

INTRODUCTION

In January 2016, the Scientific Advisory Committee on Radiofrequency and Health, known as CCARS, its Spanish acronym, began a new stage. The Official College of Telecommunications Engineers, also known as COIT, has taken over the management and coordination of the CCARS activities that, until then, had been performed by the Fundación General de la Universidad Complutense.

In this new stage, CCARS seeks to consolidate its position as Spain's main reference for evaluating the status of the science studying the effects of radioelectric emissions on health. Our goal is to provide information to society based on the best scientific evidence from a free and independent position that considers the scientific, technological, legal, institutional and social dimension of exposure to radio frequency electromagnetic fields.

CCARS is responsible for collaborating with all public and private institutions and organizations interested in the assessment of risks to health and exposure to radio frequencies. It offers its experience and knowledge to the media and political leaders at State, regional and local levels to inform them clearly and simply about the matter.

This document is the fifth edition of the CCARS report and covers the period of January 2013 to June 2016.

Currently, the Committee composition is as follows:

- Chairman: D. Francisco Javier Lafuente Martínez, former Radiology Chief of Service of the Hospital General Universitario Gregorio Marañón in the Autonomous Community of Madrid.
- Honorary Chairperson: D. Emilio Muñoz Ruiz, Research professor of the Consejo Superior de Investigaciones Científicas (CSIC) in the area of biology and biomedicine.
- Secretary General: D. Miguel Angel García García-Tuñón, researcher for the Consejo Superior de Investigaciones Científicas (CSIC).
- Scientific Director: D. Francisco Vargas, medical epidemiologist and technical adviser to the Ministerio de Sanidad, Servicios Sociales e Igualdad (MSSI).
- Spokespersons:
 - D. Antonio Hernando Grande, Professor of magnetism at Universidad Complutense of Madrid since 1980 and Director of the Instituto de Magnetismo Aplicado at the same university.
 - D. Agustín Gregorio Zapata, Doctor in biology and Professor of cellular biology of the Universidad Complutense de Madrid

- D. Fernando Andrés Las-Heras, Telecommunications engineer, Dr. of Telecommunications Engineering for the Universidad Politécnica de Madrid (UPM) and Professor in the Electrical Engineering Department of the Universidad de Oviedo.
- José Ignacio Alonso Montes, Telecommunications Engineer and Doctor of telecommunications engineering for the Universidad Politécnica de Madrid, and Professor in the UPM Department of Signals, Systems and Radiocommunications.
- Narcís Cardona, UPC telecommunications engineer, Doctor of telecommunications engineering and Professor of the Universidad Politecnica de Valencia (UPC).
- Rafael Herranz Crespo, Bachelor in Medicine and Specialist in Oncology radiation from the Universidad Complutense de Madrid, Professor in the Universidad de Zaragoza, del Pais Vasco and Complutense de Madrid from 1973 until 2014.
- Ricardo de Ángel, Doctor of Law from the University of Granada and Professor of Civil Law of the Law School of the Universidad de Deusto.

Although CCARS assumes collective responsibility for the content of this report, the drafting of the various chapters is responsibility of their author or authors and does not necessarily represent the position of the institution for which they work. The distribution of each chapter's authorship is as follows:

The preface to this report, which includes an introduction to the history electromagnetic fields and their interaction with biological matter, was written by Antonio Hernando.

Chapter 3 describes the methodology used to make this report and was written by Miguel Ángel Garcia.

In Chapter 4 on dosimetry and evaluation of exposure, Narcís Cardona drafted paragraph 4.1 on the RF of new mobile telephony networks; José Ignacio Alonso drafted paragraph 4.2 on wireless systems and health effects and section 4.6 on regulations and levels of exposure in Spain and Fernando Las-Heras presented paragraph 4.3 on electromagnetic fields in millimeter-wave and Terahertz. Rafael Herranz and Javier Lafuente were involved in writing paragraph 4.4 on medical applications of the RF and workplace exposure to EMF, RD 299/2016 and Directive 2013 /35/EU, respectively. Paragraph 4.5 on electromagnetic compatibility of RF was drafted by Francisco Vargas.

Agustín Gregorio Zapata wrote Chapter 5, which deals with experimental studies on cells and animals.

Clinical and epidemiological studies are addressed in Chapter 6. Francisco Vargas wrote Sections 6.1 Brain tumors and 6.2 Electromagnetic Hypersensitivity; Section 6.3, corresponding to the effects on reproduction and development, was written by Javier Lafuente and Miguel Ángel García.

