-square test with Yates correction. The results that were obtained underline that certain complaints are experienced only in the immediate vicinity of base stations (up to 10 m for nausea, loss of appetite, visual disturbances), and others at greater distances from base stations (up to 100 m for irritability, depressive tendencies, lowering of libido, and up to 200 m for headaches, sleep disturbances, feeling of discomfort). In the 200 m to 300 m zone, only the complaint of fatigue is experienced significantly more often when compared with subjects residing at more than 300 m or not exposed (reference group). For seven of the studied symptoms and for the distance up to 300 m, the frequency of reported complaints is significantly higher ($P < 0.05$) for women in comparison with men.

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DOI: 10.1081/JBC-120020353
1536-8378 (Print); 1536-8386 (Online)

Significant differences are also observed in relation to the ages of subjects, and for the location of subjects in relation to the antennas and to other electromagnetic factors.

Key Words: Cellular phone base stations; Bio-effects.

INTRODUCTION

Chronic exposure to ultra-high-frequency electromagnetic fields or microwaves brings on bioeffects in man such as headaches, fatigue, sleep, and memory disturbances (Bielski, 1994; Santini, 1999). These biological effects, associated with others (skin problems, nausea, irritability) constitute what is known as "Non Specific Health Symptoms" (NSHS) that characterize radiofrequency sickness (Johson Liakouris, 1998). Cellular mobile phone technology uses microwaves (frequencies of 900 or 1800 MHz in France) pulsed with extremely low frequencies (frequencies <300 Hertz) (Linde and Mild, 1997). However many of the biological effects resulting from mobile phone use are relatively well-known and bring to mind those described in radio-frequency sickness (Mild et al., 1998; Santini et al., 2002).

We are reporting here the results concerning 530 people living in France, in the neighborhood or not, of cellular phone base stations, in relation to their exposure conditions to antennas, their sex, and their age.

MATERIALS AND METHODS

Questionnaire Used

A questionnaire similar to that developed for the study on mobile phone users (Santini et al., 2002) was sent to people wishing to participate in the study. Subjects were enrolled through information given by press, radio, and web sites, about the existence of a study on people living near cellular phone base stations. The questionnaire was filled out by subjects without the presence of a person in charge of the study and was returned (generally by mail) to a person responsible for the study.

General questions pertained to age, sex, estimated distances from base stations (less than 10 m, 10–50 m, 50–100 m, 100–200 m, 200–300 m, more than 300 m) and their location in relation to the antennas (facing, beside, behind, beneath in the case of antennas placed on rooftops). The exposure conditions of subjects were also defined by the length of time living in the neighborhood of base stations (less than 1 year, 1–2 years, 2–5 years, more than 5 years).

Participants were asked to indicate the presence or not of electrical transformers (at less than 10 m), high or very high tension electric power lines (at less than 100 m) and radio and television transmitters (at less than 4 km). The questionnaire sought information on computer use (more than 2 hours per day) and cellular telephone use (more than 20 minutes per day).

The level of complaints for the studied symptoms was expressed by the study participants using a scale of: 0 = never, 1 = sometimes, 2 = often, and 3 = very often. Of 570 questionnaires received, 40 were not used because of lack of information

on the distance from the base stations or on the level of the complaints experienced. Among the 530 questionnaires studied, 270 came from men (45 years ± 20) and 260 from women (47 years ± 19). Eighteen symptoms referenced in the NSHS were found in the questionnaire; one of which, premature menopause, concerned only women.

Analysis of Results

The results obtained, concerning the frequency of the complaints experienced in relation to responses with 0 = never, were analyzed by the chi-square test with Yates correction (Dabis et al., 1992) by means of a software program (STATITCF, 1987, France). Results were compared with the frequency of complaints of the reference group (subject exposed at >300 m or, living in the vicinity of nonoperating base stations) for incidences of distance and age. The comparisons were done with the frequency of complaints expressed by subjects exposed up to 300 m for length of exposure (comparison to <1 year), for location of subjects (comparison of locations among themselves) and for sex. A $P < 0.05$ was considered significant.

We are presenting here the results tallied with: (1) the influence of subject's exposure conditions to base stations (distance, length of exposure, location in relation to the antennas other electromagnetic factors), and (2) the influence of sex and age of subjects.

