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SCIENTIFIC ADVISORY COMMITTEE ON RADIO FREQUENCIES AND HEALTH (CCARS)

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Apdo. de Correos 155, 28230 Las Rozas, Madrid

www.ccars.es

Introduction

This is the third edition of the report by the Scientific Advisory Committee on Radio Frequencies and Health (*CCARS*). The first was published in 2006, commissioned by the Ministry of Industry, Trade and Tourism, and the second (corresponding to the two years 2007-2008), which included an assessment of risks related to exposure to radio frequencies, especially those used for radio communication, was published in 2009. This second report aroused considerable interest among those involved in the issue.

The infrastructures needed to supply mobile telephony services are growing rapidly, while the potential use of mobile phones is increasing with attractive new applications. A study published recently in a Spanish newspaper (El País, Thursday 30 September 2010) reported that the mobile phone, present in 93% of Spanish homes, is the second most frequently found device in the bedroom, after the television.

The frequent use of the mobile phone has led to concern about the effects radio frequencies may have on health. The involvement of institutions and reference committees which advise on technical and healthcare issues is thus considered necessary. In Spain this responsibility has been assumed by the Scientific Advisory Committee on Radio Frequencies and Health (*CCARS*), under the auspices of the Madrid Complutense University, through the General Foundation of the University. *CCARS* is an independent institution formed by recognised experts in medicine, physics, chemistry, biology, epidemiology and law. Its composition changes according to the issues it is to analyse. The present composition of *CCARS* can be found in an appendix to this report and on the Committee's website (*www.ccars.es*), which also contains information about the aims and activities of *CCARS*. In 2010 a Bulletin was also launched and this is sent by e-mail to the distribution lists held on the database belonging to the Committee's Secretariat. New readers who would like to receive it are welcome to request copies. As composed at present, *CCARS* has tried to reinforce its expertise in basic biology and regulatory and law.

As pointed out in the introduction to the report for 2007-2008, the main objectives of *CCARS* include providing scientific advisory services and clear, independent and up-to-date information to all public and private bodies as well as to the general public regarding the expansion of radio frequency electromagnetic fields and their effect on human health. During the period 2009-2010, covered by this report, research has continued and experimental studies have been published, as well as reports on the effects on health of exposure to the radio frequency magnetic fields produced by mobile telephony base stations (antennae) and by the use of mobile phones. Work has also been carried out using models and in laboratory conditions. The publication of the results of the *INTERPHONE* study has been of particular interest and this receives special attention in section 3.3.2. This report provides summaries of revised scientific views on the possible effects of exposure to radio frequency magnetic fields published by leading international institutions. They include the EU Scientific Committee on Emerging and Newly Identified Health Risks (*SCENIHR*); the

International Commission for Non-Ionizing Radiation Protection (*ICNIRP*); the World Health Organisation (*WHO*); the Agencie Française de Securité Sanitaire de l'Environment et du Travail (*AFSSET*); and three French academies: the National Academy of Medicine, the Academy of Science, and the Academy of Technology. The position of the authorities in Scandinavian countries has also been analysed.

The two years have not been characterised by particularly high levels of social concern. In 2009 France was the country expressing most concern, especially regarding the growing and excessive use of mobile phones by children. This may explain why there have been such significant reactions by scientific organisations in France and the French regulators. However, according to the results of the special 2010 Eurobarometer survey of the effects of electromagnetic fields on health, Spaniards are among those most worried about the potential effects of electromagnetic fields on health in Europe, although they are also among those who know least about the subject. The existence of independent bodies such as *CCARS*, whose aims include providing objective information based on scientific evidence, is thus increasingly necessary in our society.

This report not only analyses scientific findings regarding exposure to radio frequency electromagnetic fields but also deals with another area of great importance in the relationship between society and new technologies: the legal aspect. The report therefore analyses the outcome of various court cases in Spain dealing with exposure to electromagnetic fields.

Public discussion during the years covered by the report has been largely in response to an initiative by the Spanish National Research Council (*CSIC*). As part of a cycle of scientific debates organised by the Deputy Vice-Presidency for Scientific Organization and Culture, the topic of radio frequencies and health was discussed, with the participation of two former members of *CCARS*, Professor Antonio Hernando and Doctor Alejandro Úbeda. As has been the normal practice, these debates have been followed by the publication of the book Radiofrecuencias y Salud (*(Radio Frequencies and Health),* CSIC, Los Libros de la Catarata, Madrid, 2010), in which, as well as contributions by the two scientists mentioned, there is a text by José María Suárez, journalist and coordinator of the healthcare policy section of Diario Médico, which concludes with the following statement: *"If you rightly decide to continue reading this book, you will have the same sensation as I do every time I have the pleasure of speaking to a researcher: nobody, in any field, is in possession of the absolute truth, even more so, if possible, in the fields of medicine and science in the broadest sense, where there appears to be no limit to progress or their ability to surprise us*." We thus see the work of *CCARS* as increasingly important.

Contents

1. Executive Summary

This report is based on the results published in recent years, especially in 2009 and 2010, by organisations, committees, agencies and research groups of recognised standing in the field of study and assessment of possible risks caused by exposure to radio frequency electromagnetic fields. Most studies have focused on the radio frequency fields associated with mobile telephony, largely as a result of the social concern aroused by the spreading use of these new technologies in certain sectors of the population.

In vivo and *in vitro* experimental studies have shown that the radio frequency electromagnetic fields used in mobile telephony, and whose levels are below those set by the *ICNIRP* and those recommended by the *EU* are not *genotoxic* or *mutagenic* and do not lead to *apoptosis* or cell death. Although some studies have reported alterations in cell dynamics, it should be pointed out that in most studies the levels of exposure used are considerably higher than the limits for which there is believed to be no harmful effect on health.

In the area of epidemiological studies, the results of the *INTERPHONE* study have been published. This is an epidemiological research project, using case-control studies, in which 13 countries have participated, using a common methodology. Its aim is to assess the relationship between the use of mobile phones and the risk of developing certain tumours. The authors of the *INTERPHONE* report conclude that, overall, no increase in the risk of *gliomas* or *meningiomas* due to the use of mobile phones has been observed. There are some indications of an increased risk of *gliomas* in the group with the highest level of exposure (use of mobile phone) but the bias of the study and its methodological errors make it impossible to establish a causal relationship.

Taken together, the epidemiological studies indicate that exposure to mobile phones for periods of less than 10 years in healthy adults does not constitute an additional risk of developing brain tumours. There have been no conclusive studies of exposure for longer periods and the effects over such periods need to be investigated more closely. Specific studies of the effects on children and adolescents are also called for.

Controlled studies of individuals who describe themselves as hypersensitive to the radio frequency electromagnetic fields associated with mobile telephony (*MT*) (the fields generated by phones and antennae) have shown that there is no causal relationship between the symptoms they report and their exposure to this type of radio frequency radiation.

In studies of public exposure to the radio frequency fields associated with base stations (telephony antennae), experimental measurements taken in the vicinity of base stations and in "sensitive" areas show that levels of exposure are well below the reference values established in Spanish legislation, as specified in Royal Decree 1066/2001, of 28 September 2001, approving regulations to establish conditions for protection in the public radio-electric domain, restrictions on radio-electric emissions, and measures to protect public health from radio-electric emissions. These limits are those set by the *International Commission on Non-Ionizing Radiation Protection (ICNIRP)*, an organisation supported by

the *World Health Organization* and the *European Union*.

The analysis of various court decisions on the risks arising from exposure to electromagnetic fields reveals certain contradictions when considering the *state of the science* on the matter and how it should be applied when the court is reaching a verdict.

The *special Eurobarometer* on electromagnetic fields published in June 2010 shows that Spanish people are among those most worried about the potential effects of electromagnetic fields on health in Europe, although they are also among those who know least about the subject.

Lastly, the report presents some general conclusions and recommendations for priorities in research and future measures. They include the need to promote experimental and epidemiological studies and develop new strategies in the field of dosimetry allowing for better measurement of the levels to which people are exposed.

2. Experimental studies on the effects of radio frequency electromagnetic fields which are relevant to health

The most significant experimental data has been related to three fields which are of basic and clinical importance: cellular biology, neurobiology and immunology. Although we could conclude that, according to the data published, the electromagnetic fields used in mobile telephony are not *genotoxic* or *mutagenic* and do not cause *apoptosis*, we must point out that there is, unfortunately, little data, and that the experimental models used bear little relationship to each other, making it difficult to compare the results, which are often contradictory and do not clarify a key aspect of the problem: the mechanism by which waves may directly or indirectly affect cells and tissues.

It would thus seem necessary to standardise experimental procedures, both for *in vivo* and *in vitro* models, to increase the number of studies dealing with a particular type of cell or tissue, and to tackle the question of the molecular mechanisms which enable the waves to have an effect.

2.1 Effects of exposure to radio frequencies on the biology of cells: studies *in vivo* and *in vitro*

This section summarises the results obtained from *in vivo* and *in vitro* studies of the exposure of different cell types to radio frequencies. To facilitate reading we have chosen to reduce the number of references to individual articles and instead refer the reader to reviews conducted by national and international committees. These studies, which are listed below and can be accessed directly on the internet, include references to the articles used in the preparation of this report:

[SCENIHR-2009] *Health Effects of exposure to EMF*, *SCENIHR,* 19 January 2009.

[ICNIRP-2009] *ICNIRP Statement on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)".*

The conclusions of the joint note dated 17 December 2009 from three French Academies (National Academy of Medicine, Academy of Science and Academy of Technologies) [AcadFranc-2009], regarding the effects of radio frequencies on cells, include the following points:

1. The electromagnetic fields used in mobile telephony do not generate *oxygen free radicals* or promote *oxidative stress*.
2. They are not *genotoxic* or *mutagenic*.
3. They appear not to bring about *apoptosis* and have no discernible effects on human or animal reproduction or development.
4. Even more importantly, no possible mechanism for the interaction of waves and cells has been identified.

However, when the findings are reviewed in more detail and certain studies are analysed, it could be concluded that the results available are insufficient

and often contradictory. For example, when using the concentration of nitric oxide in blood as a marker for *oxidative stress*, the same research group has described two totally opposed results: one showing an increase in the marker used [Sirmantel-2007a] and the other reporting an increase in overall oxidative capacity and a decrease in oxidising status and the index for *oxidative stress* [Sirmantel-2007b]. We also find that individual neurones subjected to magnetic fields are sometimes stimulated and sometimes inhibited [Todorovic-2007]. There are similar contradictions in reports of the effects on arterial and venous diameter and in general on blood flow in different animals used in experiments, as well as weight gain/loss and levels of glucose [Hashish-2007].

In some studies with cell lines their exposure *in vitro* to several hundred millitesla ($1\,\mathrm{mT} = 0.001\,\mathrm{T}$) produces modifications in the genetic pattern or damage to the *DNA* but in others these alterations have not been observed, even with much greater radio frequencies. In this connection it should be noted that different doses lead to different results regarding the transitory behaviour of certain genes. In other cases the cells recover quickly from the effects of the radio frequencies, as assessed by the induction of micronuclei, a marker of *DNA* damage.

Recently, L. Verschaeve has reviewed the studies carried out on genetic damage in subjects exposed *in vivo* to different radio frequencies, mostly because of their jobs, including those generated by X-rays, radar, telephone antennae and mobile phones [Verschaeve-2009]. Although most of the studies concluded that the individuals exposed to radio frequencies suffered more frequently from different types of genetic damage, others found no difference between the individuals exposed and the controls. The author also emphasised that all the studies suffered from serious methodological problems, including lack of information about the doses of exposure, insufficient numbers of samples both in those exposed and in the control group, and inadequate or incomplete statistical analysis, making it impossible to reach clear, definitive conclusions.

It thus seems important, before reaching any definitive conclusions, to substantially increase the number of studies and establish standard protocols for research and assessment which will allow us to compare the results obtained.

2.2 Studies of the nervous system

Mobile phones function by emitting radio waves at frequencies of around *1000 MHz*. The total power emitted by the appliance is measured in watts (*W*) and is partially absorbed by the body. The absorbed radiation is measured in watts per kilogram (W/kg). The degree of absorption is expressed as the *Specific Absorption Rate (SAR).*

The issue being discussed is whether exposure to this radiation can be toxic for living organisms, especially whether it can be harmful for human beings, it having been postulated that the radiation might damage genetic material, causing breaks in *DNA*. Moreover, and more specifically, studies have been carried out to determine whether this radiation can affect the nervous system.

Some of the work published on the subject is discussed in our brief summary.

2.2.1 Studies of blood circulation in the brain

The consequences of a radiation level of *900 MHz* for *30* minutes, at a *SAR* of *1* W/kg has been studied in young humans using positron emission

tomography. Under these conditions, an increase in circulation was observed in the subjects, compared to the control group [Hubert-2005]. However, in a later study it was found that there were differences in circulation in different parts of the brain, as it increased in the frontal lobe and decreased in the temporal lobe [Aalto-2006].

2.2.2 Studies of memory in young rats

Using the Morris water maze test, which measures memory in rodents, the effects of a radiation level of *900 MHz* for 2 hours per day for a total of 5 days (*SAR* calculated between 0.3 - 3.0 W/kg) on young rats were studied. The results showed that the memory of rats which were exposed improved compared to that of those which were not [Kumlin-2007].

2.2.3 Studies of neurone cultures

The effect of radiation on primary neurone cortical cultures has been dealt with in two studies. In the first, the effects of a radiation level of *900 MHz* (*SAR* = *1* W/kg) on the viability of neurone cultures was studied. No differences were detected [Del Vecchio-2009].

A second study did indicate a slight level of neurone death under similar radiation conditions, although in this case it was observed that the culture medium was heated by the radiation (from *37* ^oC to *39* ^oC) and the controls were therefore incubated at the same temperature [Joubert-2008]. In this study *DNA* fragmentation was observed in the neurones exposed to radiation. In another study [Iijima-Ando-2010], which was not related to radiation, it was observed that the activity of *DNA damage-activated checkpoint kinase 2* may favour the *phosphorylation* of tau protein and cause *neurodegeneration*. It remains to be seen if this can happen under the conditions described for the study referred to above [Joubert-2008].

2.2.4 Study of glial cell cultures

Considering that most of the cells in the human brain (see Figure 1) are glial cells (mostly astrocytes), the effects of radiation on certain glial markers have been studied. A first study gave negative results [Miyakoshi-2005], but in a second a certain level of astrocyte activation was observed after they had been exposed to radiation [Ammari-2008].

In brief, the findings published suggest a slight effect or none at all on the parameters analysed, under the radiation conditions studied.

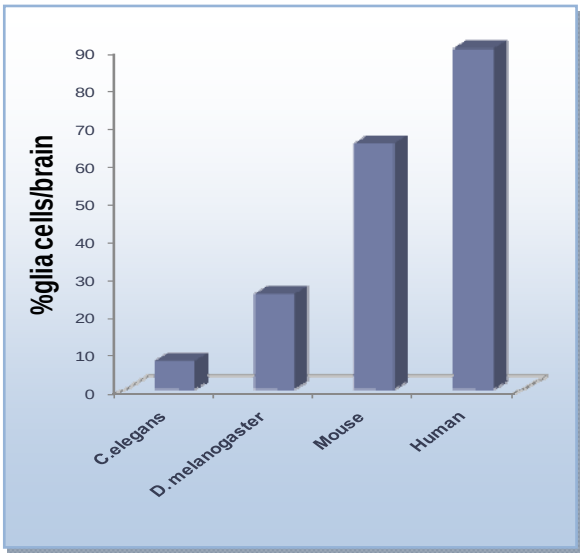

Figure 1. Proportion of glia cells in the brains of different species (C. elegans = Caenorhabditis elegans; D. melanogaster = Drosophila melanogaster, also known as the fruit fly).

Some studies indicate the effect of radiation on the activity of some enzymes [Hoyto-2007] and gene patterns in glia cells [Zhao-2007], but other research indicates few changes in other parameters [Lee-2006]. Regarding the effects on neurones, the

following articles comment on possible alterations to neurone areas [Del Vecchio-2009b], [Erdine-2009], [Huang-2008], [Ragbetli-2009] and to *organelles* [Xu-2010]. However, in most of these studies the exposure to electromagnetic radiation took place under conditions we can only describe as extreme, in particular in view of the high SAR levels to which cultures were subjected.

2.3 Effects of radio frequency emissions on the immune system

Today there is a substantial amount of data on the effects of radio frequencies on the immune system. Nevertheless, the data is very varied and difficult to synthesise. Experimental approaches vary widely in the radiation frequency considered and in the subjects used for the experiment, leading to clear contradictions in the works which have attempted to review the findings.

In *"Biological and Medical Aspects of Electromagnetic Fields" (Handbook of Biological Effects of Electromagnetic Fields, 3Ed)*, which is considered a reference work on the subject, there is a chapter on *"Effects of radio frequency and extremely low frequency electromagnetic fields radiation on cells of the immune system"* by T. Paunescu and G. Woloschak [Panescu-2007], which comes to the conclusion that it is difficult to obtain definite results in this area or identify a single study in which the electromagnetic effects could be distinguished from the *thermal effects* with proper controls.

In 2009 a revised version of O. Johansson's work was published [Johansson-2009] along similar lines to the controversial Bioinitiative Report [BioR-2007]. The revision, entitled "*Disturbance of the immune system by electromagnetic fields—A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment"*, gives an alarmist view based on the analysis of 94 cases, most included in studies carried out between 1995 and 2008, with a relative peak in 2006.

The view of the *CCARS* group who have analysed the revised study and other related publications is that the data presented does not lead to any clear conclusions and that a certain ideological leaning can be detected, as the studies referred to by O. Johansson do not justify the author's conclusions and would even point in the opposite direction, all of which casts doubt on the author's objectivity.

From the point of view of general effects, an effect on the increase of haematopoiesic progenitor cells in mice has been observed. However, the physiological effects depend on temperature and environmental factors [Bonhomme-Faivre-1998]. Although there seem to be effects in T cells in rabbits (due to immuno-complex deposits), there are no observable effects on lymphocyte B capping in mice. Capping is a phenomenon involving aggregation at one of the poles of the molecules on the surface of a cell after it is linked to certain antibodies. This phenomenon shows the mobility of the cell plasma membranes.