Ricardo de Ángel Yagüez analyzed new policies and the main legal resolutions on risks derived from exposure to EMF in Chapter 7.

Francisco Vargas Marcos wrote Chapter 8 on RF research projects.

The Executive summary, introduction, recommendations and conclusions were written by the Chairman, Secretary General, Scientific Director and the General Technical Secretary of the COIT, from the contributions of all the members of the CCARS.

This report is dedicated to the memory of Dr. Patricia Crespo del Arco, who unfortunately died in 2015; she had been a member of CCARS since its foundation.

1. EXECUTIVE SUMMARY

The main objective of this report is to update scientific evidence on radio frequencies and health published between January of 2013 and June of 2016.

The methodology used is similar to that of earlier reports. The better-designed studies of high methodological quality have been given priority for inclusion in the review process. These types of studies provide objective and relevant information to establish guidelines and recommendations on the effects of radio electromagnetic frequency fields on human health.

Remember that not all the studies published are of equal scientific value. CCARS has evaluated the weight and the quality of the evidence of each study selected for review. Although the research has been exhaustive, some articles were not cited due to their low methodological quality.

Numerous observational studies obtained information about the alleged risks of radio frequencies (mobile phone antennas and mobile phone use) through surveys and interviews. The results of such studies are very subjective and partial, lack objective assessments of exposure to electromagnetic fields and are subject to numerous biases that make their conclusions irrelevant for risk assessment and management. The same can be said of other studies (experimental and epidemiological) that do not provide data on dosimetry, did not use a control group, or their replication is not allowed.

This edition of the report includes new chapters that review the evidence on new aspects such as fourth generation telephony networks, applications of wireless systems (Wi-Fi), in millimeter-wave band electromagnetic fields or Terahertz (airport scanners), electromagnetic compatibility and implantable devices, the use of the RF in medicine and legislation on occupational exposure to electromagnetic fields.

The critical analysis of the evidence indicates that no technical or health reasons exist that justify the arbitrary and discretionary imposition of more demanding exposure limits than those recommended by the WHO-ICNIRP and the European Union. The application of more restrictive limits would involve increasing the number of antennas with the consequent visual, social and economic impact.

The population's RF exposure levels from Wi-Fi devices, well studied in realistic operating conditions, are much lower than those recommended by scientific agencies and committees (WHO-INCNIRP, FCC and IEEE). The conclusions and recommendations of the previous CCARS report (CCARS 2013) on WI-FI networks are still valid.

Regarding airport scanners (work with low power levels, little penetration and surface exposure) and sensors that use wireless technologies (smart counters, IoT, RFID, etc.) the dosimetries show that limits of exposure are much lower than those recommended as safe.

There is sufficient evidence to say that mobile phone use is safe in the hospital environment as long as it is a safe (1 meter) distance from the medical devices-equipment used for monitoring and treatment of patients. Regarding users of implantable devices (e.g. cardiac pacemaker), the use of the phone mobile is safe although a distance of 15 cm. must be maintained. Mobile phone antennas do not cause interference with these devices.

In this period, various rules have been adopted that are of great interest for the evaluation and management of electromagnetic fields, among which stands out Royal Decree 299/2016, which has incorporated Directive 2013/35/EU into our legislation. This new legislation has established less-demanding exposure levels than anticipated in the previous European proposal (Directive 2004/40/EC) on workers' exposure to risks arising from physical agents (electromagnetic fields). At the same time, this exceeds the problems raised by some industrial sectors and by health professionals who work with medical magnetic resonance diagnosis procedures.

Regarding emissions from mobile telephony base stations, the Ministry of Energy, Tourism and Digital Agenda carries out annual inspections that allow verifying compliance with applicable exposure limits. The last report published (November of 2016), found that "the levels of intensity of the electric field (V/m) and power density levels ($\mu\text{W}/\text{cm}^2$), measured by the Administration's Telecommunications Inspection Services is far below the levels of reference established in the Royal Decree 1066/2001." During 2015, the average value was $0.89\mu\text{W}/\text{cm}^2$.

Certifications on the compliance of the limits to emission levels were made correctly and allowed checking that exposure levels in the station environments, where people customarily remain, were below the limits established.

In any case, the methodological problems persist that affect the validity of the experimental studies in animals and cells, so it is necessary to improve designs, standardize protocols, increase the number of samples and objectively evaluate the dosimetry used. In this way, more reliable comparisons may be established between different published studies that prevent the loss of time and both human and material resources.