RESULTS

Influence of Exposure Conditions

Distance

The 530 study subjects were distributed in the following manner: 19.6% were less than 10 m from cellular phone base station antennas, 26.2% between 10 and 50 m, 13.8% between 50 and 100 m, 9.6% between 100 and 200 m, 10.1% between 200 and 300 m, and 20.7% were at more than 300 m or not exposed; these last subjects were chosen as the reference group.

In comparison with the reference group, the complaints are experienced in a significantly higher way by the subjects located in the distance zones of <10 m to 300m from base stations. Certain symptoms are experienced significantly more often ($P < 0.05$) only in the immediate vicinity of base stations (up to 10 m) and not beyond that: Nausea, loss of appetite, visual disturbances, and difficulty in moving. Significant differences ($P < 0.05$) are observed up to 100 m from base stations for symptoms such as: Irritability, depressive tendencies, difficulties in concentration, loss of memory, dizziness, and lowering of libido. In the zone 100 m to 200 m from base stations, the symptoms of headaches, sleep disruption, feelings of discomfort, and skin problems are again experienced significantly more often ($P < 0.05$) in comparison with the reference group. Beyond 200 m, only the symptom of fatigue is reported at a significantly high frequency ($P < 0.05$) (Table 1). By contrast, no significant effect is demonstrated in relation to distance for the symptom of premature menopause. A significant lowering of libido was reported by subjects living at the distances of less than 10 m, 10–50 m, and 50–100 m from base stations.

Table 1. Influence of distances from cellular phone base stations on the percentages of complaints

	Distances from base stations in meters (m)											
	< 10 m		10–50 m		50–100 m		100–200 m		200–300 m		> 300 m	
Symptoms	2	3	2	3	2	3	2	3	2	3	2	3
Fatigue	76*	72*	63.5*	50.9*	60.6	56.6*	64.2	41.1	66.6*	43.7	40.7	27.2
Irritability	32.8	23.2*	41.7*	25.7*	47.2*	44.1*	25.8	4.1	25	9	18	3.3
Headaches	51*	47.8*	40*	26.1*	40.6*	36.7*	60.7*	31.2*	19.3	0	15.6	1.8
Nausea	14.5*	6.9	8.4	3	5.7	3.8	2.4	4,6	0	2.3	2,1	1.1
Loss of appetite	20.4*	8.3	8	5.5	5	5	6.9	0	4.2	0	3.3	3.3
Sleep disturbances	41.3*	57.1*	41.4*	57.5*	46.9*	58.5*	45.8*	50*	33.3	35.5	13.8	21.1
Depressive tendencies	16,9	26.8*	21.6	19.7*	11.6	24*	16.2	3.1	13.6	2.5	10.3	3.7
Feeling of discomfort	28*	45.4*	25.2*	18.9	30.6*	12.8	15.7*	0	9.7	5.1	2.4	8.1
Difficulties in concentration	39.3	28.8*	37.5	16.6	34.2	26.4*	25	12.5	43.3	5.5	26.7	7.1
Memory loss	27.8	25.4*	29.4	26.6*	37.1*	29*	25	15.6	17.2	11.1	17.9	5.8
Skin problems	18.1*	17.1*	6.6	10.8	11.1*	11.1	13.9*	7.5	8.7	0	1.2	4.6
Visual disturbances	14.5	24.3*	23	13.5	22	7.1	2.5	4.9	15	2.8	13.6	4.1
Hearing disturbances	33.3*	17.4	17.7*	12	8.3	15.5	7.7	7.7	11.6	9.5	5.6	8.7
Dizziness	10	12.5*	17.3*	7,5*	9.6	9.6*	12.2	2.7	7.7	5.2	6.2	0
Movement difficulties	5.6	7.7*	8.2	1.7	3	3	0	0	2	0	2.9	1
Cardiovascular problems	10.1*	13*	15.3*	9.6	12.3*	7.4	8.7	0	8.5	6.5	1	3

for 16 non Specific Health Symptoms experienced by 530 people (270 men + 260 women).

* = $P < 0.05$ in comparison to the reference group (> 300 m) for the responses 2 = often and 3 = very often.

Length of Exposure

There is no significant difference in the frequency of symptoms expressed by subjects living up to 300 m from cellular phone base station, according to the length of time (<1 year to more than 5 years) they have lived in the neighborhood of base stations.