There is a great deal of data, much of it subjective, regarding symptoms which can be attributed to other causes rather than the real effects of radiation (sleep disorders, tiredness, skin complaints, allergies, etc.).

Increases in skin mastocytes have also been reported but this has occurred in individuals with a previous condition and cannot be definitely attributed to electromagnetic radiation [Johansson-2009].

In experiments with animals there is evidence of an increase in serotonin production in the skin cells of rats after repeated exposure (*50 Hz*) [Johansson-2001].

It has been suggested that there are changes in *CD4*⁺ cells, which would indicate an alteration in the innate immune response. However, the response to *mitogens* in cells obtained from donors and subjected to radiation (*1800 MHz*) seems not to be affected.

There is a revision which shows very clearly the controversy about the analysis of the cytogenic effects of radio frequency radiation in biological processes [Vijayalaxmi-2004]. If we analyse the publications in the period 1990-2003 dealing with the possible effects of exposure to radio frequencies we find that 58% are negative, 23% are positive and 19% are inconclusive.

3. Clinical and epidemiological studies

The previous report by *CCARS*, *Report on Radiofrequency and Health (2007-2008)* [CCARS-2009], included a short section explaining some basic concepts in epidemiology and we would refer the reader to this in the event of any doubt about the terminology used.

In this new version of the report on radio frequencies and health, the Clinical Studies and Epidemiology Group in CCARS has reviewed the new epidemiological evidence on exposure to radio frequencies emitted by mobile telephony technologies and their effects on health.

This section presents a summary of the updated findings of the most significant clinical and epidemiological studies published in 2009-2010.

3.1 Methodology

An exhaustive review of the scientific bibliography published in the period from January 2009 to 22 July 2010.

Over 100 articles published in leading reviews during this period have been considered. A systematic search has also been carried out in databases such as *PUBMED*, *EMBASE*, *DARE* and *LILACS*, in English, French and Spanish. The descriptors used have been the usual terms in this type of search related to radio frequency, mobile telephony, base stations, adverse effects on health, brain tumours, electromagnetic hypersensitivity, etc.

We have included the clinical and epidemiological studies which provide the most convincing evidence, depending on the design of the study, methodology used, quality, validity, consistency and reproducibility. Studies dealing with experimentation on animals, *in vivo* and *in vitro*, studies, are the subject of another chapter in this report.

Lastly, priority has been given to systematic reviews [Delgado-2006], meta-analysis [Guerra-2010], and the reviews carried out by agencies, international committees and relevant authorities dealing with the evaluation of risks related to radio frequencies, including the *European Union Scientific Committee on Emerging and Newly Identified Health Risks* (*SCENIHR*); *the French Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail* (*AFSSET*); *the International Commission on Non-Ionizing Radiation Protection* (*ICNIRP*) and the *World Health Organization* (*WHO*), as the scientific information they provide is exhaustive and reliable.

3.2 Effects of RF EMF on health

In recent years numerous studies of the effects of Radio Frequency (*RF*) from mobile telephony (*MT*) on health have been published. News about the theoretical effects of mobile telephony has great impact on public opinion and tends to generate alarm about its long-term effects.

Mobile phones and antennae have been associated with brain tumours, electromagnetic hypersensitivity and a wide range of other symptoms and diseases.

However, to date there is no evidence to support these opinions.

The most exhaustive reviews of the effects of *RF* carried out by leading competent organisations published in 2009 all coincide in stating that there is no evidence for these effects, see [SCENHIR-2009], [ICNIRP-2009], [AFSSET-2009]. However, applying the precautionary principle, they insist on the need to continue doing research in view of the short period of exposure since mobile telephony became widespread in Europe (mid 1990s).

Epidemiological research on the effects of *RF* have focused in recent years on identifying possible links between the use of mobile phones and tumours in the central nervous system (*CNS*) (*gliomas*, *meningiomas* and *acoustic neurinomas*) and the salivary gland. They are characterised by low prevalence and may be latent for long periods. A good system for registering tumours is needed, providing accurate and reliable information about the most significant characteristics of all cases of cancer.

Most epidemiological studies published to date are *case-control studies*. They are subject to certain types of *bias* (in selection and participation) and methodological limitations (errors in recording exposure), which have recently been assessed [Vrijheid-2009], [Vrijheid-2009b].

The main problem in epidemiological studies of mobile telephony and its effects on health is measurement of exposure. There are numerous difficulties in quantifying real exposure objectively, consistently and comparably. The errors and *bias* introduced in estimates of doses make it difficult or impossible to obtain reliable results. Estimates of exposure are usually based on interviews, surveys, or records of calls provided by mobile phone operators. Such methods are likely to suffer from numerous distortions of recollection and information.

We should also remember that the world of mobile telecommunications is changing very quickly. A large proportion of current users have *third generation (3G or UMTS mobile telephony) devices* and fourth generation appliances are now being introduced. The results of the epidemiological studies currently being published refer to users of phones with analog technology, whose emissions were more intense. This type of device is hardly used at all today.

For these reasons, the most valuable scientific information will not come from a single study but from the results of systematic reviews and meta-analysis of the cumulative bibliography dealing with the greatest number of cases.

A review of the effects on the nervous system shows that exposure *to GSM* signals may lead to changes in brain activity but they have never been linked to adverse effects [Van Rongen-2009]. Significant consistent effects have not been observed in the cognitive performance of the adults studied. The effects in children are similar to those in adults.

Subjective symptoms, such as headaches, fatigue and itching, have been attributed to various sources of Electromagnetic Fields (*EMF*) in the home and the workplace. However, in studies where subjects were deliberately exposed to such fields, no causal relationship could be demonstrated between *EMF* and these symptoms. The most plausible hypothesis is that people who claim to be hypersensitive are influenced by psychological factors such as the expectation of a negative effect *(nocebo effect)*.

A study financed by the European Commission, *EMFnEAR (Exposure at UMTS Electromagnetic Fields: study on Potential Adverse Effects on Hearing)*, conducted research into the potential short-term effects on human hearing of exposure to *UMTS* at high *SAR* levels [Parazzini-2010]. *73* volunteers showed no effect on their auditory system after 20

minutes exposure to *1947 MHz*. The analysis of the results included a *double blind* comparison of real and simulated exposure. The authors concluded that a short period of exposure to a *UMTS* emission source at relatively high levels of *SAR* does not lead to immediate effects on the human auditory system.

In October 2002 the media gave extensive coverage to the Freiburger Appeal by a group of German doctors who warned other healthcare professionals, politicians and the public about an increase in the incidence of symptoms and diseases in the population at large which could be caused by radio frequency waves and mobile telephony [Freiburg]. A recent study has examined official databases to determine whether the incidence and prevalence of these symptoms and diseases (Alzheimer's disease, dementia, sleep disorders, tinnitus, cerebrovascular diseases, ischemic cardiopathy, headache and migraine) has increased [Zur Nieden-2009]. In the Appeal it was stated that the frequency of these symptoms and diseases had "increased dramatically" or that they occurred "very frequently" in adults. If this were true it should be possible to observe a clear trend over time related to the use of mobile communication technologies. The data on these conditions was analysed for the period 1993-2005. No "dramatic increase" was observed for any of these conditions, despite the methodological difficulties concerning the different diagnoses and terms used in the studies reviewed, which made it difficult to establish comparisons. It can thus be concluded that the allegations in the Freiburg Appeal are not supported by public health data.

A recent study by the Danish Institute of Cancer Epidemiology analysed the incidence of brain tumours in various northern European countries [Deltour-2009]. In Scandinavia the use of mobile phones increased significantly from the mid-1990s. Consequently, the study of the incidence of tumours after 1998 could provide valuable information about the connection between the use of mobile phones and the occurrence of brain tumours.

The authors of the report analysed the annual incidence of *gliomas* and *meningiomas* in adults aged 20 to 79 in Denmark, Finland, Norway and Sweden. The study examined the cases of a total of 59,984 patients who had had this type of tumour diagnosed in the period 1974 to 2003. It concluded that there were no substantial changes in the incidence of these brain tumours between 1998 and 2003, 5 and 10 years after the increase in the use of mobile phones. The information was obtained from the cancer registers in the four Scandinavian countries. Nevertheless, the authors are aware of the limitations of the study. The records studied might have been incomplete in the case of *meningiomas*, i.e. some cases might not have been detected. We also have to bear in mind the scientific advances that have taken place in the diagnosis of these tumours: new techniques have led to considerable improvements in the speed and effectiveness of diagnosis. These developments can have an effect on the analysis of long-term trends.

The results of this study coincide with those of similar studies carried out in Scandinavia and the UK.

3.3 Mobile phones

The rapidly growing, widespread use of mobile phones, since their appearance in the 1980s, has led to concern in some sectors about possible health risks.

The question of whether the use of mobile phones is connected with an increased risk of suffering from brain tumours cannot be resolved by the publication of a single study, however thorough and rigorous it may be. Not even a study as extensive as the *INTERPHONE* report has achieved this. Although its

conclusions have cast light on some uncertain areas, it has not dissipated all the doubts [INTERPHONE-2010].

If the massive exposure to radio frequencies associated with mobile telephony has some effect, this should be reflected in the incidence of brain tumours over time. To verify this effect it is indispensable to have a system for recording tumours which is exhaustive, effective and representative of the population being studied. The monitoring of the incidence of *CNS* tumours is an excellent indicator to determine whether any effect is being produced.

Most of the epidemiological studies published to date have not reported increases in the risk of brain tumours related to exposure to radio frequencies. One of the most exhaustive and rigorous reviews of the epidemiological evidence for links between the use of mobile phones and brain tumours concludes that "overall the studies published to date do not show an increase in the risk of brain tumours over a period of use lasting 10 years" [Ahlbom-2009]. Even so, in the case of tumours which have long periods of latency *(meningioma* and *acoustic neurinoma)* we should adopt a cautious approach and continue to do research. However, it seems reasonable to assume that, if there were any causal relationship, we would now be detecting it in the changing incidence of these tumours, at least in the case of those which are latent for shorter periods. This position coincides with that of the organisations responsible for the assessment of risk from *EMF* (*ICNIRP, WHO, SCENHIR; AFSSET, IARC,* among others)

Opposed to this majority position, we find other authors who maintain that there is an increased risk of some of these tumours associated with the use of mobile phones [Hardell-2009], [Khurana-2009]. Hardell's work has been analysed critically by Ahlbom, [Ahlbom-2009], because of differing decisions on methodology and analysis, and overlapping data, which makes correct interpretation of the results difficult. These discrepancies, reflected by the media in some cases, have fuelled doubts and fears about the safety of using mobile telephony.

To establish the starting point and track the number of cases of this type of tumour we need to have objective, comparable data of the kind which can only be provided by the relevant institutions and organisations, such as the Spanish National Statistics Institute and official registers of tumours. An analysis of trends in this type of tumour gives us clear, reliable and consistent information about their real incidence and prevalence, broken down by age, sex and type of tumour, which can then be compared with estimates of exposure in mobile phone users.

This line of analysis is one of the research priorities proposed by various leading international organisations, as there are already a reasonable number of studies dealing with mobile phone users over periods of less than 10 years but very few for longer periods.

Inskip and associates have analysed trends in the incidence of brain tumours associated with the use of mobile phones in the USA [Inskip-2010]. The author maintains that massive exposure to mobile telephony should be reflected in the incidence of tumours. His results, based on information from the *Surveillance, Epidemiology and End Results (SEER) Program* of the *National Cancer Institute (NCI),* establish that in the years 1992-2002 numbers decreased or remained stable. He concludes that overall these figures do not support the view that mobile phones produce brain tumours.

Currently the Mobi-Kids [Mobi-Kids] study is in progress, an epidemiological control-case study whose aim is to determine whether the brain tumours diagnosed in children and young people are related to communication technologies and environmental

risk factors in 13 countries. The study will continue for 5 years and approximately 2,000 young people aged 10 to 24 who have developed brain tumours will be invited to participate, together with a similar number who have not developed tumours.

3.3.1 Trends in the incidence of central nervous system tumours in childhood (0-14 years) in Spain

Central nervous system *neoplasia* accounts for approximately 20-25% of all childhood cancer (0-14 years) and is the largest group of solid childhood tumours and the leading cause of death from cancer in childhood in developed countries. Its incidence in Europe and North America is high, at 20 to 40 cases per million children (standardised rate for the world population) [Parkin-1998], [Peris-Bonet-2006], while in Africa and developing countries the incidence is low. As well as reflecting possible ethnic variations, this suggests that the fact that diagnostic techniques are not widely available may affect the rates recorded [Reutfords-2002]. In Spain the crude incidence rate of CNS tumours was 31.9 cases per million (32.8 cases per million standardised for world population) in the period 1983-2002 [Peris-Bonet-2010]. There have been reports of an increase in childhood tumours in various countries: Sweden 1960-1998 [Dreifald-2004] and 1973-92 [Hjalmars-1999]; United States 1975-1999 [Gurney-1999], [Linet-1999]; and north-west England [McNally-2001], among others.

The *ACCIS* (*Automated Childhood Cancer Information System*, [ACCIS]) project, the most extensive study of the incidence of childhood cancer carried out to date in Europe, with 19,531 cases of *CNS* tumours in childhood (0-14 years) showed a rising trend in Europe throughout the period 1978-1997, with an average annual increase of 1.7% for the whole of Europe, reflected to a greater or lesser extent in all the regions studied, in both sexes and all parts of the age range [Peris-Bonet-2006], [Kaatsch-2006]. In the *ACCIS* project the incidence rate over time was assessed using *Poisson regression models* adjusted for sex, age and region, but there was no evaluation of the presence of change points in the trend. The *ACCIS* project did not produce results for individual countries.

Trends in the incidence of childhood *CNS* cancer (*0-14* years) in Spain for the period *1983-2002* were analysed recently as part of the most extensive study carried out to date of changes in the incidence of childhood cancer by the Spanish cancer registries [Peris-Bonet-2010]*. The population based study deals with 1,291 cases of *CNS* cancer. In the analysis of the trend over time, as well as studying the whole period using Poisson models, a new *Bayesian joinpoint approximation* was used to detect inflections in incidence over time.

Figure 1 shows the incidence of *CNS* tumours in Spain (standardised for world population) for the period 1983-2002, in 5-year periods, distinguishing malignant tumours from all other *CNS* tumours.

The results of the Spanish study show a significant rising trend for the whole period with an annual change for all tumours of 2.18% (95%CI: 1.17; 3.20), falling to *1.46%* (*95%CI*: 0.40; 2.54) when non-malignant tumours are excluded from the analysis, although the trend is still upward and statistically significant.

** Cooperative study involving the cancer registries of Albacete, Asturias, the Basque Country, Gerona, Granada, Mallorca, Murcia, Navarre, the Registers of Childhood Tumours of the Valencian Community, Tarragona and Zaragoza, and the National Register of Childhood Tumours.*

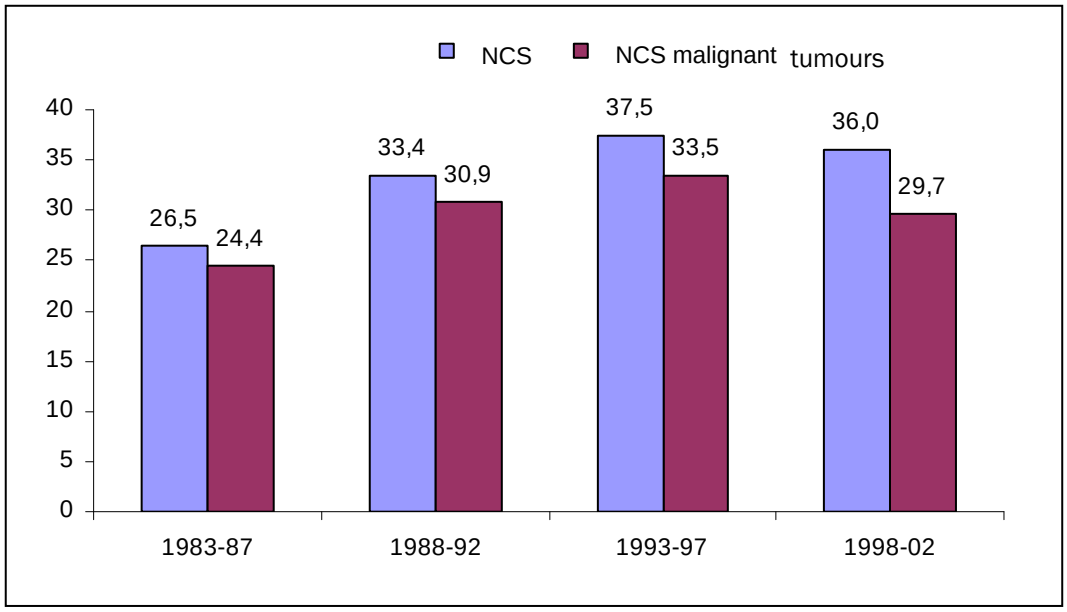

Figure 1. Incidence of CNS tumours in Spain (standardised for world population), 1983-2002

However, the Bayesian joinpoint analysis shows a change in the trend in the first half of the 1990s, both for all *CNS* tumours, where the change point would be centred on 1993, and for malignant tumours only, where the change point would centre on 1994. In both groups, the average annual change before the change point is positive and statistically significant, while after this point the statistical significance is lost. The increase in the incidence of *CNS* tumours is thus confined to the earlier part of the period and is not seen after the early 1990s.

The findings of current studies in other countries agree with these results. A recent study in the US, using data from the *SEER* programme, shows no significant trend in the incidence of childhood *CNS* tumours after 1992 [Linabery-2008]; the results of an analysis of *CNS* tumours (all ages) in England in 1979-2003 indicate the same [Arora-2010], as do those of the combined study of Denmark, Finland, Norway and Sweden for the period *1974-2003*, in subjects aged *20* to *79* [Deltour-2009].

The changing incidence of *CNS* tumours may be explained by the wider use of new diagnostic neuro-imaging technology, leading to an increase in the incidence observed (and recorded), followed by a saturation stage in which the level stabilises [Linet-1999], [Smith-1998]. In the case of Spain, in spite of the scope of the study, which includes the equivalent of a third of the child population, one must be very cautious when extrapolating the results to the whole country. Prolonged monitoring and a detailed study of the different groups included in the *CNS* tumour study (now in progress) are necessary.