The results of epidemiological studies in the period reviewed confirm that no higher risk of brain tumors is observed in cell phone users. This conclusion coincides with those of other systematic reviews and risk assessments in the same period by agencies and competent international committees in the evaluation of the effects of electromagnetic fields on health.

Regarding the previous CCARS report, published in 2013, there is no increased risk of brain tumors in people exposed to the radio frequencies emitted by the antennas for mobile telephones, radio and television.

The evolution of the incidence rates of brain tumors in developed countries does not support the relationship between mobile phone use and the perception of an increased risk of developing these tumors.

However, in some segments of the population, there is still a certain contradictory rejection of the antennas of mobile phone and Wi-Fi networks. While their installation is essential to receive quality service, this aversion is not the same with respect to the use of the mobile phone, which is fully integrated into our daily lives.

However, among some people, the beliefs about hypothetical effects of the RF emitted by the mobile phone antennas become an unreasonable fear of these facilities. These people claim to have “Electromagnetic hypersensitivity,” which is not recognized in the international classification of diseases (CIE-WHO); there is no protocol validated and accepted by the scientific community for its diagnosis and treatment.

Controlled clinical studies confirm a causal relationship between exposure to radio frequency sources and symptoms of electromagnetic hypersensitivity. People who claim to suffer from these symptoms are not capable of distinguishing, in experimental conditions, whether or not they are exposed to electromagnetic fields.

New published evidence confirms that there are no adverse health effects deriving from exposure to radio frequencies from telephony mobile antennas, Radio and Television transmission and wireless systems (Wi-Fi) used at work, school or home. Despite this, there have been few advances in the degree of knowledge and information of the population about the effects of electromagnetic fields. To improve the current situation and perform these tasks in an efficient manner, it is necessary to increase public and private financing of communication about research, development and innovation projects on the effects of electromagnetic fields.

The introduction of new technologies and applications of telecommunication systems should be accompanied by pedagogical work on their implications and tips on safe use (driving of vehicles, public transportation), respect (privacy, reducing the volume in public transportation and places of leisure) and responsible use, especially during childhood and adolescence (in school, social networking, internet, etc.).

Information and education should be objective and backed by the best scientific evidence contributed by national and international agencies with accredited experience, responsibility and competition.

Commitment to this task requires coordination and participation of all the parties involved: State, regional and local authorities; Professional Organizations; Scientific associations; Operations or Distribution Companies; Associations of users and consumers; Parents and educators, etc., through an open and transparent dialogue.

2. CONCLUSIONS

New radio frequency sources. Evolution of mobile telephony (2011-2015). Fourth generation (4 G-LTE) mobile networks

- New generation (LTE) mobile networks allow improving mobile services (better quality, higher speed, mobile communications in vehicles, etc.) without increasing the exposure of the population.
- The levels of exposure of the general public to new networks and terminals based on the LTE measured by several international agencies confirm that they are far below the limits considered safe.
- There are no technical or health reasons that justify the arbitrary imposition of much more restrictive exposure limits significantly lower than those recommended by ICNIRP-WHO and the European Union. Applying more restrictive limits means increasing the number of antennas, with the consequent impact (environmental, economic, administrative, etc.).

Wireless systems and health effects

- Wi-Fi devices' peak power density is reasonably well characterized by the data supplied by the various agencies, such as direct measures in various scenarios.
- Exposure levels to RF deriving from Wi-Fi networks, low realistic operating conditions, represent a fraction of the limits set by scientific committees (as the ICNIRP) or Standardization organisms (such as the FCC and the IEEE). All the conclusions and recommendations contained in the previous CCARS report and cited above about Wi-Fi networks are still valid.

EMF in millimeter-wave and Terahertz (THz) bands

- Studies that measure the general public's exposure levels subject to safety inspection, by means of scanners installed at airports, demonstrate that the values the human body received are much lower than those established as safe by the EU and the ICNIRP.
- Dosimetries of sensors that use wireless technologies (IoT, smart counters, RFID, etc.) indicate that exposure levels are far below recommended limits.

- Regarding emerging applications (Drones, UAV, RPA, etc.), it is necessary to make more assessments of dosimetry to establish recommendations for safe use of this type of technologies.

Occupational exposure to radio frequencies. Directive 2013/35/EU and Royal Decree 299/2016.