Location of Subjects

The location of subjects in relation to the antennas (facing, beside, behind, beneath) taken alone has little impact on the frequency of symptoms reported. When comparisons are made in relation to the different distance zones, significant increases of complaints ($P < 0.05$) are observed for some distances and for some symptoms in the facing position: visual disturbances for distance <10 m as compared with beneath, fatigue for distance 10 to 50 m as compared with beneath, headache for distance 10 to 50 m as compared with beside, memory loss for distance 50 to 100 m as compared with beside. When comparisons are made for all subjects exposed at a distance of up to 300 m from base stations, it is only observed a significant increase in headaches ($P < 0.05$) for subjects in the beneath position as compared with subjects in the facing position.

Table 2. Influence of sex on the percentages of complaints

Symptoms	Men (%)	Women (%)
Fatigue	41.4	57.5
Irritability	17.9	28.3
Headaches (3)	14.4	45.6*
Nausea (3)	0	5.9*
Loss of appetite (3)	1.9	8*
Sleep disturbances (3)	45.4	61*
Depressive tendencies (3)	9.8	26.7*
Feeling of discomfort (3)	15	25.4*
Difficulties in concentration	18.4	21.6
Memory loss	18	27.7
Skin problems	8	13.1
Visual disturbances (2)	12.2	22*
Hearing disturbances	9.6	19
Dizziness	6	9.8
Movement difficulties	3.3	2.7
Cardiovascular problems	8.3	8.8
Lowering of libido	18	12

for 17 Non Specific Health Symptoms reported by 420 people (205 men vs. 215 women) living in the vicinity of cellular phone base stations (all distances from <10 m to ⩽300 m).

* = $P < 0.05$ for level of complaints in parenthesis, 2 = often and 3 = very often.

Exposure to Other Electromagnetic Factors

The presence of factors such as an electrical transformer, very high tension electric power lines, radio-television transmitters, the use of computers, or cellular phones has little influence on the frequency of symptoms reported by subjects living at a distance of up to 300 m from base stations. However, a significant decrease of sleep disturbance for cellular phone users, and significant increases of discomfort and dizziness with the presence of an electrical transformer, and of difficulties in concentration with the presence of a radio-television transmitter, are observed in comparison with subjects living at a distance of up to 300 m, but not exposed to those factors.

Table 3. Influence of age on the percentages of complaints

	≤20 years		21–40 years		41–60 years		>60 years	
	Distances of subjects from antennas (in meters)							
Symptoms	≤300	>300	≤300	>300	≤300	>300	≤300	>300
Fatigue	56.7	62.5	82.4*	25	81.4*	57.8	73.3*	40
Irritability	16.2	11.1	46.2	18.2	50.5	35.3	52.1*	21
Headaches	42.4	26.3	57.6*	18.2	52*	13,3	49.5*	10
Nausea	2	0	12.9	0	9.9	0	15.6	15.7
Loss of appetite	13.3	8.8	12.7	0	11.8	0	15.9	15
Sleep disturbances	26.1	14.8	53*	12,5	73.9	52.6	68.5*	44.4
Depressive tendencies	10.2	5.7	14	5.8	36	20	41.7	27.7
Feeling of discomfort	4.4	2.9	26.3	6	41.6	16.6	45*	19
Difficulties in concentration	30.3	40	42.1	18.7	45.8	36.8	53.3*	20
Memory loss	7.5	8	21.8	6.6	43	40	64	36.8
Skin problems	16.6	9.3	24.2	6.6	18.3	0	20.4	5.2
Visual disturbances	16.3	12.5	14.7	12.5	26.6	26.3	36.8	17.6
Hearing disturbances	9.4	5.1	15.4	0	29.8	21.7	43.8	31.5
Dizziness	6.2	5.2	3.2	6.6	15.4	4.5	39.3*	9.5
Movement difficulties	0	2.3	0	0	3.5	4	21.4	10.5
Cardiovascular problems	0	2.3	5.1	0	19.2*	0	36.4	15

for 16 Non Specific Health Symptoms experienced by 530 people (270 men + 260 women) in relation to their distances from cellular phone base stations (≤300 m vs. >300 m [reference group]).

* = $P < 0.05$ for levels of complaints 2+3 pooled.

Influence of Sex and Age

Sex

In terms of the different distance zones, two complaints were experienced significantly more often for women ($P < 0.05$): nausea in the zone of less than 10 m, headaches in the zones of 10–50 m, 50–100 m, 100–200 m, and 200–300 m. Men complain significantly more often ($P < 0.05$) than women about lowering of libido in the zone of 50 to 100 m from cellular phone base stations.