A reliable interpretation of this information must take account of variations in the tumour registries (national and international) when applying criteria for the inclusion of different tumours. Some

registries only include malignant tumours, others include all types and others record malignant and doubtful cases but not benign. Since 1998 it has been recommended that benign *CNS* tumours should also be recorded and the specialised registries for children were among the first to apply this criterion.

Calculations of the numbers of *benign tumours* (*meningioma* and *acoustic neurinoma)* can be seriously affected by the restrictive and exclusive criteria applied by some registries. In the light of their interest for epidemiological and healthcare studies CCARS recommends that this type of tumour should be included in the criteria for registration.

3.3.2 INTERPHONE study.

On 17 May 2010 the *INTERPHONE* Study Group and the World Health Organization's International Agency for Research on Cancer (*IARC)* published the long-awaited final results of the *INTERPHONE* study on the risk of brain tumours and the use of mobile phones [INTERPHONE-2010], [INTERPHONE-IARC-2010].

In 1988-89 the *IARC* proposed that a study should be carried out and this began in 2000, with the aim of assessing the relationship between mobile phones and the risk of suffering from 4 types of tumour: brain tumours (*gliomas* and *meningiomas*), tumours of the acoustic nerve (*neurinoma* or *schwannoma*) and tumours of the parotid gland, i.e. those affecting the tissues that could absorb most energy in view of their proximity to the mobile phone when the user is speaking.

The object of the study was to determine whether the use of mobile phones increased the risk of developing these tumours and, in particular, whether the radio frequency radiation energy emitted by mobile phones has carcinogenic potential.

It should be remembered that at present the etiology of brain tumours is not known [Ohgaki-2009]. We know that some cases of *gliomas* have been associated with hereditary syndromes, certain occupations, environmental carcinogens, and diet (N-nitrous compounds), but the only factor which is undeniably associated with increased risk of glioma is exposure to radiotherapy. Children treated with radiotherapy for lymphoblastic leukaemia run a significant risk of developing a glioma. Finally, a significant correlation has been observed between certain types of damage to genes and enzymes, leading to *DNA* damage, which facilitates the development of *glioma*s.

3.3.2.1 Methodology

The *INTERPHONE* study is a case-control epidemiological study in which 13 countries have participated (Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden and the United Kingdom). It is the most extensive study undertaken to date. A case-control methodology has been used, based on the combined analysis of 2,708 cases of glioma and 2,409 cases of meningioma, with the corresponding control groups in the 13 countries participating.

The results presented in the published article do not include those for acoustic tumours and those of the parotid gland, as these will be dealt with in future papers.

To maximise its statistical validity, the study focused on tumours in people aged 30-59 living in urban areas, it being supposed that this group would have used mobile phones extensively in the 5 to 10 years prior to the study.

The compilation of information about exposure, the selection of cases and controls, the statistical

methods and the sensitivity analysis (bias detection) can be considered satisfactory, the bias inherent in this type of design being analysed and recognised by the authors.

3.3.2.2 Results of the study

The main conclusion is that it has not been observed that the use of the phone for ten years or more after its first use poses a greater risk of developing *gliomas* or *meningiomas*.

Overall, individuals with *gliomas* and *meningiomas* used mobile phones less than the control group. According to the authors, this lower level of risk may be due to *bias* related to participation and other methodological limitations.

According to the *WHO* *"There are certain indications of increased risk of glioma in individuals whose cumulative use of mobile phones is in the top 10%*. However, there is no uniform tendency for the risk to increase with more prolonged use* [WHO-2010]. The researchers concluded that the bias and errors limit the validity of these conclusions and do not allow a causal connection to be made.

The long-awaited results had aroused great expectation in all the parties involved in the assessment and management of risk related to the *RF* electromagnetic fields used in mobile telephony. As was to be expected, and *CCARS* expressed this view in a previous document on changes in rates of brain tumours in various Scandinavian countries, the results do not provide a definitive answer to the question but they allow us to clarify a number of doubtful points [CCARS-Nórdico-2010].

To reach definitive conclusions we need to continue advancing in our knowledge of cause and effect and this calls for a large number of studies (experimental, *in vivo*, *in vitro*, clinical and epidemiological). An epidemiological study, even on the scale of the *INTERPHONE* project, is not sufficient to answer all the questions posed by science. We need to remember that all the agencies and institutions responsible coincide in pointing out the need to continue doing research into the long-term effects of exposure to mobile telephony, especially bearing in mind the constant advances in technology. The extensive periods during which these tumours may be latent and the exposure of a very young sector of the population call for rigorous epidemiological studies, preferably *cohort studies*, which allow us to draw conclusions based on a more exact assessment of real exposure times. Case-control studies such as the *INTERPHONE* project have methodological limitations which prevent us drawing definitive conclusions.

3.3.2.3 Conclusions

The authors of the *INTERPHONE* report conclude that, overall, no increase in the risk of *gliomas* or *meningiomas* due to the use of mobile phones has been observed. There are some indications of an increased risk of *gliomas* in the group with the highest level of exposure (use of mobile phone) but the *bias* of the study and its methodological errors make it impossible to establish a causal relationship. The long-term risk affecting individuals who report very extensive use requires deeper research.

* *This refers to individuals using mobile telephony for a total of 1,640 hours or more over a period of 10 years or longer. However, the authors do not consider these figures for use to be fully realistic or plausible in view of the likely distortions in recollection of real exposure.*

In this connection Dr. Christopher Wild, Director of *IARC* has declared that *"from the data gathered in the Interphone study it has not been possible to establish an increase in the risk of brain tumours. However, the results observed in the group with the highest levels of exposure (greater cumulative call time) and changing patterns of use since the Interphone project started, especially in young people, justify the need to continue doing research into mobile phones and the risk of brain tumours".*

It is clear that new patterns of mobile phone use in the last 5 or 6 years, especially among younger people, help to reduce the exposure of the head, thanks to the introduction of new, more efficient technologies, the use of *SMS,* communication via computers, the internet, hands free systems, etc.

CCARS agrees with the need to support the studies which are currently in progress [Mobi-Kids] to determine the risks of brain tumours related to the use of mobile telephony during childhood and adolescence.

3.4 Summary of international scientific studies and reviews

3.4.1 SCENIHR

The *European Union Scientific Committee on Emerging and Newly Identified Health Risks, SCENIHR*, is one of the three independent scientific committees advising the European Commission. Its reports serve to establish the European Commission's proposals and policies on public health.

One of the topics this committee deals with is assessment of the risks from radio frequency electromagnetic fields, medium frequency, low frequency and static fields.

The aim of the 2009 report [SCENIHR-2009] was to update the opinions in the *SCENIHR* report issued on *21* March *2007* [SCENIHR-2007]. The Committee has reviewed the new studies published since 2007.

The Committee's opinion regarding radio frequencies is as follows:

From a study of the evidence (epidemiological, studies *in vitro* and in animals) it can be deduced that exposure to radio frequency fields is unlikely to cause an increase in cancer in humans. The report points out, however, that the period of exposure to mobile telephony is shorter than the induction time for some tumours. More long-term studies (over 10 years' exposure) are needed to determine whether there is any risk.

It should be remembered that the tumours that have been associated with exposure to mobile telephony are brain tumours, which may have a *long latency period.*

With regard to other non-carcinogenic effects on health, some studies have been made of individuals who experience subjective symptoms. From an analysis of their overall findings we would conclude that the scientific studies published do not support the existence of a relationship between exposure and subjective symptoms. They rule out the possibility that anyone, even individuals who claim to suffer from *electromagnetic hypersensitivity*, is able to detect when they are exposed to electromagnetic fields and when they are not.

What has been observed is a *nocebo effect*, defined as an unspecified adverse effect caused by the expectation or belief that something (in this case *EMF*) is harmful for health. This *nocebo effect* may account for the appearance of symptoms associated with exposure to mobile telephony.

There is some evidence that exposure to *RF* electromagnetic fields can affect sleep and electroencephalograph readings but their relevance to health is uncertain and there is no explanation for the changed mechanism. More studies are needed for us to have a deeper understanding of these effects.

Other studies dealing with different aspects of the nervous system (brain functions: cognitive, memory, sensory, structural stability and cellular response) have not detected any effects or those observed have not been consistent. Recent studies of exposure to *RF* electromagnetic fields and their effects on reproduction and development have not found any effects on human health.

From the point of view of assessing risk, it is recognised that the information concerning the effects of RF electromagnetic fields in children is insufficient.

In July 2009 *SCENIHR* also published a document entitled *"Research needs and methodology to address the remaining knowledge gaps on the potential health effects of EMF"* [SCENIHR-2009b], in which the following research priorities are put forward:

- The study of the association between brain tumours and the use of mobile phones over periods exceeding 10 years.

- Prospective long-term cohort study to determine whether there is a connection between brain tumours and the use of mobile telephony for periods longer than 10 years.

- Assessment of individuals' total exposure to radio frequencies. This study calls for the selection of groups of subjects who can wear individual dosimeters for a certain time.

- Replicate or enlarge on experimental studies to confirm or disprove the results obtained in some of the studies on genotoxicity and effects on the nervous system (sleep and electroencephalograph results).

3.4.2 ICNIRP

The *International Commission on Non-Ionizing Radiation Protection* (*ICNIRP*) has conducted an exhaustive review of the scientific bibliography dealing with the biological and health effects of *EMF*. Its general conclusions coincide with those reported by other international organisations [ICNIRP-2009].

The *ICNIRP* Epidemiology Committee has reviewed the epidemiological evidence for the risk of brain tumours and the use of mobile phones [Ahlbom-2009]. The conclusions of this exhaustive study are as follows: The studies published to date do not demonstrate an increase in the risk of brain tumours when mobile phones are used for approximately 10 years. Although some methodological problems persist, the available data does not suggest a causal relationship between the use of mobile phones and rapidly developing tumours such as *glioma*, a tumour which is latent for a relatively short time, in adults. Concerning slowly developing tumours, such as *meningioma* and acoustic *neurinoma*, and glioma in long-term users, the absence of a connection so far is less conclusive, as the period of observation is too short as yet and monitoring needs to be continued for some years. At present there is no data on the carcinogenic potential of exposure to mobile telephony during childhood and adolescence.

3.4.3 AFSSET

In October 2009 *AFSSET* published a new report which updated the scientific information on the effects of radio frequencies [AFSSET-2009].

The methodology used was a review of the scientific bibliography, complemented by numerous meetings with leading figures in the world of science, experts and associations. Over 1,000 works were reviewed, published between the appearance of the previous report in 2005 and April 2009, dealing with the range of frequencies above *400 MHz*. Of the publications assessed, 226 dealt with issues related to mobile telephony. Other international reports were also taken into account, such as those issued by *SCENIHR* in 2007 [SCENIHR 2007] and 2009 [SCENIHR 2009] and the UK's *Mobile Telecommunications and Health Research Programme* (*MTHR*) in 2007 [MTHR-2007], among others.

Regarding the clinical and epidemiological studies analysed *AFSSET* came to the following conclusions:

- The epidemiological studies available do not suggest any short-term effects of mobile telephony, although there are still doubts about its possible long-term effects.
- Concerning people who complain of symptoms which they attribute to exposure to radio frequencies (*electromagnetic hypersensitivity*), it has not been possible to identify any physiopathological mechanism to explain the relationship with radio frequencies.

Regarding measurement of exposure to radio frequencies:

- Exposure during childhood to radio frequencies and their possible effects have not been adequately described.
- Exposure to *RF* electromagnetic fields emitted when mobile phones are being used is greater than exposure to base station (antenna) emissions.
- Mobile telephony antennae do not emit low frequency electromagnetic fields.
- The newly developed information technologies which use radio frequencies do not cause exposure of a different type or intensity from the sources mentioned previously.

We may summarise the findings of the *AFSSET* review by stating that its main recommendations coincide with those of other international agencies, committees and organisations which have carried out similar studies.

It confirms the priorities for research into *RF* already established by other organisations, which include the following:

- Evaluating long-term effects.
- Monitoring the quality of experimental studies.
- Replicating studies.
- Improving dosimetry to measure real exposure more effectively (measurement procedures, individual metering, surveillance programme, etc.), especially during childhood.

The *AFSSET* proposal to establish a surveillance programme has been implemented in Spain since the enactment of Royal Decree 1066/2001 [RD 1066-2001]. Information about emissions from base stations (antennae) is freely accessible to the public without charge. The Spanish system for controlling people's exposure to emissions is one of the most rigorous and preventive in Europe and what constitutes a legal obligation in this country is rarely an obligation in others.

It is interesting to note that *AFSSET* warns of the need to assess carefully the consequences of reducing the power of emissions from base stations, both for the general public and for mobile phone users. A reduction in limits could lead to an increase in head exposure to mobile phones, as they would

have to be more powerful to capture the signal. This recommendation is significant for evaluating the demands in some quarters for a reduction in present levels or for antennae to be positioned further from towns.

One recommendation which has had considerable impact in the media is to reduce the exposure of children by encouraging moderation in the use of mobile phones. This proposal is based on our limited knowledge of the long-term effects of exposure during childhood to *RF* from mobile telephony. This cautionary approach has been applied in France, where the Senate discussed a ban on the use of mobile phones in infant and primary schools, as part of a law on national commitment to the environment. Children are not banned from having mobile phones but they are not allowed to use them in class time.

Exposure to *RF* electromagnetic fields emitted by mobile phones is greater than exposure to base station emissions. This evidence does not coincide with the public's perception of the risk.

Following an analysis of the results of studies on non-thermal effects, it is considered that there is no point in proposing new limits to exposure based on the hypothetical effects of exposure to lower levels than at present.

3.4.4 World Health Organization (WHO)

As part of its work assessing risk from electromagnetic fields (through the *EMF-NET International Project* [EMF-NET]), the *WHO* has updated its position regarding the effects of *EMF* from mobile phones on public health [WHO 2010].

It reports that the main short-term consequence of the interaction between radio-electric energy and the human body is the heating of tissues. In the case of the frequencies used by mobile phones, most of the energy is absorbed by the skin and other surface tissues, so that the increase in temperature in the brain and other organs is insignificant.

Various studies have investigated the effects of radio frequency fields on electrical activity in the brain, the cognitive function, sleep, cardiac rhythm and arterial pressure in volunteers. To date these studies seem to indicate that there is no reliable evidence that exposure to radio frequency fields which are less intense than those that cause tissue heating has any harmful effect on health. It has also been impossible to demonstrate a causal relationship between exposure to electromagnetic fields and certain symptoms reported by patients, a phenomenon known as *electromagnetic hypersensitivity.*

Regarding the long-term effects the *WHO* points out that: "*Epidemiological research examining potential long-term risks from radio frequency exposure has mostly looked for an association between brain tumours and mobile phone use. However, because many cancers are not detectable until many years after the interactions that led to the tumour, and since mobile phones were not widely used until the early 1990s, epidemiological studies at present can only assess those cancers that become evident within shorter time periods. However, results of animal studies consistently show no increased cancer risk for long-term exposure to radio frequency fields.*"

Extensive *studies of cohorts* have been carried out and are being carried out now. One is the *Cohort Study of Mobile Phone Use and Health* [COSMOS] with the participation of many countries, as part of which case studies have been conducted with controls and prospective studies of cohorts, designed to analyse a series of health variables in

the adult population. To date the results of these epidemiological studies have not provided homogeneous or convincing data showing a causal relationship between exposure to radio frequencies and harmful effects on health. However, the studies suffer from too many limitations for this possibility to be completely ruled out, especially in the case of heavy, long-term use.

"While an increased risk of brain tumours is not established from INTERPHONE data, the increasing use of mobile phones and the lack of data for mobile phone use over time periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. In particular, with the recent popularity of mobile phone use among younger people, and therefore a potentially longer lifetime of exposure, WHO has promoted further research on this group. Several studies investigating potential health effects in children and adolescents are underway."

3.4.5 French National Academy of Medicine, Academy of Sciences and Academy of Technologies

On 17 December 2009 the three academies published a joint review of the report on radio frequencies published by *AFSSET* in October. The report by the academies is entitled: *"Réduire l'exposition aux ondes des antennes-relais n'est pas justifié scientifiquement" (There is no Scientific Justification for Reducing Exposure to Waves from Telephony Antennae)* [AcadFranc-2009].

The analysis carried out by these institutions is very critical of the press release by *AFSSET* announcing the publication of its technical report [AFSSET-2009-Press release]. It seems clear that *AFSSET* exaggerated the results of the study to justify a possible reduction in exposure to *RF*. The press release drew attention to 11 studies which reported biological effects to justify a reduction in exposure.

The warning signs referred to do not correspond to the conclusions of the final report and contradict the recommendations of the *AFSSET* experts.

- The measures to reduce exposure referred to in the press release probably correspond to a political initiative for the management of risk, as the *AFSSET* report states that most studies have not observed biological effects and the few detected have not been replicated.

- There are no scientific reasons to justify a reduction in the present limits on exposure to electromagnetic waves from mobile telephony.

- Once again it has been shown that the most effective method for reducing current levels of exposure is to increase the number of antennae and their coverage.

- The conclusions of the *WHO*, *ICNIRP*, *SCENIHR*, *the French Academy of Medicine,* and other organisations responsible for risk assessment are confirmed.

- Certain biological effects which had been associated with exposure to *RF* electromagnetic fields were not confirmed (they do not generate *free radicals*, they are not *genotoxic* or *mutagenic*, they are not carcinogenic and do not have other non-thermal effects).

- There is no evidence at present that regular use of mobile telephony increases the risk of brain tumours via a *mechanism of promotion.*

- It has not been demonstrated that *electromagnetic hypersensitivity* is caused by electromagnetic waves.

- The *AFSSET* report confirms that people's exposure to mobile telephony antennae does not constitute a health hazard for those living near them.

Lastly the academies point out that an ill-thought out reduction in exposure could have the opposite effect on most users.

In this country we find examples of similar thinking in some cases, where, on the grounds of reducing exposure, antennae have been rejected, leading to a loss of coverage, an increase in the power of other nearby antennae and an increase in the operating power of mobile phones, increasing exposure in the head unnecessarily.

3.5 Mobile telephony antennae

Epidemiological studies of the effects of base station emissions suffer from numerous methodological shortcomings, due, among other reasons, to the difficulty of assessing real exposure.

