

(English translation)

## **Study of the health of people living in the vicinity of mobile phone base stations: I. Influences of distance and sex\***

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### **Summary**

A survey study using a questionnaire was conducted on 530 people (270 men, 260 women) living or not in the vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaint frequencies (CHI-SQUARE test with Yates correction) in relation to the distance from base stations and sex show significant ( $p < 0.05$ ) increase as compared to people living  $> 300$  m or not exposed to base stations, up through 300 m for tiredness, 200 m for headache, sleep disruption, discomfort, etc., 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men ( $p < 0.05$ ) complained of headache, nausea, loss of appetite, sleep disruption, depression, discomfort and visual disruptions. This first study on symptoms experienced by people living in the vicinity of base stations shows that, in view of radioprotection, the of minimal distance of people from cellular phone base stations should not be  $< 300$  m. © 2002 Editions scientifiques et medicales Elsevier SAS

### **base station / bioeffects / cellular phone**

#### **1. INTRODUCTION**

Chronic exposure to high frequency electromagnetic fields or microwaves brings on bioeffects in man such as headaches, fatigue, and sleep and memory disruptions [1, 2]. These biological effects, associated with others (skin problems, nausea, irritability, etc.) constitute what is known in English as “Non Specific Health Symptoms” (NSHS) that characterize radiofrequency sickness. [3] Cellular mobile phone technology uses hyperfrequencies (frequencies of 900 or 1800 MHz) pulsed with extremely low frequencies (frequencies  $< 300$  Hertz) [4]. Even though the biological effects resulting from mobile phone use are relatively well known and bring to mind those described in radiofrequency sickness [5, 6], to our knowledge no study exists on the health of people living in the vicinity of mobile phone base stations.

We are reporting here the results pertaining to 530 people living in France, in the vicinity or not, of base stations, in relation to the distances from these stations and to the sex of the study participants.

#### **2. MATERIALS AND METHODS**

##### **2.1. Questionnaire employed:**

A questionnaire similar to that developed for the study on mobile phone users [6] was sent to people wishing to participate in the study. General questions pertained to age, sex, estimated distance from base stations (less than 10 m, 10 to 50 m, 50 to 100 m, 100 to 200 m, 200 to 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 were defined by the length of time living in the neighborhood of base stations, (less than 1 year through more than 5 years), the number of days per week and the number of hours per day (less than 1 hour through 16-24 hours per day).

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 also sought information on computer use (more than 2 hours per day) and portable 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, 3 = very often. Of 570 questionnaires received, 40 were not used due to lack of information on the distance from the base stations or on the level of the complaints experienced. For the 530 questionnaires studied, 270 came from males (average age  $\pm$  variation: 45 years  $\pm$  20) and 260 from females (47 years  $\pm$  19). 18 symptoms referenced in the “NSHS” were the subject of the questionnaire, one of which, premature menopause, concerned only females.

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\* The results presented in this study do not involve INSA in Lyon. INSA is the French National Institute of Applied Sciences.

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## 2.2 Analysis of results:

The results obtained, pertaining to the frequency of the complaints experienced (in comparison to complaints at a level of "0"), were analyzed by the CHI-SQUARE test with Yates correction [7] using a program (STATITCF, 19787, France). We present here the results tallying:

- a) The influence of distance for the base stations on the frequency of reported complaints, by comparison with the reference subjects, exposed at >300 m or not exposed (no existing base stations or non-operating base stations).
- b) The influence of sex on the frequency of reported complaints, and this independent of the age of the subjects.

## 3. RESULTS

### 3.1 Influence of distance:

The study subjects are distributed in the following manner: 19.6% are at less than 10 m from 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% are at more than 300 m or not exposed (reference group).

In comparison with the reference subject group located at >300 m or not exposed to base stations, the complaints are experienced to a significantly higher degree by the subjects located in the distance zones of <10 m through 300 m from base stations. Certain symptoms are experienced significantly more often ( $p < 0.05$ ) uniquely in the immediate vicinity of base stations (<10 m) and not beyond that: nausea, loss of appetite, visual disruptions, difficulty in moving. Significant differences ( $p < 0.05$ ) are observed up through 100 m from base stations for symptoms such as: irritability, depressive tendencies, difficulties in concentration, loss of memory, dizziness, lowering of libido). In the zone 100 m to 200 m, 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 group of subjects at > 300 m or not exposed. 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 is reported for the distances of less than 10 m, 10 to 50 m and 50 to 100 m from base stations. For fatigue and headaches Figures 1 and 2 present the percentages of complaints expressed as a function of distance from base stations.