When the men/women comparison is made for all subjects exposed at a distance up to 300 m, seven symptoms (i.e., headaches, nausea, loss of appetite, sleep disturbances, depressive tendencies, feeling of discomfort, and visual disturbances) are experienced significantly more often in women ($P < 0.05$) (Table 2). On the contrary, for the subjects of the reference group, there appears to be no significant difference related to sex in the frequency of complaints reported for the different symptoms.

Age

Significant differences are observed in relation to the age of the subjects (from 21 to >60 years) for symptoms such as fatigue, irritability, headaches, sleep disturbances, feeling of discomfort, dizziness, cardiovascular problems when comparisons are made between subjects living up to 300 m vs. subjects of the reference group. For subjects younger than 20 years of age, there is no significant difference in the frequency of symptoms between subjects living at up to 300 m vs. subjects of the reference group (Table 3).

DISCUSSION

This study gives evidence of the fact that NSHS are reported by people at distances up to 200 m to 300 m from cellular phone base stations. The significant increase in the frequency of complaints in relation to the reference group (people exposed at >300 m or not exposed) goes in the direction of the observation found in an Australian governmental report, which had signaled that at 200 m from a base station, some people exposed in their homes are complaining of chronic fatigue and sleep disturbances (Australian Report, 1996). Our results agree with those of a Spanish preliminary study on people living in the vicinity of cellular phone base stations, where symptoms as irritability, headaches, nausea, and sleep disturbances are experienced in a significantly higher way by the subjects located at a distance up to 150 m vs. subjects at a distance >250 m (Gomez-Perretta Cl, personnal communication, 2002).

The number of reported symptoms is higher close to base stations, and that number decreases with increased distance from them, in relation to the fact that some symptoms such as nausea, loss of appetite, visual disturbances, and difficulties in movement are no longer experienced in a significant way beyond 10 m.

Symptoms such as fatigue, headaches, and sleep disturbances, which are experienced significantly at considerable distances from base stations, exhibit no notable

diminishment in the percentages of complaints experienced with increased distance. But the measurements of electromagnetic fields in the neighborhood of cellular phone base stations show a reduction in strength over distance (Petersen and Testagrosa, 1992; Santini, 1999). One could expect that human sensitivity to electromagnetic waves is such that increased distance from cellular phone base stations has no significant effect on certain NSHS symptoms up to a distance of 200 to 300 m (difference in receptors sensibility to microwaves?). It is also possible that the measurements of electromagnetic fields found around base stations may not be the true representation of populations exposure. In fact, different parameters are likely to interfere to modify the measurements and in particular fluctuations in emission strengths relating to the number of calls handled by base stations, the reflection of electromagnetic waves, etc. (Santini et al., 2000).

No significant decrease was observed in the frequency of symptoms in relation to the length of time living in the neighborhood of base stations (from <1 year to >5 years). This result shows that there is no acclimation of subjects to microwave bioeffects with duration of exposure.

This study shows that for some distances and for some symptoms, the facing location is the worst position, especially for distances of <100 m from cellular phone base stations. This result can be related to the fact that antennas emit microwave at a higher level in front than in other directions (Petersen and Testagrosa, 1992).

The results obtained demonstrate the greater sensitivity of women for 7 of the studied NSHS. One earlier study related to cellular phones users demonstrated an increase in women's sensitivity for the symptom of sleep disturbances (Santini et al., 2002). This sex-related difference is parallel to the particular sensitivity of women to electromagnetic fields (Loomis et al., 1994; Santini, 1998). The results obtained in this study also show the existence of a greater sensibility for some NSHS symptoms, in relation to age, in subjects older than 20 years. This sensibility is particularly high in subjects older than 60 years. This last results agrees with the greater sensibility of the elderly to radiofrequencies (Tell and Harem, 1979).

CONCLUSION

From these results and in applying the precautionary principle, it is advisable that cellular phone base stations should not be sited closer than 300 m to populations and most significantly because exposed people can have different sensitivities related particularly to their sex and their age. The facing position appears to be the worst one for distances from cellular phone base stations <100 m.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Janet Newton, President of the EMRNetwork, for her help in editing this article. The authors also thank the participants in the study.

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