The studies usually quoted [Wolf-2004], [Eger-2004] and [Oberfelf-2008] on the hypothetical risks of antennae are difficult to interpret, because of the few cases studied and biases in selection and participation (individuals affected and *nocebo effect*). In these studies errors can be detected in the exaggeration of the risk because of the choice of areas to be studied, time-frames and demographic variables, estimates of exposure according to distances from antennae, subjective questionnaires, errors in identifiers, the non-existence of objective measurements, failure to identify other sources of exposure (radio, TV, *DECT* systems, domestic electric appliances, computers, etc.) and biases in publication. As a result, these studies are not really informative because of methodological inconsistencies which invalidate any relevant conclusions.

Recently a study was published on mobile telephony antennae and cancer in children. The aim of the study was to determine whether pregnant women who live near an antenna run a greater risk of having children who suffer from cancer [Elliot-2010]. The study involved 1,397 cases of cancer (children aged 0 to 4 years) and 5,588 controls. *CNS cancers, leukaemia, non-Hodgkin lymphoma*s and all combined types of cancer were studied, with adjustments for level of education, economic situation, population density and and other socio-demographic factors. Information was compiled for 81,781 antennae over the period 1 January 1996 to 31 December 2001. The study concluded that there is no connection between the exposure of pregnant women to mobile telephony antennae and greater risk of tumours in their children.

A Japanese study has examined the possible short-term effects of *W-CDMA* (*UMTS*) antennae in women who presented mobile phone related symptoms (*MPRS)* [Furubayashi-2009]. This was a *double-blind* provocation case-control study, designed to confirm whether subjects who claim to experience symptoms related to the use of mobile phones are more susceptible than the control subjects to the effects of EMF emitted by base stations (frequency $2.14\,GHz$, intensity of field $10\,V/m$, *W-CDMA-UMTS*). 11 cases were selected with 43 controls. The conditions of exposure (all lasting 30 minutes) were of 4 types: continuous, intermittent, simulated with noise, and simulated without noise in a shielded room which simulated the exposure of the whole body to a mobile telephony antenna. The power of the emissions was greater than the usual levels used by antennae. Various psychological and cognitive parameters were measured before and after exposure and the functions of the autonomic

nervous system (surface skin temperature, heartbeat and local blood flow) were also recorded. The participants were asked about their perception of electromagnetic fields and level of discomfort during the experiment. The results showed that the group with *MPRS* were no different from the control group in their ability to detect whether they were exposed to electromagnetic fields. However, they experienced more discomfort independently of whether they were exposed to *EMF*, although there were no changes in the functions of their autonomic nervous systems.

There was, therefore, no difference in the psychological, cognitive and autonomic responses of the two groups to real or simulated exposure. The conclusion of this interesting study is that the authors did not find evidence of any causal relationship between hypersensitivity symptoms and exposure to *EMF* from mobile telephony antennae.

A controlled clinical study examined *electromagnetic hypersensitivity* to the radio frequencies emitted by mobile telephony systems using *CDMA* technology [Nam-2009]. Two groups of volunteers consisting of 18 individuals who claimed to be hypersensitive and 19 who did not were subjected to real and simulated exposure to *CDMA* mobile phone radio frequencies with a maximum power of $300\,mW$ for half an hour. The study considered physiological parameters such as heart and breathing rate, cardiac variability rate, subjective symptoms, and perception of electromagnetic fields. The conclusion was that exposure to *RF* had no effect on the physiological parameters or the subjective symptoms in either group. There was no evidence that the hypersensitive group perceived electromagnetic fields better than the group not claiming to be hypersensitive. These results are in line with those of other similar studies.

Another study was aimed at evaluating the hypothesis that continued exposure to low levels of *RF* electromagnetic fields emitted by base stations was related to various health issues [Berg-Beckhoff-2009]. A questionnaire was given to 3,526 people, who reported the extent to which base stations affected their health and dosimeters were used to assess the real level of exposure to the antennae. The conclusion of the study is that the *RF* electromagnetic fields emitted by base stations were not linked to adverse effects on health.

The aim of another study was to clarify whether short periods of exposure (50 minutes at $10\,{}^{mW}\!/_{m^2}$) to signals from *GSM* and *UMTS* antennae affected attention, memory, and other physiological functions in 44 hypersensitive subjects and 44 controls [Eltiti-2009]. Test exposure to *RF* was *double-blind* type with real and simulated exposure. The result of this clinical study was that cognitive functions were not affected by exposure to *GSM* or *UMTS* frequencies. Exposure did not alter the arterial pulse rate, heartbeat or skin conductivity, these being measured while the participants were undergoing the tests.

A systematic review by Rubin et *al.* on *Idiopathic environmental intolerance attributed to electromagnetic fields (IEI, formerly electromagnetic hypersensitivity)* analysed *46 blind* and *double-blind* provocation studies involving 1,175 volunteers, who were examined to determine whether exposure to electromagnetic fields was responsible for the appearance of *IEI* symptoms [Rubin-2010]. This exhaustive review concludes that no solid evidence to support this theory has been observed. However, the studies analysed support the role of the *nocebo effect* in the appearance of acute symptoms in such hypersensitive subjects. Although the subjects are convinced that these symptoms are due to exposure to *EMF*, the repeated experiments carried out to

date have not been able to replicate this phenomenon under controlled conditions.

3.6 Declaration by the Scandinavian Authorities

The Scandinavian authorities agree that there is no scientific evidence of adverse effects on health caused by radio frequency fields of an intensity found in normal living conditions today [Nordic-Auth-2009]. This conclusion is in line with the opinion of international scientific and advisory organisations such as the *International Commission on Non-Ionizing Radiation Protection* (*ICNIRP*) [ICNIRP-1998] and [ICNIRP-2009]; the *World Health Organisation* (*WHO*) [WHO-2006] and [WHO-2010]; the *European Union Scientific Committee on Emerging and Newly Identified Health Risks* (*SCENIHR*) [SCENIHR-2009]; the *Swedish Radiation Protection Institute* (*SSI*) [SSI-2008]. At present, therefore, the authorities in the Scandinavian countries do not see any need for a common recommendation to adopt new measures to reduce these RF fields.

It is important to remember, nevertheless, that many of the technologies using radio frequency electromagnetic fields have been in use for less than two decades. It is thus important to continue active research into the possible effects on health of *RF* radiation and review the scientific literature on the subject.

It is also important to monitor the development of exposure to different sources and the possible consequences for health of this exposure.

The authorities in the Scandinavian countries emphasise the fact that, to reduce the public's total exposure to wireless communication systems, integrated planning is needed, taking into account both the radiation from fixed antennae and that from mobile phones. In terms of the general public's overall exposure, mobile phones are a stronger source of radiation than fixed antennae.

If the number of fixed antennae is reduced, mobile phones will have to use more power to maintain their connection, which may mean an increase in the general public's exposure to radiation.

This evidence coincides with the opinion expressed by *AFSSET* [AFSSET-2009] and the French Academies of Medicine, Science and Technologies regarding the need for the location of new antennae to be planned so that the base stations provide good coverage, allowing overall exposure to be lower [AcadFranc-2009].

3.7 Final comments

As a final summary of the evidence published to date, we may formulate the following conclusions:

- Present evidence from clinical and epidemiological studies indicates that there is no causal relationship between exposure to the radio frequencies used in mobile telephony and adverse effects on health.

- There are still problems regarding the accuracy of estimates of exposure to carry out reliable, consistent and comparable studies.

- Controlled studies of individuals who describe themselves as hypersensitive to the radio frequency electromagnetic fields associated with mobile telephony (generated by phones and antennae) have shown that there is no causal relationship between the symptoms they report and their exposure to this type of radio frequency radiation.

- A comprehensive interpretation of the results of the epidemiological studies on brain tumours and the use of mobile phones published to date does not

show an increase in the risk of developing brain tumours over a period of use lasting 10 years.

- Some studies have observed a slight increase in the risk of developing tumours among mobile phone users when the number of hours' use is very high. - The errors and bias detected in these studies make it impossible to establish causal relationships.

- If there was any effect caused by massive exposure to mobile telephony, this should be reflected in the incidence of tumours. These changes have not been observed in the studies carried out in a number of countries.

- The short periods of exposure to mobile telephony and the long periods for which brain tumours may be latent make it advisable to continue long-term studies on its effects.

4. Sources of radio frequency emissions and exposure

Radio frequency electromagnetic waves are non-ionising radiation (they have insufficient energy to ionise atoms) whose frequencies range from *30 kHz* to *300 GHz* .

The values used to describe exposure to waves of this type, such as *frequency* (*f*), *electric field* (*E*), *magnetic field* (*H*), *power density* (S) and *specific absorption rate* (*SAR*), vary depending on the type of source and the medium through which the waves are propagated. Radio frequencies are produced by the new communications technologies, such as mobile telephony base stations (*GSM*, *UMTS*), radio antennae (*AM* and *FM*), civil and military radar, etc. which operate at a considerable distance from the human body. In addition to these there are sources of radio frequencies which operate near the body, such as mobile phones, Wi-Fi and Bluetooth devices, DECT cordless phones, etc.

4.1 Levels of exposure to radio frequencies

For frequencies between *100 kHz* and *10 GHz* , the band which includes mobile communications antennae and terminals, the *SAR* must be limited to prevent heat fatigue of the body and local tissue overheating. Calculated locally, this means that the limit of $2\,{}^{W}\!/_{kg}$, averaged for *10 gr.* of tissue must not be exceeded, as specified in the Recommendation of The European Union Council issued on 12 July 1999 [EU-1999]. This *basic restriction* for *SAR* was formulated using a safety factor of 50, compared with proven harmful effects.

However, although in near-body exposure, as in the case of mobile phones, SAR is the factor which must be assessed, in exposure to more distant sources, such as mobile telephony antennae, the values which must not be exceeded according to the Recommendation are the so-called *reference values*. The *reference values* place limits on the magnitude of *electric field* (*E*), *magnetic field* (*H*) and *power density* (S). The levels for these magnitudes depend on the *frequency* (*f*) considered and are shown in Table I.

These *reference values* are derived from the *SAR* for worst case exposure. If the reference values are verified the basic *SAR* restrictions are applicable. In certain cases the *SAR* may be verified when the reference values are not reached.

Table I. Reference values for electric, magnetic and electromagnetic fields (0Hz-300GHz, RMS values undisturbed)

Frequency range (f)	Intensity of field E (V/m)	Intensity of field H (A/m)	Field B (μT)	Equivalent flat wave power density S (W/m^2)
0.1 Hz	------	3.2×10^4	4×10^4	------
1 - 8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	------
8 - 25 Hz	10,000	4,000/f	5,000/f	------
0.025 - 0.8 kHz	250/f	4/f	5/f	------
0.8 - 3 kHz	250/f	5	6.25	------
3 - 150 kHz	87	5	6.25	------
0.15 - 1 MHz	87	0.73/f	0.92/f	------
1 - 10 MHz	87/ f½	0.73/f	0.92/f	------
10 - 400 MHz	28	0.073	0.092	2
400 - 2,000 MHz	1.375/ f½	0.0037f½	0.0046/ f½	f/200
2-300 GHz	61	0.16	0.20	10

4.2 Europe: Exposure to different sources

According to reports such as that by the French *Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail* (*AFSSET*) in October 2009, see [AFSSET-2009], and the latest report by the *European Union Scientific Committee on Emerging and Newly Identified Health Risks*, (*SCENIHR*) in January 2009, see [SCENIHR-2009], exposure to radio frequencies from sources at a distance from the human body come mainly from mobile telephony antennae (*GSM*, *UMTS*), and these are the ones causing people most concern. In the case of *GSM*, the levels of exposure measured in flat wave equivalent power density range from hundreds of nW/m^2 to a few dozen mW/m^2 (*), the regulation limit being set at $4.5 W/m^2$ for a frequency of $900\,MHz$ (Table I). In the case of *UMTS*, the values range from nW/m^2 to $1\ mW/m^2$, well below $9.5 W/m^2$, the power density allowed for these frequencies.

For sources affecting the human body, such as mobile phones, *DECT*, *Wi-Fi* and *Bluetooth* devices, studies have shown that the greatest exposure is due to mobile phones, whose *SAR* ranges from *0.2* to $1.5 W/kg$, although this latter figure would only occur under special circumstances with the system operating at full power. In any case, the values obtained are below the limit of $2 W/kg$, averaged for *10 gr.* of head tissue, established in legislation.

It should be remembered that mobile telephony, in normal conditions, operates at lower power levels, which may be as little as 100,000 times less than the maximum allowed. This is the case when we consider optimum reception conditions with an optimised antenna system.

Recently there has been growing concern about exposure to radiation from *Wi-Fi* devices but exposure to these is less than that from mobile phones and would only be similar to it if the *Wi-Fi* antenna were nearby, which is not likely. Exposure to these devices and to *DECT*, *Bluetooth*, etc. cordless phones falls rapidly as the distance from the source of emissions increases, and averaged *SAR* in normal conditions of use is less than $0.6 W/kg$. In 2009 the *British Health Protection Agency* (*HPA*) issued a report which states that emissions from *Wi-Fi* devices, the power of whose emissions is less than $100mW$, do not affect health and nor do other radio frequency signals which are somewhat stronger, such as those from mobile phones [HPA-WIFI-2009].

4.3 Spain: Levels of public exposure to radio emissions from radio communications base stations

Article 9 of Royal Decree 1066/2001 of 28 September [RD1066-2001], approving the regulations which establish health protection measures against radio electric emissions, stipulates that the technical services of the Ministry of Industry, Tourism and Trade will draw up inspection plans to ensure that facilities such as mobile telephony base stations comply with the regulations.

(*) $1\,nW = 10^{-9}\ W = 0.000000001\ W$

$1\ mW = 10^{-3}\ W = 0.001\ W$

The latest report, published by the Ministry in 2010 [MICyT-2009], describing measures taken in 2009, describes and analyses the results of the inspections and other work carried out by the Directorate General of Telecommunications to determine the state of the radio-electric facilities of telecommunications operators in Spain and the technical certifications issued by technical staff in 2009.

It states that *"all the measurements carried out in Spain have returned radio-electric exposure values well below those indicated in Royal Decree 1066/2001, the official limit which ensures that there is no danger to human health"*. The report also indicates that the highest average provincial value measured is $5.010\ \mu W/cm^2$, at $900\ MHz$, well below the reference value of $450\ \mu W/cm^2$ established in the Royal Decree for this frequency (*).

These measurements have been made according to the specifications of Royal Decree1066/2001 and the stipulations of ministerial order CTE/23/2002 of 11 January, which establishes conditions for the presentation of certain studies and certifications by radio communication service operators [ORDER CTE/23/2002].

All the information regarding emissions from different mobile telephony base stations can be seen on the *MITyC* website, (http://www.mityc.es/telecomunicaciones/Espectro/NivelesExposicion/Paginas/niveles.aspx), which can be accessed free by the public.

4.3.1 Measurements in sensitive areas

Sensitive places and areas are defined as those in which, by their very nature, it is considered that there is a greater perception of risk from exposure to electromagnetic fields, and where levels of exposure need to be minimised, in accordance with Article 8.7 of the regulations set out in Royal Decree 1066/2001. These places include crèches, infants' schools, health centres, hospitals and parks.

The first action taken during the 2009 round of inspections, as indicated in the report, involved sensitive areas. The experience of previous years and the results obtained served as the basis for identifying sensitive areas, a total of 3,818 being classified as such.

The Ministry's 2009 report reveals that the total of sensitive sites has not changed from the 3,818 previously recognised, as the new facilities constructed by operators, mainly third generation UMTS automatic mobile phone base stations have been sited preferably near those already existing for *GSM-900*, *GSM-1800 and DCS 1800 systems.*

The breakdown of measurements by province and Autonomous Region in the 149 sensitive sites examined, situated within an approximate 100 metre radius from a mobile phone base station, can be seen in Appendix I of the Ministry's report. This appendix also records the distribution by teaching centres, healthcare centres, hospitals and parks, as required by the regulations.

(*) $1\ \mu W/cm^2 = 0.01\ W/m^2$

4.3.1.1 Analysis of levels of exposure in sensitive sites

The inspection services of the Directorate General of Telecommunications in different provinces have been responsible for measuring field intensity and power density, as required in the protocol set out in Ministerial Order CTE/23/2002 [ORDER CTE/23/2002].

According to the 2009 report, average levels of radio-electric exposure in the Autonomous Regions ranges from a maximum of $2.212\ \mu W/cm^2$ in Madrid (a small drop of *18,97 %* from the maximum recorded in Madrid the previous year) to a minimum of $0.007\ \mu W/cm^2$ in Ceuta (a decrease of *66.7 %* from the minimum recorded the previous year in Navarre), the national average for 2009 being $0.462\ \mu W/cm^2$, *11.7 %* less than the average level for 2008.

It should be remembered that the reference level is $450\ \mu W/cm^2$ for a frequency of $900\ MHz$. It can be seen that the results obtained are well below the reference values, clearly a positive indication.

The conclusion we may draw from the data presented and analysed in the Ministry report is that, in the sensitive areas identified, levels of exposure to radio-electric radiation is well within the reference levels established by current legislation.

4.4 Audits of annual certification

As part of the annual inspection plans, audits are conducted of the certifications presented by mobile phone operators, their purpose being to verify *in situ* the validity of the information provided.

In the Ministry of Industry, Tourism and Commerce's report on work done in 2009, 54,119 cases were analysed, including the certification provided by the operators. With such a high volume of facilities analysed, this is probably one of the fullest studies in Europe.

The maximum value measured during auditing was $29.41\ \mu W/cm^2$ at a *UMTS* station in the Andalusian Autonomous Community, while the minimum found was below the threshold level of the measuring equipment used.

Considering that the reference value for the frequency $1800\ MHz$ at the *UMTS* station is $1000\ \mu W/cm^2$, we may conclude that the levels of emission measured remain below the reference values.

Measurements were made of levels of exposure for each station in each province and these are shown in Appendix II of the Ministry's report [MICyT-2009].