### 3.2 Influence of sex:

Two symptoms were experienced significantly more often in women ( $p < 0.05$ ) as a function of different distance zones: nausea at a distance of less than 10 m, and headaches at distances of 10-50m, 50-100 m, 100-200 m, and 200-300 m. Men complained significantly more often ( $p < 0.05$ ) than women of decrease in libido at a distance of 50 to 100 m from base stations.

When the men/women comparison is made for subjects exposed at a distance of < 300 m, seven symptoms (headaches, nausea, loss of appetite, sleep disruptions, depressive tendencies, feeling of discomfort, and visual disruptions) are experienced significantly more often in women ( $p < 0.05$ ) (Table II). On the contrary, in the group of subjects living beyond 300 m or not exposed to base stations, no significant difference related to sex appears in the frequency of complaints reported for the different symptoms.

## 4. DISCUSSION

This study gives evidence of the fact that bioeffects are reported by people exposed at up to 300 m from base stations. The significant increase in the frequency of complaints in relation to the reference group (people exposed at > 300 m or not exposed) leads toward the observation found in the Australian governmental report indicating that at 200 m from a base station, some people exposed in their homes are complaining of chronic fatigue and sleep disruption [8].

The number of reported symptoms is higher close to base stations and it decreases with increased distance from them. 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. For symptoms that, like fatigue, headaches, and sleep disruptions, are experienced significantly at considerable distances from base stations, no notable diminishment is observed in the percentages of complaints experienced with increased distance. However, the measurements of electromagnetic fields in the neighborhood of base stations show a reduction in field strength over distance [1,9]. One can expect that human sensitivity to electromagnetic waves is such that increased distance from base stations has no significant effect on certain symptoms up to a distance of 200 to 300 m. It is equally possible that the levels of electromagnetic fields found around base stations would not be the exact representation of the levels of exposure of populations. In fact, different parameters are likely to interfere to modify the levels and in particular fluctuations in emission strengths such as the number of calls handled by the base stations, the reflection of electromagnetic waves, etc. [10].

The results obtained demonstrate the greater sensitivity of women for 7 of the studied NSHS. One earlier study relating to portable phone users demonstrated a greater sensitivity of females to the symptom of sleep disturbance. This sex-related difference is parallel to the particular sensitivity of females to electromagnetic fields [11, 12].

## 5. CONCLUSION

From these results and in applying the precautionary principle, it is advisable that mobile phone base stations not be sited closer than 300 meters to populations and most significantly because exposed people can have different sensitivities related particularly to their sex.

**Table I.** Percentages of complaints reported compared to responses of a level of « 0 », by persons living in the vicinity of base stations as a function of their distance away from a base station.

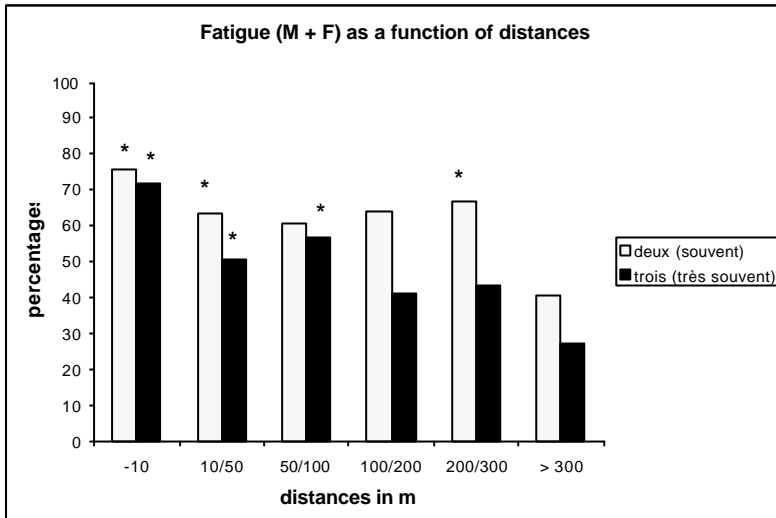
Symptoms	Distances from base stations in meters (m)											
	< 10 m		10 to 50 m		50 to 100 m		100 to 200 m		200 to 300 m		> 300 m ...	
	2	3	2	3	2	3	2	3	2	3	2	3
Fatigue	76 *	72 *	63.5*	50.9*	60.6	56.6*	64.2	41.1	66.6*	43.7	40.7	27.2
Irritability	32.8	23.2*	41.7*	25.7*	47.2*	44.1*	25.8	4.1	25	9	18	3.3
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 Disruption	41.3*	57.1*	41.4*	57.5*	46.9*	58.5*	45.8*	50*	33.3	35.5	13.8	21.1
Depression	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
Difficulty 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 Disruptions	14.5	24.3*	23	13.5	22	7.1	2.5	4.9	15	2.8	13.6	4.1
Hearing Disruptions	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
Cardio-vascular Problems	10.1*	13 *	15.3*	9.6	12.3*	7.4	8.7	0	8.5	6.5	1	3

\* Significant difference ( $p < 0.05$ ) in comparison to reference subjects found at > 300 m or not exposed, for the responses 2 = « often » and 3 = « very often ».