4.5 New considerations in dosimetry

If we bear in mind the considerations of the *SCENIHR* report issued in January 2009, see [SCENIHR-2009], and the opinion of *SCENIHR* expressed later in July 2009, see [SCENIHR-2009b], we can see that there is still concern over the vulnerability of children to exposure to RF fields, mainly on the grounds that their nervous system is still developing and could potentially be more susceptible than that of an adult and that they will be exposed for a longer period because of their life expectancy. Regarding the assessment of SAR there is controversy concerning the phantoms used in numerical simulations, to which a satisfactory solution must be found. The reports mentioned point out that it is necessary to evaluate exposure at points distant from the source,

as in the case of antennae, and exposure at close quarters, as in the case of mobile phones, considering different types of use (*SMS*, speech, radio controlled toys, etc.), taking different ages into account. Some reports, such as that by the French *Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail* (*AFSSET*), consider that, as the main source of exposure to *RF* is mobile phones, we should promote the use of mobile phones with the lowest level of *SAR* possible, and draw up a more detailed description of public exposure to all *RF* sources [AFSSET-2009].

Regarding mobile telephony antennae, although some authors are in favour of a reduction in their emissions, according to the joint report by the French academies on mobile telephony, published in December 2009, an ill-thought out reduction in their emissions could lead to greater exposure for users of mobile phones [AcadFranc-2009].

4.6 Regulations on exposure: directives and standards

In Europe, with the aim of guaranteeing protection for people exposed to electromagnetic fields from radio-electric emissions, in accordance with European Recommendation 1999/519/EC [EU-1999], work has continued on standardisation, following European Commission mandates M/132 and M/351, the latter dealing with workers' exposure to such fields. The European standardisation group formed by *CENELEC*, *CEN* and *ETSI*, with the participation of AENOR's AEN/CTN215 committee from Spain, in conjunction with *IEC*, has worked on improving existing standards and formulating new standards dealing with the measurement and calculation of electromagnetic fields from different emission sources and the specific absorption rate in the human body. For the formulation of these standards the presence of different emission sources to which employees may be exposed in real conditions is being taken into account.

In Spain the European standards approved by *CENELEC* are being progressively adopted with the participation of the AEN/CTN215 committee. The Spanish standard corresponding to each European EN standard is referred to as UNE-EN. All this standardisation work is aimed at improving methods for evaluating compliance with the reference values and basic restrictions established in the 1999 Recommendation, [EU-1999], which will contribute to better health protection for the public.

Concerning exposure to EMF in the workplace, which may be considered controlled exposure, Directive 2004/40/EC of the European Parliament and the Council was passed on 24 April 2004, dealing with minimum health and safety provisions regarding the exposure of workers to to risks deriving from physical agents (EMF) [EU-2004] (amended in [EU-2004b] and [EU-2004c]). However, because of the criticism to which the Directive was subjected by various parties, especially Academies of Medicine, concerning its application to staff operating medical equipment which uses electromagnetic fields, its implementation has been postponed until 2012. Meanwhile, in the different Member States, guides are being prepared for the Directive to be applied in different sectors when the time comes.

5. Court decisions on the risks arising from exposure to electromagnetic fields

With regard to the analysis of court decisions on the risks arising from exposure to electromagnetic fields, *CCARS* has published a detailed opinion which can be consulted on the Committee's website, *www.ccars.es*, [CCARS-JUR-2010]. A summary of this document is presented in this section of the report.

For the purposes of this report, now would seem a good moment to highlight the contrasts, we might even say paradoxes, apparent in recent Supreme Court decisions, based on cases which pose the same central question, although from different perspectives: What is the legal position on what we may refer to as "concerns" regarding the risks arising from exposure to electromagnetic fields?

The legal doctrine of "nuisance" is based on the concept of interference with a third party's legal rights, which includes the results of the propagation of harmful or disturbing substances or effects. Past experience and, thus, legal precedents relate to "classical" nuisances such as smell, noise and vibration, or to more "modern" nuisances such as light pollution. These latter include, of course, "electromagnetic pollution". Nuisance, which does not require harmful physical substances to be introduced into neighbouring properties (consider noise), is an interference which can, firstly, be "measured" with scientific instruments or apparatus and, secondly, must exceed limits of "normal tolerability".

Tolerability (for legal purposes) is based on measurements that must, by definition, override the perceptions of the claimant. In other words, for the purposes of peaceful coexistence, the definition of what is tolerable must be determined according to objective bases or criteria. In some, limited, cases, limits can be determined scientifically (medical limits can be prescribed for resistance to noise or the presence of certain substances in the atmosphere, for example). Other judgements can only be formulated, however, on the basis of the average person: not the most daring or the most timorous, not the most tolerant or the most irascible.

There is a range of legal instruments that may apply to any nuisance, including electromagnetic fields. The first is "preventive", whereby the person claiming to suffer from the nuisance can apply to the courts for the "source" of the interference to be removed. Secondly, there is reparation or compensation, when the claimant alleges that he/she has suffered, or is suffering, harm as a result of exposure to a certain electromagnetic field. A third instrument consists of developing legal standards and regulations aimed at establishing the requirements, conditions and limits governing the installation of any type of electromagnetic field generating equipment. Finally, legal challenges may be brought against decisions to authorise, or deny authorisation for, such installations.

There is a real contradiction inherent in this process. It relates to how the First and Third Chambers of the Supreme Court, and on one of the Chambers, the Third itself, interpret and apply the concept of the "state of the science" in order to resolve controversies related to these issues.

The First (or Civil) Chamber of the Supreme Court ruled on 19 February 2010 that the state of the

science supported the decision to disallow a claim for compensation by persons claiming to have suffered harm as a consequence of electromagnetic fields generated by a power transformer station. The court based its ruling on key "scientific criteria" provided in expert evidence, citing the following documents, among others: [EU-1999], [RD 1066-2001], [CIEMAT-1998], [REE-UNESA-2001], [MSC-2001], [RAC-2001], [EU-COM(2000)1].

The Third Chamber is involved in the Judicial review on Administration Issues (a characteristic of the Spanish Judicial System, not easy to translate into English). This Chamber of the Supreme Court ruled on 19 April 2006 on an appeal for reversal brought by an Association against Royal Decree 1066/2001. The appeal was rejected in its entirety. Although it did not use the precise expression *the state of the science*, this was clearly the thinking behind the ruling. Faced with radically different interpretations and theories, all of them apparently "scientific", the Chamber proceeded to treat the question as one of differentiating between a range of opinions. The Third Chamber finally accepted the parameters, criteria and guidelines of the EU Council Recommendation of 12 July 1999 [EU-1999] as representing the state of the science.

The contradiction referred to in this section lies in appeal decisions that have raised the question of the constitutionality (or legality) of municipal regulations on the installation of radio-electric equipment and radio-frequency equipment (in particular, mobile telephony antennae).

In the past there have been rulings rejecting appeals against local regulations that imposed restrictions on the construction of these facilities, based on town and country planning principles.

A change came with a ruling by the Third Chamber of the Supreme Court on 17 November 2009 on an appeal against a Barcelona City Council agreement on the partial modification of a town planning order. A detailed legal analysis of this ruling, which many found puzzling, was given in an article by Prof. Ricardo de Ángel "*Legal rulings on risks arising from exposure to electromagnetic fields*" which can be found on the CCARS website [CCARS-JUR-2010].

One of the most important rulings involving claims for damages is that of the First Chamber of the Supreme Court of 19 February 2010, which established that the state of the science is a key criterion for setting the limits of what is "tolerable" with regard to exposure to electromagnetic fields. The document [CCARS-JUR-2010] on the *CCARS* website contains a detailed analysis of the ruling:

- The Supreme Court ruled on the basis of extensive arguments presented by the parties, including a wide range of scientific opinions.
- The First Chamber did not only consider the *state of the science*, but also distinguished between the various "opinions" put forward during the case, i.e. the Court determined precisely which sources of information it considered defined the *state of the science* regarding the issue under dispute.
- The ruling went even further in, firstly, formulating an interesting reflection on the empirical scientific method, in this case with regard to the proof of harmlessness. Secondly, the Chamber did not ignore the precautionary principle, but rather took it expressly into consideration.
- The Supreme Court ruled on the basis of an *overall assessment* of the scientific evidence placed before it, but it seems clear that the EU Council Recommendation of 12 July 1999 also formed a key part of the basis for the ruling.

Rulings on public authorities' regulatory actions include that of the Third Chamber of the Supreme Court of 19 April 2006, indicating that the state of the science should guide regulatory action and clarifying some points regarding the so-called "precautionary principle".

Regulatory action by public authorities is one of the legal instruments available to protect the public against nuisances. Regulatory action refers to laws in the strictest sense, as well as to regulations and any other type of rule issued by legislative chambers or governments.

When a legal provision is challenged as being unconstitutional or illegal, the courts consider two questions: firstly that of legislative hierarchy, and secondly that of competence, i.e. whether the public power, authority or body is empowered to act in the matter concerned.

With regard to electromagnetic nuisances, the laws to be considered are:

- Article 149.1.16 of the Constitution which attributes powers relating to the "general structure and coordination of health issues" exclusively to the State.

- Section 21 of the same article assigns to the State exclusive competence regarding "*general provisions on communications".*

- Article 24 of the General Health Law of 25 April 1986 states: *"Public or private activities that may have direct or indirect negative consequences for health will be subjected by the competent bodies to legal limits of a preventive nature in accordance with the basic laws of the State".*

- Article 42.2 of the same law states that local councils, notwithstanding the competences of other government bodies, will have a range of *"minimum responsibilities*" (which the Article lists) "*in relation to enforcing compliance with health regulations and plans*". The responsibilities listed therein all refer to "health monitoring" and include the environment, air pollution, industrial activities and services, buildings, homes and public spaces, the supply and distribution of food, drinks and other products for direct or indirect human consumption, etc..

- Article 43, Section 1 of the General Law on Telecommunications of 13 November 2003 states that "*the radio-electric spectrum is a public asset which is owned, managed, planned, administered and controlled by the State*". Section 2 of the same Article establishes that: "*The administration, management, planning and control of the radio-electric spectrum includes the preparation and approval of general usage plans, the establishment of the conditions for granting usage rights, the awarding of said rights and the technical monitoring of radio-electric emissions*".

- Article 25.2h) of the Law establishing the bases of the local government system of 2 April 1985 attributes competences to local councils, within the scope of State and Regional Legislation, on issues related to protecting public health.

The ruling of the Third Chamber of the Supreme Court of 19 April 2006 rejected an appeal against Royal Decree 1066/2001.

The ruling did, however, consider at length the "precautionary principle", which the Association making the appeal claimed had been threatened by the Royal Decree, concluding, in a series of complex

arguments, a summary of which can be found in the contribution by Prof. Ricardo de Ángel [CCARS-JUR-2010], available on the CCARS website, that the Royal Decree had not infringed this principle.

Prof. de Ángel considers that the reasoning of the Third Chamber was in line with best scientific and legal doctrine on the misnamed "precautionary principle". It is misnamed because the concept in itself is not in any way a scientific principle.

A document cited in the ruling, "Communication from the Commission on the precautionary principle, COM (2001),1" [EU-COM(2000)1], states that the precautionary principle applies where preliminary objective scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen for the Community (Summary, paragraph. 3).

The Communication goes on to state that recourse to the precautionary principle presupposes:

the identification of potentially dangerous effects deriving from a phenomenon, product or process;

a scientific evaluation of the risk which, because of the insufficiency of the data, its inconclusive or imprecise nature, makes it impossible to determine with sufficient certainty the risk in question.

In any case, we may state that the Communication does not modify or affect the provisions of the European Union Treaty or secondary Community legislation. This means that, for the purposes of the issues that concern us, there is no modification to the EU Council Recommendation of 12 July 1999 on electromagnetic fields.

Prior to the publication of COM (2000) 1, the eminent scientist Philippe KOURILSKY, of the Pasteur Institute, and member of the French Academy of Sciences, and renowned legal expert Geneviève VINEY, Lecturer in Civil Law at the University of Paris I, delivered on 29 November 1999 a report to the French Prime Minister on the precautionary principle, which he had commissioned and which was published by *Éditions Odile Jacob* in January 2000. Of particular note are the authors' comments on the "regulatory content of the precautionary principle" (pages 119 ff) in which they define the principle. This definition is subsequently transposed to the "Definitions" section which opens the "Recommendations" chapter of the report (pages 215 ff). The authors state that: *"The precautionary principle defines the attitude that any person should adopt when making a decision regarding an activity which may be reasonably supposed to involve a serious danger to the health or safety of present or future generations or for the environment. This applies especially to public authorities, who must give precedence to health and safety imperatives over the free exchange of goods between individuals and States*".

CCARS wishes to point out important criteria which form part of procedures based on the precautionary principle. These include transparency and public information and participation (this is already widespread and is generally used with affected or stakeholder groups), and step-by-step, case-by-case traceability, authorisation and inspection.

In the following legal reasoning, the ruling stated why the Court considered that the Royal Decree complied with the "precautionary principle":

"In the case before us, all these conditions appear to be fulfilled. Clearly, given the sequence of events referred to in the seventh consideration of this ruling, both the EC Recommendation and Royal Decree 1066/2001 were based on rigorous prior study and scientific analysis. The view that emerges, supported

from a scientific perspective by the aforementioned committees and organisations, is that, subject to the limitations established in the Recommendation, exposure to low intensity electromagnetic fields has no harmful effect on human health in terms of both thermal and non-thermal effects".

After referring to the many benefits deriving from the introduction and universal expansion of mobile telephony, the ruling concluded:

"Finally, requirements of caution exist in other measures deemed necessary in both the EC Recommendation and Royal Decree 1066/2001. This is not, therefore, a closed question that must be considered forever fixed, but a regulatory benchmark that is open to modification and, furthermore, subject to constant scrutiny at the behest of the public authorities."

In 1999 the Council recommended research be carried out into the short- and long-term effects of exposure to electromagnetic fields at all relevant frequencies and, specifically, recommended cooperation between the competent international organisations in this field. It also proposed that the limits set be revised and updated 'taking into account also possible effects, which are currently the object of research, including relevant aspects of precaution and the preparation for the Community of 'a report, within five years, taking into account the reports of the Member States and the latest scientific data and advice'. We have referred to this in the corresponding legal consideration, once it had been published by the EC Commission.

With reference to Spanish legislation, Article 7 of Royal Decree 1066/2001 states that on the basis of the 'available scientific evidence' and information provided by the Ministry of Science and Technology, the Ministry of Health and Consumer Affairs, in coordination with the governments of the Autonomous Communities, will assess the potential health risks for the general public of exposure to radio-electric emissions and 'will adapt Annex II in line with scientific developments, taking into account the precautionary principle and the assessments carried out by the competent national and international organisations'. The reports provided by the Ministry to support this ruling show that the monitoring and subsequent studies required by Royal Decree 1066/2001, and which prudence would advise, are being carried out.

Nevertheless, the criterion established in the ruling of the Third Chamber of the Supreme Court is not that followed in some recent rulings by the same Court. We need to look at rulings given in appeals against municipal regulations regarding radio-frequency infrastructure installations, at least some of which establish, particularly with regard to protecting health, more severe or restrictive conditions on construction or installation than those set out in Royal Decree 1066/2001 (and thus more severe or restrictive than those of the 1999 EC Recommendation).

Local government powers allow for the establishment or installation of activities, including all types industrial activities, under special circumstances. This has been confirmed in a wide range of judicial rulings. One example is the Third Chamber's ruling of 23 May 2006, rejecting an appeal by a mobile phone company against a Santander City Council town planning order on the location of mobile phone and other radio-electric installations. This ruling is discussed at length in the aforementioned talk by Prof. de Ángel [CCARS-JUR-2010].

It can be deduced from the cases quoted in the ruling that the conflict identified is that between the legal position regarding telecommunications and town and country planning rules, including environmental rules. Quoting from Prof. de Ángel's article:

It is true that the passage reproduced here also alludes to municipal powers with regard to public health, but it must be pointed out that the ruling in question did not need to deal with health issues. It seems opportune to distinguish at this point between "public health" and "health". Article 25, section 2 of the Law establishing the bases of the local government system distinguishes between "protection of public health" (letter h) and "participation in the management of primary healthcare" (letter i).

Article 25.2 goes on to attribute a range of competences to municipal authorities but adds that these are "*within the scope of State and Regional Legislation*".

The problem arose when, as highlighted at the start of this talk, the 17 November 2009 ruling of the Third Chamber of the Supreme Court touched on the thorny issue of municipal powers to establish measures to protect health, in particular with regard to the installation of equipment that generates radio-electric emissions.

Two statements in the ruling of the Third Chamber should be emphasised.

Firstly, it stated that the risk "*from electromagnetic fields generated by radio-electric emissions may not be considered a closed subject from a strictly scientific perspective*".

Secondly, therefore, "*it is logical that Town Councils, within the scope of the powers available to them, are tempted to impose additional protective measures in this area*".

The first of these assertions does not appear to be scientifically, and not, therefore, legally, sustainable. An analysis carried out by *CCARS* indicates that this statement must cast doubt on, or even contradict, the considerations presented by the same Chamber in its ruling of 19 April 2006 stating, firstly, that exposure to electromagnetic fields at levels below those established in the 1999 EC Recommendation (and thus, by definition in Royal Decree 1066/2001) does not constitute a risk to human health and, secondly, that it dismisses any appeal to the so-called "precautionary principle".

According to Prof. de Ángel:

> In other words, it is clear that the Third Chamber's 17 November 2009 ruling and others following the criterion contained therein (there have been several), contradict that of 19 April 2006 with regard to their understanding or assessment of the state of the science on the subject. That is, unless it is understood (and this is not scientifically sustainable) that not being able to consider the analysis of a risk as "closed" (i.e. it cannot be called "zero risk") is incompatible, at a given moment, with the formulation of a statement on the matter according to the state of the science.
>
> The second assertion of the 17 November 2009 ruling, although closely linked to the first, also gives some cause for surprise.

Indeed, the Chamber's reasoning that, as the risk from electromagnetic fields generated by radio-electric emissions is not a "closed" question, "*it is logical that Town Councils are tempted to impose additional protective measures*", is, in the view of the legally qualified members of *CCARS*, an appeal to a blatantly *extra-legal* principle and, therefore, not an appropriate basis for a legal ruling.

In the words of Prof. de Ángel:

> It does not seem too difficult to argue that a Court should not rule on a City Council's actions on the basis of measures it is "tempted to impose". The issue would clearly be quite different if we were discussing a "political" assessment of the local authority's actions (i.e. a question of image or appropriateness). But this, and all the CCARS' legal experts agree on this, must be treated as a question of Law.
>
> In this manuscript, I have tried to highlight not only the threat to the criterion (which, it must be remembered, is a legal criterion) known as "the state of the science", but also the fact that ignoring (or even just postponing) it could have outcomes which are legally unsound and contrary to the principles that prohibit arbitrary public powers, to the legislative hierarchy, and to the principle of equality. These are important constitutional principles.
>
> It would be paradoxical, to say the least, that if "the state of technical or scientific knowledge" is a criterion determining when the government is not liable (article 141.1 of the post-1999 version of the Law on Public Administration and Common Administrative Procedure), this same criterion does not then guide legal rulings (based on unchanging considerations) on such issues.

6. Social perception in Europe of the effects of electromagnetic fields

In June 2010 a Special Eurobarometer Report (73.3) was published in response to a proposal of the European Commission's Directorate-General for Health and Consumer Policy (DG SANCO), coordinated, as is normal for these studies, by the Directorate-General Communication (DG COMM) [Eurobarometer-EMF-2010]. Surveys were carried out in early spring 2010, the analysis taking in the 27 countries of the European Union and involving 26,602 respondents.

The report presents its findings under five headings. The first, in the context of environmental health, considers public perception of the potential risks of five sources of electromagnetic fields for health, compared with ten other environmental factors. The following three sections attempt to explore, in the cultural setting of the information available and knowledge of the potential risks of EMF, levels of knowledge and concern, levels of satisfaction regarding information, and the means by which information is provided. The fifth section deals with policy and the role of the European Union.

The Special Eurobarometer for 2010 (73.3) is the second dealing with the effects of EMFs on health, the first survey having been carried out in autumn 2006 and the results published in June 2007 [Eurobarometer-EMF-2007].

6.1 Some results

The first finding of note is that, among the 15 environmental factors which are potentially dangerous for health, the five sources of electromagnetic fields (high-voltage power lines, mobile phone antennae, mobile phones, computers and electric appliances in the home) occupy the last places, after chemical agents, the quality of foodstuffs, the quality of air outdoors, noise, the quality of air indoors, the quality of water in rivers and lakes, exposure to the sun, and housing conditions.

Among the low levels of concern about EMF sources as a risk factor, high voltage power lines and mobile phone antennae are those causing most concern, with a third of respondents saying that they affected their health to a large extent, while mobile phones elicited this response in a quarter of those surveyed.

The Spanish respondents show medium or low levels of concern about the ten factors that most worry Europeans in the EU 27. They range from 51% for chemicals to 31% for housing conditions. However, the Spanish occupy a different position regarding risks deriving from EMF sources and are among the most concerned about these, ranging from 44% for high voltage power lines (as against a European average of 35%) to 27% for mobile phones (European average 26%). 18% of Spanish respondents express a high level of concern about the use of computers and computing equipment (European average 20%) and about electric appliances (European average 17%).

The most surprising result of the survey was the significant decrease in European citizens' knowledge of the objects which are sources of electromagnetic fields, compared with the Eurobarometer 2006 report [Eurobarometer-EMF-2007].. Responses on this point

are compiled by presenting respondents with a list of objects and inviting them to say whether they are sources of EMF, either asking about them one by one or asking respondents to spontaneously produce a list. The objects considered were the following (affirmative answers in brackets): mobile phone antennae (59%), mobile phones (59%), high voltage power lines (58%), computers (40%), radar equipment (39%), electric appliances (35%), wireless computer networks (32%). Those mentioned less frequently included anti-theft devices (20%), movement detectors and security doors, and the induction heating systems used in electric cookers and heaters (17%). Only 9% of respondents spontaneously mentioned all the devices, while 2% answered that none of them was a source of electromagnetic radiation.

It was pointed out that these responses show a marked drop in knowledge of *EMF* sources. The decrease ranges from 14% in the case of spontaneous listing (23% mentioned all the devices in 2006) to 1% for high voltage power lines, with intermediate values for the other devices.

Spanish respondents also exhibited this paradoxical trend, which we may call *increased cognitive deficit*. Spanish responses occupy a middle position, as they do throughout the survey, except in the case of newer or more complex technologies, such as radar and wireless computing, especially regarding spontaneous responses, where Spaniards show a considerably greater decline than the European average.

Concerning the important issue of public concern about the potential health risks of electromagnetic fields, the survey shows a split: 46% report that they are worried about these risks, while 51% say they are not. Only a very small percentage say they do not know or fail to answer (6%). As mentioned previously, concern among Spanish respondents about the potential risks of *EMFs* is relatively high, 7 points above the European average, placing Spain in fifth position after Greece, Italy, Cyprus and Slovenia, these countries being identified as most alarmist throughout the survey. In Spain there is an increase of 16 points in concern about these matters compared to the results for 2006. The reverse is true of the Scandinavian countries and some countries in the Baltic. Information is mentioned as the main factor shaping opinions about risks and the resulting concern, although the type and quality of information are not specified.

Information and respondents' satisfaction with it are analysed in the third section of the report. Paradoxically, once more, only 20% of those surveyed report that they have received information, while 78% say that they have definitely not received any. Analysis of the degree of satisfaction with the information provided has been made more difficult by the low number of respondents who have received any. Only 15 of the 27 Member States of the EU have enough respondents answering affirmatively (n > 200) to conduct the analysis and Spain is not among them.

Concerning the channels of communication through which information is conveyed, the subject of the fourth section, television and the printed press (newspapers and magazines), are mentioned most often (55% and 33% respectively). Internet is in third place (19%), an increase of 4 points since 2006, although, somewhat paradoxically, the percentage of users is greater than the percentage of those who express a preference for this medium. Preferences for the two traditional channels used most often record drops of 9 and 7 points compared with 2006. Figures for Spanish preferences are higher than the European average for television (the same level as 2006), while they are lower than the average for the printed press (2 points) and the internet (5 points).

The fifth section deals with policies related to potential health hazards from electromagnetic fields. The results are hardly satisfactory, as 58% of respondents do not believe that the authorities protect them from these risks. Greece and the Balkan countries are the most critical (70-75%) and Spain, which is also among the most critical (66%), is the country where this attitude has increased most (15%) since the 2006 survey.

In view of this general critical climate, respondents were asked about the role which the European Union can play in helping national governments to deal with the problem of electromagnetic fields and the associated health hazards. The solution mentioned most often (48% of respondents) is that the *EU* should *inform the public*, so that the following measures could then be taken: *establishing safety standards for products* (*39%*), *preparation of guides to protect health* (*36%*), *funding research into these matters* (*31%*), *setting safety standards for working conditions* (*27%*), reviewing scientific evidence (23%), and *standardising national policies* (17%). The results cannot be compared with the 2006 report, as this section is new in the *2010 Eurobarometer*. Figures for Spain are significantly above average (9 points) for the EU's role in providing information but are average or below average for the other measures proposed.

6.2 Final comment

This valuable, interesting exercise in survey analysis highlights once again the problems and limitations besetting such studies, where data is sometimes contradictory and the findings paradoxical, though we should not ignore their importance for decision making. The decline in knowledge of electromagnetic fields is particularly striking. This "increase in ignorance" is even more surprising, as one of the arguments for carrying out the Eurobarometer study is the following: *"In view of the persistent high level of public concern and the sustained media coverage of this issue, a first Eurobarometer on electromagnetic fields was commissioned in 2006. In view of the many scientific, technological and policy developments since then, it was felt that a new Eurobarometer, asking mostly the same questions, would deliver valuable information on trends in the level of public concern."* It seems, however, that the developments and the expectations are not reflected in the results. This also applies to the question of information.

In the case of Spain it is important to emphasise that Spanish people are among the most concerned in Europe regarding these issues, although the level of their knowledge is among the lowest, and their interest and preferences regarding information are also limited.

CCARS thus has important work to do. It may be necessary to review its strategy on the circulation of information and knowledge generated as a result of its activities, especially if it wishes to reach a wider public and not only those who are informed and interested. The internet is still not a vehicle for general communication, as it is normally used by those who have a specific interest in a subject. Another alternative to be considered is a diversification of sources of information.

7. Conclusions

1. *In vivo* and *in vitro* experimental studies have shown that the radio frequency electromagnetic fields used in mobile telephony whose levels are below those set by the *ICNIRP* and those recommended by the EU are not *genotoxic* or *mutagenic* and do not lead to *apoptosis* or cell death.

2. Present evidence from clinical and epidemiological studies indicates that there is no causal relationship between exposure to the radio frequency fields used in mobile telephony and adverse effects on health.

3. A comprehensive interpretation of the results of the epidemiological studies on brain tumours and the use of mobile phones published to date does not show an increase in the risk of developing brain tumours over a period of use lasting 10 years. However, some studies have observed a slight increase in the risk of developing tumours among mobile phone users when the number of hours' use is very high, although the errors and bias detected in these studies make it difficult to establish causal relationships.

4. Insufficient data is available regarding longer periods of exposure in adults and the situation of children and young people, so rational use of these devices is advisable.

5. Controlled studies of individuals who describe themselves as hypersensitive to the radio frequency electromagnetic fields associated with mobile telephony (generated by phones and antennae) have shown that there is no causal relationship between the symptoms they report and their exposure to this type of radio frequency radiation.

6. One would expect that, if there was any effect caused by massive exposure to mobile telephony, it would be reflected in the incidence of tumours. These changes have not been observed in the studies carried out in a number of countries.

7. The exposure of the Spanish population to the radio frequency electromagnetic fields associated with mobile telephony is well below the limits set in the EU's *ICNIRP* recommendations and in current legislation. However, people in Spain are among the Europeans most concerned about the effects on health of exposure to electromagnetic fields, so it would be advisable to introduce measures to inform the public.

8. The most effective way of reducing current levels of exposure is to increase the number of antennae so that their power can be reduced.

9. The differences between certain decisions by the Supreme Court, even within one of its chambers, with differing appreciations of and weight given to the "state of science" and the application of the "precautionary principle", raise certain issues of judicial inconsistency which, in the opinion of CCARS, call for reflection and discussion.

10. According to various competent bodies, there are not sufficient scientific reasons at present to justify a reduction in current levels of exposure to electromagnetic waves from mobile telephony, either for the general public or in the workplace.

8. Recommendations

In view of the conclusions of this report, *CCARS* considers that measures should be adopted for basic and epidemiological research into the effects of electromagnetic fields, while new approaches to dosimetry are needed to measure exposure to radio frequency fields. *CCARS* considers that:

- Research needs to be promoted and financed to determine how electromagnetic fields and biological systems interact and to carry out specialised studies of a particular cell type or tissue.

- Experimental procedures need to be defined, for both *in vitro* and *in vivo* studies, so that the results of work done by different research groups can be compared.

- Regarding epidemiological studies it is necessary to define procedures to evaluate exposure to electromagnetic fields which allow us to conduct reliable, consistent and comparable studies.

- Research to establish a possible causal relationship between the use of mobile phones and brain tumours must be continued, especially studies of those who have used them for more than 10 years, young people and children. The short periods of exposure to mobile telephony to date and the long periods of latency of brain tumours make it advisable to continue with long-term studies of the effects of mobile telephony.

- New dosimetry procedures need to be established and the models used in simulations improved, so that exposure to multiple radio frequency fields can be assessed and quantified.

- It would be advisable for the relevant authorities, especially those concerned with healthcare, to introduce programmes and activities to inform and educate people on the effects of radio frequencies.

9. References

[Aalto-2006] Aalto S., Haarala C., Bruck A., Sipila H., Hamalainen H., Rinne, J.O. *Mobile phone affects cerebral blood flow in humans*. J Cereb Blood Flow Metab 26, 885-90 (2006).

[AcadFranc-2009] *"Réduire l'exposition aux ondes des antennes-relais n'est pas justifié scientifiquement",* Académie Nationale de Médecine, Académie des Sciences, Académie des Technologies (17/12/2009).

This document can be found at the web sites of each Academy

http://www.academie-sciences.fr/actualites/textes/ondes_17_12_2009.pdf

http://www.academie-medecine.fr/detailPublication.cfm?idRub=27&idLigne=1891

http://www.academie-technologies.fr/fileadmin/templates/PDF/presse/MiseAuPoint.pdf

NOTE: On the website of the *Académie des Technologies* there are also:

Glossary, (Glossaire)

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Members of the working group (GroupeTravail)

http://www.academie-technologies.fr/fileadmin/templates/PDF/presse/GroupeTravail.pdf

Technical notes on the 11 studies indicated in the AFSSET press note (EtudesNotesTech)

http://www.academie-technologies.fr/fileadmin/templates/PDF/presse/EtudesNotesTech.pdf

[AFSSET-2009] *Mise à jour de l'expertise relative aux radiofréquences*, Agence Française de Sécurité Sanitaire de l'Environnement et du Travail, Comité d'Experts Spécialisés liés à l'évaluation des risques liés aux agents physiques, aux nouvelles technologies et aux grands aménagements , Groupe de Travail Radiofréquences, Octobre 2009.

http://www.afsset.fr/index.php?pageid=2456

[AFSSET-2009- Press release] Communiqué de presse. *Radiofrequences : L'Afsset recommande de réduire les expositions*, 15 octobre 2009

http://www.afsset.fr/upload/bibliotheque/264098609003221287575149142226/CP_radiofrequencesVF_V2.pdf

[Ahlbom -2009] Ahlbom, A*., Epidemiologic Evidence on Mobile Phones and Tumor Risk: A Review*. Epidemiology 20(5), 639-652 (2009).

[Ammari-2008] Ammari M., Brillaud E., Gamez C., Lecomte A., Sakly M., Abdelmelek H., de Seze, R. *Effect of a chronic GSM 900 MHz exposure on glia in the rat brain*. Biomed. Pharmacother. 62, 273-81 (2008).

[Arora-2010] Arora R.S., Alston R.D., Eden T.O., Estlin E.J., Moran A., Geraci M., Birch J.M. *Are reported increases in incidence of primary CNS tumours real? An analysis of longitudinal trends in England, 1979-2003*. Eur J Cancer 46(9), 1607-1616 (2010).

[Berg-Beckhoff-2009] Berg-Beckhoff G., Blettner M., Kowall B., Breckenkamp J., Schlehofer B., Schmiedel S., Bornkessel C., Reis U., Potthoff P., Schüz J. *Mobile phone base stations and adverse health effects: phase 2 of a cross sectional study with measured radio frequency*. Occup Environ Med 66(2),124-30 (2009)

[BioR-2007] *"BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)".*

http://www.bioinitiative.org/

[Bonhomme-Faivre-1998] Bonhomme-Faivre L, Macé A, Bezie Y, Marion S, Bindoula G, Szekely AM, Freńois N, Auclair H, Orbach-Arbouys S, Bizi E. *Alterations of biological parameters in mice chronically exposed to low-frequency (50 Hz) electromagnetic fields*. Life Sci. 62 (14), 1271-80 (1998)

[CCARS-2009] *Informe sobre radiofrecuencias y salud (2007-2008).* (*CCARS Report on Radio Frequencies and Health (2007-2008).* Comité Científico Asesor en Radiofrecuencias y Salud (CCARS), Ed. Complutense, Madrid 2009, ISBN 9788474919912

http://www.ccars.es
http://www.ucm.es/BUCM/ecsa/36254.php?id=294

[CCARS-Nórdico-2010] *Comentario CCARS sobre el estudio nórdico sobre Tendencias en la Incidencia de Tumores Cerebrales (in Spanish) (CCARS comment on the Nordic study on Trends in Incidence of Brain Tumors) (in Spanish)*

http://www.ccars.es

[CCARS-JUR-2010] *"Resoluciones jurídicas sobre riesgos de exposición a campos electromagnéticos" (Legal rulings on risks arising from exposure to electromagnetic field)*, Prof. Ricardo de Ángel, Enero de 2011, CCARS (in Spanish)

http://www.ccars.es

[CIEMAT-1998] Informe del Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT) de febrero de 1998 sobre "Posibles Efectos sobre la Salud y el Medio Ambiente de los campos electromagnéticos producidos por las líneas eléctricas de alta tensión" Report by CIEMAT *(Possible Effects on Health and the Environment of the electromagnetic fields produced by high voltage power lines) (in Spanish)*

[COSMOS] *Cohort Study of Mobile Phone Use and Health*, (COSMOS)

http://www.ukcosmos.org/

[CSTEE-2002] Scientific committee on toxicity, ecotoxicity and the environment (CSTEE) September 24th 2002. *OPINION OF THE CSTEE ON "EFFECTS OF ELECTROMAGNETIC FIELDS ON HEALTH*. (CSTEE,

http://ec.europa.eu/health/ph_determinants/environment/EMF/out161_en.pdf

[Del Vecchio-2009] Del Vecchio G., Giuliani A., Fernandez M., Mesirca P., Bersani F., Pinto R., Ardoino L., Lovisolo G.A., Giardino L., Calzà L. *Effect of radiofrequency electromagnetic field exposure on in vitro models of neurodegenerative disease.* Bioelectromagnetics 30, 564-72 (2009).

[Del Vecchio-2009b] Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzà L. *Continuous exposure to 900MHz GSM-modulated EMF alters morphological maturation of neural cells*. Neurosci. Lett. 455, 173-7 (2009)

[Delgado-2006] Delgado M., Palma S. *Aportaciones de la revisión sistemática y del metanálisis a la salud pública*. Rev. Esp. Salud Pública 80(5), 483-489 (2006)

[Deltour-2009] Deltour I., Johansen C., Auvinen A., Feychting M., Klaeboe L., Schüz J. *Time trends in brain tumor incidence rates in Denmark, Finland, Norway, and Sweden, 1974-2003*. J Natl Cancer Inst 101(24), 1721-1724 (2009)

[Dreifald-2004] Dreifald A.C., Carlberg M., Hardell L. *Increasing incidence rates of childhood malignant diseases in Sweden during the period 1960-1998*. Eur J Cancer 40(9), 1351-60 (2004)

[Eger-2004] Eger, H., Hagen, K.U., Lucas, B., Vogel, P., Voit, H. (2004). Influence of the spatial proximity of mobile phone base stations on cancer rates (article in German). Umwelt-Medizin- Gesellschaft 17:273-356.