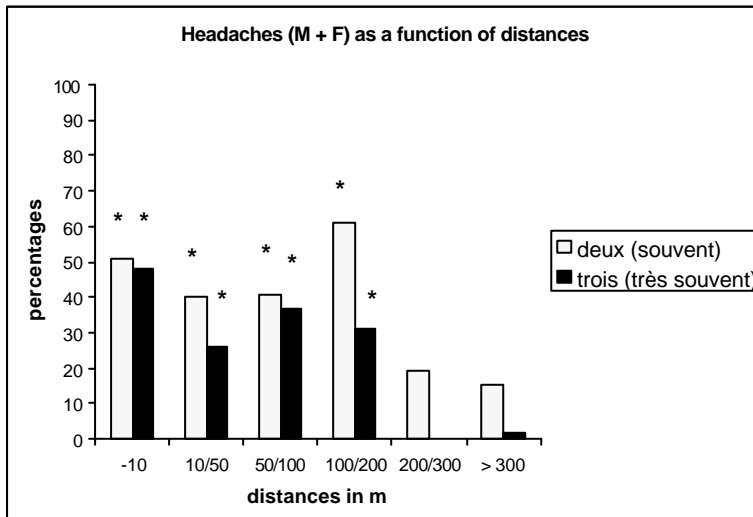
**Table II.** Influence of sex on the frequency of symptoms reported by subjects (205 men, 215 women) living in the vicinity (all distances < 300 m) of mobile phone base stations

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

\* $p < 0.05$ . Levels of complaints in parentheses.



**Figure 1.-** Frequencies of complaints compared to a response level of « 0 » for the symptom of fatigue, in people living in the vicinity of mobile phone base stations as a function of their distance from base stations.  
M = Males, F = Females, m = meters, deux (souvent) = two (often),  
trois (tres souvent) = three (very often).  
\* =  $p < 0.05$  (comparison with the subjects at a distance > 300 m or not exposed).



**Figure 2.** Frequencies of complaints reported in comparison to a response level of « 0 » for the symptom of headaches in people living in the vicinity of base stations as a function of their distance from base stations.  
M = Males, F = Females, m = meters, deux (souvent) = two (often),  
trois (tres souvent) = three (very often),  
\* =  $p < 0.05$  (comparison with the subjects at a distance > 300 m or not exposed).

## REFERENCES

1. Santini R. Les téléphones cellulaires et leurs stations relais: risques pour la santé ? La Presse Médicale 1999 ;28: 1884-6.
2. Bielski J. Bioelectrical brain activity in workers exposed to electromagnetic fields. Ann NY Acad Sci 1994 ; 724: 435-7.
3. Johnson Liakouris AG. Radiofrequency (RF) sickness in the Lilienfeld study: An effect of modulated microwaves? Arch Environm Health 1998 ; 53: 236-8.
4. Linde T, Mild KH. Measurement of low frequency magnetic fields from digital cellular telephones. Bioelectromagnetics 1997 ; 18: 184-6.
5. Mild KH, Oftedal G, Sandströms M, Wilen J, Tynes T, Haugsdal B *et al.* Comparison of symptoms experienced by users of analogue and digital mobile phones. Arbetslisrapport 1998 ; 23: 1-47.
6. Santini R, Seigne M, Bonhomme-Faivre L, Bouffet S, Defrasme E, Sage M. Symptme experienced by users of digital cellular phones: A study of a French engineering school. Electro And Magnetobiology 2001 (in publication).
7. Dabis F, Drucker J, Moren A. Epidémiologie d'intervention. Editions Arnette ; 1992. 589 pages.
8. Rapport australien. A local government and community ressource document : « Mobile phone and their transmitter base stations – The evidence for health hazards». EmFacts Informations Service, 1996. 240 pages.
9. Petersen RC, Testagrosa PA. Radiofrequency electromagnetic fields associated with cellular radio cell-site antennas. Bioelectromagnetics ; 1992 ; 13: 527-42.
10. Santini R, Seigne M, Bonhomme-Faivre L. Danger des téléphones cellulaires et de leurs stations relais. PatholBiol 2000;48: 525-8.
11. Loomis DP, Savitz DA, Ananth CV. Breast cancer mortality among femal electrical workers in the United States. J. National Cancer Institute. 1994 ; 86: 921-5.
12. Santini R. Breast cancer in women, high voltage power lines and melatonin. Bioelectromagnetics Newsletter 1998 ; 144: 5.
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