[Elliot-2010] Eliott P., Toledano M.B., Bennett J., Beale L., de Hoogh K., Best N., Briggs D.J. *Mobile phone base stations and early childhood cancers: case-control study*. BMJ 2010; 340: c3077 (2010)

[Eltiti-2009] Eltiti S., Wallace D., Ridgewell A., Zougkou K., Russo R., Sepulveda F., Fox E. *Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls*. Bioelectromagnetics 30(7), 556-63 (2009)

[Erdine-2009] Erdine S., Bilir A., Cosman E.R., Cosman E.R. Jr . *Ultrastructural changes in axons following exposure to pulsed radiofrequency fields*. Pain Pract 9, 407-17 (2009)

[EMF-NET] *"Effects Of The Exposure To Electromagnetic Fields: From Science To Public Health"*. March 1, 2004 - August 31, 2008 . Project funded by the European Commission, 6th Framework Programme

http://web.jrc.ec.europa.eu/emf-net/

[EMFnEAR] *"Exposure at UMTS electromagnetic fields: study on potential adverse effects on hearing"*. Project funded by the European Commission. Framework of the Programme of Community Action in the Field of Public Health of the EC, DG Health and Consumer Protection

Web page of the project:
http://www.emfnear.polimi.it/;
http://ec.europa.eu/eahc/projects/database.html?prjno=2004127

[EU-1999] *COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)*

http://ec.europa.eu/enterprise/sectors/electrical/files/lv/rec519_en.pdf

[EU-2004] *Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC) European Official Journal of the European Union* 30.4.04,L159/1-L159/26.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:159:0001:0026:EN:PDF

[EU-2004b] *Corrigendum to Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC) Official Journal of the European Union 24.5.2004* L 184/1-L184/9.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:184:0001:0009:EN:PDF

[EU-2004c] *Corrigendum to Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) Official Journal of the European Union L 159 of 30 April 2004. Corrected version in Official Journal of the European Union L 184 of 24 May 2004). Official Journal of the European Union 4.8.2007,L 204/29*

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:204:0029:0029:EN:PDF

[EU-COM(2000)1] COMMUNICATION FROM THE COMMISSION on the precautionary principle, 2.2.2000

http://eur-lex.europa.eu/LexUriServ/site/en/com/2000/com2000_0001en01.pdf

[Eurobarometer-EMF-2007] Special Eurobarometer *"Electromagnetic Fields Report (June 2007)"*

http://ec.europa.eu/public_opinion/archives/ebs/ebs_272a_en.pdf

[Eurobarometer-EMF-2010]. Special Eurobarometer *"Electromagnetic Fields Report (June 2010)"*

http://ec.europa.eu/public_opinion/archives/ebs/ebs_347_en.pdf

[Friburgo] *Freiburger appell*

http://www.igumed.de/images/fa_1_03.pdf

[Furubayashi -2009] Furubayashi T., Ushiyama A., Terao Y., Mizuno Y., Shirasawa K., Pongpaibool P., Simba A.Y., Wake K., Nishikawa M., Miyawaki K., Yasuda A., Uchiyama M., Yamashita HK., Masuda H., Hirota S., Takahashi M., Okano T., Inomata-Terada S., Sokejima S., Maruyama E., Watanabe S., Taki M., Ohkubo C., Ugawa Y., *Effects of Short-Term W-CDMA Mobile Phone Base Station Exposure on Women With or Without Mobile Phone Related Symptoms*. Bioelectromagnetics 30, 100-113 (2009)

[Guerra-2010] Guerra J.A., Martin P., Santos J.M. Grupo MBE. Red temática de Investigación sobre Medicina Basada en la Evidencia. *Problemas en el desarrollo de recomendaciones: la necesidad de revisiones sistemáticas- MBE: las revisiones sistemáticas*. Atención Primaria en Red.

[Gurney-1999] Gurney J.G., Smith M.A., Bunin G.R. CNS and miscellaneous intracranial and intraspinal neoplasms. In: Ries L.A.G., Smith M.A., Gurney J.G. et al. (Eds). *Cancer incidence and survival among children and adolescents: United States SEER Program 1975-1995*. Bethesda, MD: National Cancer Institute, SEER Program, NIH Publication Nº 99-4649, pp. 51-63 (1999)

[Hardell-2009] Hardell L, Carlberg M. *Mobile phones, cordless phones and the risk for brain tumours*. Int J Oncol. 35(1), 5-17 (2009)

[Hashish-2007] Hashish A.H., El-Missiry M.A., Abdelkader H.I., Abou-Jaleh R.H. *Assessment of biological changes of continuous whole body exposure to static magnetic field and extremely low frequency electromagnetic fields in mice*. Ecotoxicol. Environ. Saf. 71, 895-902 (2007).

[Hjalmars-1999] Hjalmars U., Kulldorf M., Wahqvist Y., Lannering B. *Increased incidence rates but no space-time clustering of childhood astrocytoma in Sweden, 1973-1992: a population-based study of pediatric brain*. Cancer 85(9), 2077-2090 (1999).

[HPA-WIFI-2009] General position of HPA about *Wi-Fi (October, 26th 2009),* Health Protection Agency (U.K.)

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/WiFi/

[Hoyto-2007] Hoyto A., Juutilainen J., Naarala J. *Ornithine decarboxylase activity is affected in primary astrocytes but not in secondary cell lines exposed to 872 MHz RF radiation*. Int. J. Radiat. Biol 83, 367-74 (2007)

[Huang-2008] Huang T.Q., Lee M.S., Oh E.H., Kalinec F., Zhang B.T., Seo J.S., Park, W.Y. *Characterization of biological effect of 1763 MHz radiofrequency exposure on auditory hair cells*. Int. J. Radiat. Biol. 84, 909-15 (2008).

[Hubert-2005] Huber R., Treyer V., Schuderer J., Berthold T., Buck A., Kuster N., Landolt H.P., Achermann P. *Exposure to pulse-modulated radio frequency electromagnetic fields affects regional cerebral blood flow*. Eur J Neurosci. 21, 1000-1006 (2005).

[ICNRP-1998] *ICNIRP Guidelines "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*. International Commission on Non-Ionizing Radiation Protection, Health Physics 74 (4), 494- 522 (1998)

http://www.icnirp.de/documents/emfgdl.pdf

[ICNIRP-2009] *ICNIRP Statement on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)"*, Health Physics 97 (3), 257-258 (2009).

http://www.icnirp.de/document/StatementEMF.pdf

[Iijima-Ando-2010] Iijima-Ando K., Zhao L., Gatt A., Shenton C. ,Iijima K. *A DNA damage-activated checkpoint kinase phosphorylates tau and enhances tau-induced neurodegeneration*. Hum. Mol. Genet 19(10), 1930-8 (2010).

[Inskip-2010] Inskip P.D., Hoover R.N., Devesa S.S. *Brain cancer incidence trends in relation to cellular telephone use in the United States*. Neuro Oncol. 12(11),1147-51 (2010).

[INTERPHONE-2010] The INTERPHONE Study Group. *Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study*. International Journal of Epidemiology 39, 675–694 (2010)

http://ije.oxfordjournals.org/content/39/3/675.full.pdf+html

[INTERPHONE-IARC-2010] *Interphone study reports on mobile phone use and brain cancer risk. International Agency for Research on Cancer (IARC).* WHO. Press release N° 200 17 May. 2010

http://www.iarc.fr/en/media-centre/pr/2010/pdfs/pr200_E.pdf

[Johansson-2001] Johansson O, Gangi S, Liang Y, Yoshimura K, Jing C, Liu PY. *Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs--results from open-field provocation experiments*. J. Cutan. Pathol. 2001 28 (10), 513-9 (2001)

[Johansson-2009] Johansson O. *Disturbance of the immune system by electromagnetic fields—A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment*. Pathophysiology 16, 157–177 (2009).

[Joubert-2008] Joubert V., Bourthoumieu S., Leveque P., Yardin C. *Apoptosis is induced by radiofrequency fields through the caspase-independent mitochondrial pathway in cortical neurons*. Radiat. Res. 169, 38-45 (2008)

[Kaatsch-2006] Kaatsch P., Steliarova-Foucher E., Crocetti E., Magnani C., Spix C., Zambon P. *Time trends of cancer incidence in European children (1978-1997), report from the Automated Childhood Cancer Information System Project*. Eur J Cancer 42(13), 1961-1971 (2006).

[Khurana-2009] Khurana V.G., Teo C., Kundi M., Hardell L, Carlberg M. *Cell phones and brain tumors: a review including the long-term epidemiologic data*. Surg Neurol 72(3), 205-14 ; discussion 214-5 (2009)

[Kumlin-2007] Kumlin T, Iivonen H, Miettinen P, Juvonen A, van Groen T, Puranen L, Pitkäaho R, Juutilainen J, Tanila H. *Mobile phone radiation and the developing brain: behavioral and morphological effects in juvenile rats*. Radiat. Res. 168 (4), 471-9 (2007)

[Lee-2006] Lee J.S., Huang T.Q., Kim T.H., Kim J.Y., Kim H.J., Pack J.K. Seo, J.S. *Radiofrequency radiation does not induce stress response in human T-lymphocytes and rat primary astrocytes*. Bioelectromagnetics 27, 578-88 (2006).

[Linabery-2008] Linabery A.M., Ross J.A. *Trends in childhood cancer incidence in the US (1992-2004)*. Cancer 112(2), 416-432 (2008)

[Linet-1999] Linet M.S., Ries L.A.G., Smith M.A., Tarone R.E., Devesa S.S. *Cancer surveillance series: recent trends in childhood cancer incidence and mortality in the United States*. J Nat Cancer Inst 91(12), 1051-1058 (1999)

[MICyT-2010] *Informe sobre la exposición del público en general a las emisiones radioeléctricas de estaciones de radiocomunicación (Año 2009)*, Ministerio de Industria, Comercio y Turismo (MICyT) Abril 2010 (In Spanish)

http://www.mityc.es/telecomunicaciones/Espectro/NivelesExposicion/Informes/Informes%20anuales/informe_2010.pdf

[McNally-2001] McNally R.J.Q., Kelsey A.M., Cairns D.P., Taylor G.M., Eden O.B., Birch J.M. *Temporal increases in the incidence of childhood solid tumours seen in Northwest England (1954-1998) are likely to be real*. Cancer 92 (7), 1967-1976 (2001)

[Miyakoshi-2005] Miyakoshi J., Takemasa K., Takashima Y., Ding G.R., Hirose H., Koyama S. *Effects of exposure to a 1950 MHz radio frequency field on expression of Hsp70 and*

Hsp27 in human glioma cells. Bioelectromagnetics 26, 251-7 (2005).

[Mobi-Kids] *Mobi-kids study on communication technology, environment and brain tumours in young people*. This study is funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement 226873

http://www.mbkds.net

[MSC-2001] Informe *"Campos Electromagnéticos y Salud Pública"* Informe Técnico elaborado por el Comité de Expertos Independientes. Sub. Gral. de Sanidad Ambiental y Salud Laboral. Dirección General de Salud Pública y Consumo. Ministerio de Sanidad y Consumo elaborado por el Ministerio de Sanidad y Consumo, 11 de mayo de 2001 (in Spanish)

http://www.mityc.es/telecomunicaciones/Espectro/NivelesExposicion/Aspectos%20sanitarios/1-%20Ministerio%20de%20Sanidad%20y%20Consumo/Resumen_MinisterioSanidad.pdf

[MTHR-2007] *Report 2007*, Mobile Telecommunications and Health Research Programme (MTHR)

http://www.mthr.org.uk/documents/MTHR_report_2007.pdf

[Nageswari-1991] Nageswari K.S., Sarma K.R., Rajvanshi V.S., Sharan R., Sharma M., Barathwal V., Singh V. *Effect of chronic microwave radiation on T cell-mediated immunity in the rabbit*. Int. J. Biometeorol. 35, 92–97 (1991).

[Nam-2009] Nam K.C., Lee J.H., Noh H.W., Cha E.J., Kim N.H., Kim D.W. *Hypersensitivity to RF fields emitted from CDMA cellular phones: a provocation study*. Bioelectromagnetics 30(8), 641-50 (2009)

[Nordic-Auth-2009] *Mobile Telephony and Health– A common approach for the Nordic competent authorities*

http://www.nrpa.no/dav/c7e2db2c68.pdf

[Oberfeld-2008] Umweltepidemiologische Untersuchung der Krebsinzidenz in den Gemeinden Hausmannstätten & Vasoldsberg, Dr. Gerd Oberfeld, 2008

http://www.powerwatch.org.uk/news/20080325_oberfeld_study.pdf

[Ohgaki-2009] Ohgaki H. *Epidemiology of brain tumors*. Methods Mol Biol. 472, 323-42 (2009).

[ORDEN CTE/23/2002] *ORDEN CTE/23/2002, de 11 de enero, por la que se establecen condiciones para la presentación de determinados estudios y certificaciones por operadores de servicios de radiocomunicaciones*. (In Spanish)

http://www.boe.es/boe/dias/2002/01/12/pdfs/A01528-01536.pdf

[Parazzini-2010] Parazzini M., Lutman M.E., Moulin A., Barnel C., Sliwinska-Kowalska M., Zmyslony M., Hernadi I.,Stefanics G, Thuroczy G, Ravazzani P. *Absence of short-term effects of UMTS exposure on the human auditory system*. Radiat Res. 173(1), 91-7 (2010).

[Parkin-1998] Parkin D.M., Kramárová E., Draper G.J., Masuyer E., Michaelis J., Neglia J., Quershi S., Stiller C.A., (Eds). International Incidence of Childhood Cancer. Vol II. Lyon: International Agency for Research on Cancer (IARC), p.144 (1998)

[Paunescu-2007] *"Effects of radiofrequency and extremely low frequency electromagnetic fields radiation on cells of the inmune system"* por T. Paunescu y G. Woloschak en "Biological and Medical Aspects of Electromagnetic Fields (Handbook of Biological Effects of Electromagnetic Fields), 3ra edición", Eds Frank S. Barnes y Ben Greenebaum. CRC Press, 2007.

[Peris-Bonet-2006] Peris-Bonet R., Martínez-García C., Lacour B., Petrovich S., Giner-Ripoll B., Navajas A., Steliarova-Foucher E. *Childhood central nervous system tumours – incidence and survival in Europe (1978-1997): Report from Automated Childhood Cancer Information System Project*. Eur J Cancer 42(13), 2064-2080 (2006).

[Peris-Bonet-2010] Peris-Bonet R., Salmerón D., Martínez-Beneyto M.A., Galceran J., Marcos-Gragera R., Felipe S., González V., Sanchez de Toledo Codina J. *Childhood cancer incidence and survival in Spain*. Ann Oncol 21 (supplement3): iii103-iii110, (2010)

[Ragbetli-2009] Ragbetli M.C., Aydinlioglu A., Koyun N., Ragbetli C., Karayel M. *Effect of prenatal exposure to mobile phone on pyramidal cell numbers in the mouse hippocampus: a stereological study*. Int. J. Neurosci. 119, 1031-41 (2009).

[RAC-2001] Informe de la Real Academia de Ciencias Exactas, Físicas y Naturales de 3 de octubre de 2001 (in Spanish)

http://catedracoitt.euitt.upm.es/web_salud_medioamb/seminario_cancer/documentacion/OI5.PDF

[RD 1066-2001] *Real Decreto 1066/2001 de 28 de septiembre de 2001, por el que se aprueba el Reglamento que establece condiciones de protección del dominio público radioeléctrico, restricciones a las emisiones radioeléctricas y medidas de protección sanitaria frente a emisiones radioeléctricas.* (In Spanish)

http://www.boe.es/boe/dias/2001/09/29/pdfs/A36217-36227.pdf

[REE-UNESA -2001] *" Cinco años de investigación sobre los efectos biológicos de los campos electromagnéticos de frecuencia industrial en los seres vivos. Resultados de la colaboración científica de la Universidad de Valladolid el Consejo Superior de Investigaciones Científicas, UNESA y Red Eléctrica de España durante los años 1995-2000" (In Spanish)*

http://www.ree.es/medio_ambiente/pdf/REE_UNESA_CEM_2001.pdf

[Reutfords-2002] Reutfors J., Kramárová E., Weiderpass E., Monge P., Wesseling C., Ahlbom A. *Central nervous system tumours in children in Costa Rica, 1981-96*. Paediatr Perinat Epidemiol 16(3), 219-225 (2002)

[Rubin-2010] Rubin G.J., Nieto-Hernandez R., Wessely S. *Idiopathic environmental intolerance attributed to electromagnetic fields (formerly 'electromagnetic hypersensitivity'): An updated systematic review of provocation studies*. Bioelectromagnetics 31(1), 1-11 (2010).

[SCENIHR-2007] *Possible effects of Electromagnetic Fields (EMF) on Human Health*, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), Comisión Europea, 21 de Marzo de 2007

http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_007.pdf

[SCENIHR-2009] *Health Effects of exposure to EMF*, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), Comisión Europea, 19 de Enero de 2009.

http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf

[SCENIHR-2009b] *Health Effects and EMF – Research Recommendations "Research needs and methodology to address the remaining knowledge gaps on the potential health effects of EMF"*, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), 6 de Julio 2009

http://ec.europa.eu/health/archive/ph_risk/committees/04_scenihr/docs/scenihr_o_024.pdf

[Smith-1998] Smith M.A., Freidlin B., Ries L.A.G., Simon R. *Trends in reported incidence of primary malignant brain tumors in children in the United States*. J Nat Can Inst 90(17), 1269-1277 (1998)

[SSI-2008] *Report on Electromagnetic Fields (2007)*, Swedish Radiation Protection Authority's Independent Expert Group's

http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Stralskydd/2008/ssi-rapp-2008-12.pdf

The web site of SSI is

http://www.ssi.se

[Sirmantel-2007a] Sirmatel O., Sert C., Tümer C., Oztürk A., Bilgin M., Ziylan Z. *Change of nitric oxide concentration in men exposed to a 1.5 T constant magnetic field*.

Bioelectromagnetics 28, 152-154 (2007).

[Sirmantel-2007b] Sirmatel O., Sert C., Sirmatel F., Selek S, Yokus B. *Total antioxidant capacity, total oxidant status and oxidative stress index in the men exposed to 1.5 T static magnetic field*. Gen. Physiol Biophys 26, 86-90 (2007).

[Todorovic-2007] Todorović D., Kalauzi A., Prolić Z., Jović M., Mutavdzić D. *A method for detecting the effect of magnetic field on activity changes of neuronal populations of Morimus funereus (Coleoptera, Cerambycidae)*. Bioelectromagnetics 28, 238-241 (2007)

[Van Rongen-2009] Van Rongen E., Croft R., Juutilainen J., Lagroye I., Miyakoshi J., Saunders R., de Seze R., Tenforde T., Verschaeve L., Veyret B., Xu Z. *Effects of radiofrequency electromagnetic fields on the human nervous system*. J Toxicol Environ Health B Crit Rev 12(8), 572-97 (2009).

[Verschaeve -2009] Verschaeve L. *Genetic damage in subjects exposed to radiofrequency radiation*. Mutation Research 681, 259-270 (2009).

[Vijayalaxmi-2004] Vijayalaxmi Obe G. *Controversial cytogenetic observations in mammalian somatic cells exposed to radiofrequency radiation*. Radiat. Res. 162 (5), 481-96 (2004)

[Vrijheid-2009] Vrijheid M., Richardson L., Armstrong B.K., Auvinen A., Berg G., Carroll M., Chetrit A., Deltour I., Feychting M., Giles G.G., Hours M., Iavarone I., Lagorio S., Lönn S., McBride M., Parent M.E., Sadetzki S, Salminen T, Sanchez M, Schlehofer B, Schüz J, Siemiatycki J, Tynes T, Woodward A, Yamaguchi N, Cardis E. *Quantifying the impact of selection bias caused by nonparticipation in a case-control study of mobile phone use*. Ann Epidemiol. 19(1), 33–41 (2009).

[Vrijheid-2009b] Vrijheid M., Armstrong B.K., Bédard D., Brown J., Deltour I., Iavarone I., Krewski D., Lagorio S., Moore S., Richardson L., Giles G.G., Mcbride M., Parent M.E., Siemiatycki J., Cardis E. *Recall bias in the assessment of exposure to mobile phones*. J .Expo. Sci. Environ. Epidemiol. 19(4), 369–381 (2009)

[WHO-2006] *Fact sheet N°304, "Electromagnetic fields and public health: Base stations and wireless ". (May 2006)*

http://www.who.int/mediacentre/factsheets/fs304/en/index.html

[WHO-2010] *Fact sheet N°193, Electromagnetic fields and public health: mobile phones "(May 2010)*

http://www.who.int/mediacentre/factsheets/fs193/en/index.html

[Wolf-2004] Wolf, R., Wolf, D. Increased incidence of cancer near a cellphone transmitter station. Int. J. Cancer Prev. 1:123-128 (2004)

[Xu-2010] Xu S, Zhou Z, Zhang L, Yu Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Zhong M. *Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons*. Brain Res. 1311, 189-96 (2010)

[Zhao-2007] Zhao T.Y., Zou S.P., Knapp, P.E. *Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes*. Neurosci. Lett.412, 34-8 (2007).

[Zur Nieden-2009] Zur Nieden A., Dietz C., Eikmann T., Kiefer J., Herr C.E. *Physicians appeals on the dangers of mobile communication--what is the evidence? Assessment of public health data*. Int. J. Hyg. Environ. Health 212(6), 576-87 (2009)

Glossary and acronyms

Glossary

Acoustic neurinoma

A slow-growing benign tumour affecting the nerve connecting the ear to the brain.

Apoptosis

A process involving programmed death occurring in many tissues in multicellular organisms. It is characterised by morphological and biochemical changes in cells, different from those occurring with necrosis. Apoptosis is associated with homeostatic control in many tissues.

Basic restrictions

Restrictions on the value of magnetic fields, current density, power density, and scientific absorption rate (SAR), based on current scientific data and providing an adequate level of protection from exposure to electromagnetic fields which vary over time. They are based directly on known effects on health and biological considerations.

Bayesian joinpoint

Statistical method, based on Bayes' theorem, which facilitates the identification of trends by means of significant change points in survival from cancer.

Bias

Any deviation from truth in results or the inferences drawn from them, or the processes leading to such deviation.

Blind and double blind study

Types of clinical study. The study is called "blind" if the patient does not know whether he/she is exposed or not and "double blind" if the researcher does not know this until the results are analysed.

Bluetooth

Short distance wireless transmission standard allowing transfer of voice and data between different devices via a link using the 2.4 GHz radio frequency band.

Carcinogenic

A substance or agent that can produce cancer.

Case-control study

A case-control study examines a group of subjects exhibiting a condition (cancer or another disease), who are referred to as "cases", comparing them with another group of individuals, selected by the researcher, who do not exhibit the condition, referred to as "controls". To carry out the analysis we need to determine (retrospectively) how many individuals in each group were exposed to the risk being analysed and to what extent.

CD4+ cells

A type of white blood cell which becomes active in the development of an immune response.

Cerebrovascular disease

A series of disorders in the cerebral vascular system leading to reduced blood flow in the brain, temporarily or permanently affecting the functions of a general area of the brain or a smaller or focal area.

Clinical study

A type of study in which subjects are exposed to the risk factor by the researcher under controlled conditions.

Cohort study

In a cohort study a sample is established (the cohort), consisting of a group of healthy individuals whose exposure or otherwise to the risk factor during the study is known, and this group is monitored over time to determine in how many cases the adverse event occurs.

Cytogenetic effects

Effects produced on genetic cellular material (mainly chromosomes).

DNA damage-activated checkpoint kinase 2

When DNA is damaged (broken) certain kinase proteins are activated (those involved in phosphorylation) and these interrupt the cellular cycle. One of these kinase proteins is kinase 2 ,or chk2. There is also a chk1.

Electric field (E)

The strength of an electric field is a vector value (E) corresponding to the force applied to a charged particle independently of its movement in space. It is expressed in volts per metre (V/m).

Electromagnetic field (EMF)

An electromagnetic field is a combination of an electric field and a magnetic field. Electromagnetic fields (EMFs) may be static (i.e. their strength does not vary over time) or variable. A variable electromagnetic field can be visualised as a wave propagated at the speed of light, associated with an electric field and a magnetic field, both of which are variable. When we speak of variable EMFs we are thus also referring to electromagnetic waves or electromagnetic radiation. The wave carries energy from one point in space to another and is characterised by its frequency and wavelength. The frequency determines the energy that the electromagnetic wave carries. The higher the frequency, the more energy the wave carries. Depending on the frequency, electromagnetic *radiation* is classified as *ionising* or *non-ionising.*

Electromagnetic hypersensitivity

A series of unspecified symptoms (headache, dizziness, disorientation, fatigue, insomnia, among others) which some individuals claim to feel and which they attribute to the presence of electromagnetic fields.

Electromagnetic radiation, *see EMF (electromagnetic fields)*

Electromagnetic waves, *see EMF (electromagnetic fields)*

Frequency (f)

Number of repetitions per unit of time of any repetitive phenomenon. In the case of electromagnetic waves, the frequency is related to the energy carried by the wave, $E = h \cdot f$ *, where E is the energy and h is Planck's constant..* Radio frequency electromagnetic fields have frequencies between 30 kHz and 300 GHz.

Genotoxic

Physical, chemical or biological agents which, directly or indirectly produce alterations in the DNA in cells.

Gliomas

Type of tumour produced in the brain or in the spinal cord. It is called glioma, as it comes from glial cells. It is most often found in the brain.

Haematopoietic stem cells

Cells which, through differentiation, give rise to all the blood and lymphoid cell types.

Idiopathic environmental intolerance (IEI), see electromagnetic hypersensitivity

Immunocomplexes

Complexes arising from the union of antigens and specific antibodies produced by the immune system.

In vitro study

Study conducted outside living organisms, under conditions which attempt to simulate those occurring "in vivo".

In vivo study

Study carried out directly on animals, including human beings, when they are alive or are killed to observe processes taking place directly.

Ionising radiation

Very high energy electromagnetic fields capable of ionising matter, breaking links and separating electrons from the atom.

Ischaemic cardiopathy

Cardiovascular disease characterised by obstruction of the arteries supplying blood to the heart.

Latency period

Interval between the time when a tumour begins to form at cell level and the moment when symptoms can be detected.

Leukaemia

Group of malignant diseases of the bone marrow (haematological cancer) leading to an uncontrolled increase in leucocytes or white blood cells.

Magnetic field (H)

The strength of a magnetic field is a vector value (H) which, together with magnetic induction, determines the magnetic field at any point in space. It is expressed in amperes per metre (A/m).

Mastocytes

Also known as mast cells, they play a protective role in inflammatory processes.

Meningiomas

Benign tumour of the arachnoid cells in the brain meninges

Mitogens

Molecules which bring about cell division.

Mutagens

Agents which bring about random changes in DNA or changes affecting certain specific sequences.

Neoplasia

Tumour, cancer

Neurodegeneration

Neurone death.

Nocebo effect

Unspecified adverse effect caused by the expectation or belief that something is harmful for health.

Non Hodgkin lymphomas

Cancer of the lymphatic tissue, affecting lymphatic ganglia, spleen and organs of the immune system.

Non-ionising radiation

Electromagnetic fields which do not have sufficient energy to break molecular bonds or pull electrons away from the substance they strike. The frequency range of this type of radiation is approximately from low frequencies to ultra-violet.

Organelles

Structures suspended in the cytoplasm of the Eukaryote cell. They have a clearly defined shape and specialised, differentiated functions, with their own lipid membrane envelope.

Oxidative stress

A state in which cells, tissues or other organisms exhibit a high number of free radicals as a result of an imbalance between their production and elimination, leading to faster ageing of cells and tissues, among other things.

Oxygen free radicals

Molecules or fragments of molecules which have one or more unpaired electrons in their outer orbit, making the molecule highly reactive. The commonest, all products of the metabolism, are the superoxide radical, hydrogen peroxide, and the hydroxyl radical.

Phantoms

Physical objects imitating a real biological object. Used to determine how much energy is absorbed from the electromagnetic radiation to which they are exposed. Their electrical characteristics are the same as those of the biological model they replace.

Phosphorylation

The addition of an inorganic phosphate group to any other molecule.

Physiopathological mechanism

Method explaining how damage occurs in cell functions.

Poisson regression model

A Poisson variable regression model is a model which allows us to determine whether the variable depends on one or more other variables.

Power density (S)

Power per unit of area. The radiated power falling perpendicularly on a surface, divided by the area and expressed in watts per square metre (W/m^2).

Promotion mechanism

Action to promote the production of chemical products or physical elements which can act on control mechanisms and cell proliferation emphasising their effects through synergy.

Reference values

Physical values defining electric and magnetic fields and power density, used as a general guide to limit the exposure of workers and the general public. Compliance with reference values ensures compliance with basic restrictions on exposure.

Serotonin (5-Hydroxytryptamine)

A neurotransmitter synthesised by the serotonergic neurones. It is believed to have a bearing on body temperatures, sleep and mood.

Specific absorption rate (SAR)

The power absorbed per unit of mass of body tissue, the average being calculated for the whole body or parts of it and expressed in watts per kilogram (W/kg). Whole body SAR is a widely accepted measurement for relating adverse thermal effects to exposure to radio-electric emissions.

Thermal effects

Effects on cells or organs due to variations in temperature. The best-known effects of radio frequency electromagnetic fields are thermal, i.e. they cause an increase in the temperature of the tissues exposed.

Tinnitus

Buzzing or other noises in the ear. They may be transitory or permanent, soft or loud, with various tones affecting one or both ears.

Wi-Fi

This is a term registered by Wi-Fi Alliance. It is not a technical term. It is used generically to refer to technologies using wireless connections with a narrow range of frequencies.

Acronyms

ACCIS

Automated Childhood Cancer Information System.

http://www-dep.iarc.fr/accis.htm

AENOR

Asociación Española de Normalización y Certificación (Spanish Association for Standardisation and Certification).

http:/www.aenor.es

AFSSA

Agence Française de Sécurité Sanitaire des Aliments (French Agency for Food Health Safety).

AFSSET

Agence Française de Sécurité Sanitaire de l'Environnement et du Travail (French Agency for Environmental and Occupational Health Safety).

http://www.afsset.fr

ANSES

Agence Nationale de la Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail, France (National Agency for Health Safety in Food, the Environment and Work, France).

Formed by the merger of AFSSET and AFSSA, it came into operation on 1 July 2010.

http://www.anses.fr

CCARS

Comité Científico Asesor en Radiofrecuencias y Salud (Scientific Advisory Committee on Radio Frequencies and Health, set up under the auspices of the Madrid Complutense University General Foundation).

http://www.ccars.es

CDMA

Code Division Multiple Access.

CEN

Comité Européen de Normalisation (European Committee for Standardization).

http://www.cen.eu

CENELEC

(Comité Européen de Normalisation Electrotechnique, European Committee for Electrotechnical Standardization), Comité Europeo de Normalización Electrotécnica.

http://www.cenelec.eu

CIEMAT

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Centre for Energy, Environmental and Technological Research).

http://www.ciemat.es

CNS

Central nervous system.

CSIC

Consejo Superior de Investigaciones Científicas (Spanish National Research Council).

http://www.csic.es

CSTEE

Comité Scientifique de Toxicologie, Ecotoxicologie et l'Environnement (Scientific Committee on Toxicity, Ecotoxicity and the Environment - European Commission) .

DCS

Digital Cellular System

DECT

Digital Enhanced Cordless Telecommunications.

DNA

Deoxyribonucleic acid

EMF

Electromagnetic field

ETSI

European Telecommunications Standards Institute.

http://www.etsi.org

EU

European Union

GSM

Group Special Mobile

Global system for mobile communications.

HPA

Health Protection Agency, U.K.

http://www.hpa.org.uk

IARC

International Agency for Research on Cancer.

Part of the World Health Organization (WHO)

http://www.iarc.fr

IEC

International Electrotechnical Commission.

http://www.iec.ch/

IEEE

Institute of Electrical and Electronics Engineers.

http://www.ieee.org

ICNIRP

International Commission on Non-Ionizing Radiation Protection (Sponsored by the WHO)

http://www.icnirp.de

MITyC

Ministerio de Industria, Turismo y Comercio (Spanish Ministry of Industry, Tourism and Trade)

http://www.mityc.es

MPRS

Mobile Phone Related Symptoms

MT

Mobile telephony.

MTHR

Mobile Telecommunications and Health Research Programme), U.K.

http://www.mthr.org.uk/

NCI

National Cancer Institute, USA.

http://www.cancer.gov/

RF

Radio frequency.

SAR

Specific Absorption Rate.

SEER

Surveillance, Epidemiology and End Results Program (NCI), USA

http://seer.cancer.gov

SCENIHR

Scientific Committee on Emerging and Newly Identified Health Risks, European Commission.

http://ec.europa.eu/health/scientific_committees/ merging/index_en.htm

SMS

Short Message Service.

SSI

Swedish Radiation Safety Authority.

http://www.stralsakerhetsmyndigheten.se/Allmanhet

UMTS

Universal Mobile Telecommunications System.

Also known as third generation mobile telephony 3G

W-CDMA

Wideband Code Division Multiple Access.

WHO

World Health Organization.

http://www.who.int

WLAN

Wireless Local Area Network.

WPAN

Wireless Personal Area Network.

Members of CCARS

Chairman

Prof. Emilio Muñoz Ruiz

Chairman of the Scientific Advisory Committee on Radio Frequencies and Health.

Biologist, Graduate and Doctor in Pharmacy, Complutense University of Madrid. Research lecturer *ad honorem* at the Institute of Philosophy, Human and Social Sciences Centre, Spanish National Research Council.

Member of the European Academy of Science and Arts, member of the European Molecular Biology Organisation, member of the Swedish Academy of Engineering Science.

Members

Prof. Ricardo de Ángel Yagüez

Professor of Civil Law, University of Deusto. Permanent member of the General Commission on Codification.

Prof. Jesús Ávila de Grado

Chemist, Graduate and Doctor in Chemical Sciences, Madrid Complutense University. CSIC Research Lecturer at the "Severo Ochoa" Molecular Biology Centre

Member of the Royal Academy of Exact, Physical and Natural Sciences.

Doctor Patricia Crespo del Arco

Physicist, Graduate and Doctor in Physical Sciences, Complutense University of Madrid.

Permanent Lecturer in the Department of Material Physics, Faculty of Physical Sciences, Complutense University of Madrid.

Executive Secretary, CCARS

Dr. Manuel Desco Menéndez

Medical Doctor, Graduate and Doctor in Medicine, Complutense University of Madrid.
Telecommunications Engineer

Research Coordinator at the Hospital General Universitario Gregorio Marañón.

Director of the Medical Imaging Laboratory, Experimental Medicine and Surgery Unit, Hospital General Universitario Gregorio Marañón.

Prof. Vicente Larraga Rodríguez de Vera

Medical doctor. Doctor in Medicine and Surgery, Faculty of Science, Complutense University of Madrid.

Research Lecturer and Director of the CSIC Biological Research Centre.

Doctor Mercedes Martínez Búrdalo

Physicist, Graduate and Doctor in Physical Sciences, Complutense University of Madrid and Diploma in Electronics, University of Paris.

Scientific Researcher in the Department of Electromagnetic Radiation, CSIC Institute of Applied Physics.

Prof. Rafael Peris Bonet

Doctor in Medicine and Surgery, University of Valencia.

Professor of Medical Documentation, University of Valencia, and Director of the National Register of Child Tumours (RNTI-SEHOP).

Prof. Juan Represa de la Guerra

Medical Doctor.

Professor in the Faculty of Medicine, University of Valladolid.

Researcher at the CSIC Institute of Molecular Biology and Genetics.

Prof. Carlos María Romeo Casabona

Doctor of Law, Higher Diploma in Criminology and Doctor of Medicine. Professor of Criminal Law, University of the Basque Country.

Director of the Fundación BBVA–Diputación Foral de Bizkaia Inter-University Chair of Law and Human genomes, University of Deusto and University of the Basque Country.

Prof. José Luis Sebastián Franco

Physicist. Graduate in Physical Sciences, Complutense University of Madrid and Doctorate from the University of Surrey.

Professor of Electricity and Magnetism, Faculty of Physical Sciences, Complutense University of Madrid.

Dr. Francisco Vargas Marcos

Medical doctor, Graduate in Medicine and Surgery, Complutense University of Madrid.

Senior Civil Servant, Medical Practitioner Division, National Health Service.

Prof. Agustín Gregorio Zapata González

Biologist, Doctor of Biological Science.

Professor of Cellular Biology, Complutense University of Madrid.