- Levels of occupational exposure to EMF established in Directive 2013/35/EU and in Royal Decree 299/2016 are less strict than those of Directive 2004/40/CE.
- More permissive values prevent problems posed in Directive 2004/40/CE with the workplace exposure of people who work in some industrial activities and in magnetic resonance imaging diagnosis.
- The long-term effects of chronic occupational exposure are not covered.

Electromagnetic compatibility

- The use of the mobile phone is safe in the hospital as long as a distance of less than 1 meter is kept between them and the medical devices-equipment used to treat or monitor a hospitalized patient.
- When the cell phone is on, it is recommended to keep it at a distance of 15 cm from the cardiac pacemaker.
- Mobile phone antennas do not produce electromagnetic interference in the pacemaker.

Regulations and levels of exposure in Spain.

- Electrical field levels (v/m) and levels of power density ($\mu\text{W}/\text{cm}^2$), measured by telecommunications inspection services of the Administration, field strength levels are well below the reference levels established in Royal Decree 1066/2001. During 2015, these measurement systems have been measured continuously in 43 different locations. A total of 2,390,733 measurements were performed with an average value of $0.89 \mu\text{W}/\text{cm}^2$.

- Certifications regarding compliance with emission levels were carried out correctly and allowed checking that the exposure levels in the station environment, where people usually remain, were below the limits established.

Experimental studies on cells and animals

- As long as the studies do not include a significantly high number of samples and trials and, above all, do not proceed to a standardization of protocols that allows the comparison of the different results among themselves, it will be impossible to reach definitive conclusions.
- It is necessary to design more reliable tools and experimental approaches to deepen the analysis of the pre- and postnatal effects of electromagnetism on living organisms.

Clinical and epidemiological studies. Tumors

- The results of epidemiological studies in the studied period (2013-2016) confirm that there is no increased risk of brain tumors in cell phone users.
- This conclusion coincides with those of other systematic reviews and risk assessments made by agencies and committees competent in evaluating the effects of EMF on health.
- Regarding the previous CCARS report, published in 2013, there is no increased risk of brain tumors in people exposed to the radio frequencies emitted by antennas for mobile telephones, radio and television.
- The evolution of the rates of incidence of brain tumors in developed countries does not support the relationship between cell phone use and a greater risk of suffering these tumors.

Electromagnetic hypersensitivity

- Electromagnetic Hypersensitivity is not a disease recognized in the international classification of diseases (CIE-WHO). There is no protocol validated and accepted by the scientific community for the diagnosis and treatment of EH.

- Controlled clinical studies confirm that there is no causal relationship between the exposure to various radiofrequency sources and electromagnetic hypersensitivity symptoms.
- People who claim to suffer from electromagnetic hypersensitivity, cannot distinguish, under experimental conditions, whether they are exposed to EMF or not.
- New published evidence confirms that there are no adverse health effects deriving from exposure to radio frequencies issued by mobile telephony antennas, Radio and Television transmission and wireless systems (Wi-Fi) used at work, school or home.

Legal aspects of risks derived from the exposure to EMF

- One of the main objectives of law 9/2014, General Law on Telecommunications, on May 9, 2014, is to recover market unity in the telecommunications sector.
- Article 61 regulates the powers of the Government for the administration of the public radioelectric domain, the procedure of determination, control and inspection of the only tolerable radio emission levels that do not pose a danger to public health. These levels must be respected by the different facilities or infrastructures to be installed and already installed that make use of the public radio domain. Such limits must be respected, in any case, by the rest of the public administrations, both autonomous and local.
- An administrative simplification is taking place, replacing licensing with responsibility statement from the local administrations for certain categories of installations that make use of the radioelectric spectrum (antennas).

3. RECOMMENDATIONS

This report indicates that we need to improve the knowledge and information of the population about how RF works and the real effects that electromagnetic fields have on human health.

Some segments of citizens still indicate doubts and uncertainty about the consequences of the use and exposure to new telecommunications technologies. This concern generated responses of rejection of the installation of telecommunication infrastructures; this hampers the development of new technologies and worsens the delivery of quality service.

CCARS considered that, since the publication of the previous report in 2013, there have been very few advances that allow better understanding of the RF fully integrated into our daily lives. Every day that passes, new technological applications expand EMF uses (drones, Internet of things, sensors attached to the human body, smart metering, communications in vehicles, wireless headphones, etc.). The introduction of these technologies is not accompanied by simultaneous pedagogical work on the implications and consequences of their use.

Therefore, CCARS recommends the following measures:

- Financing should be increased for public and private plans and programs for research, development and innovation on the effects of EMF on human beings.
- Our country should have a greater international presence in the research projects in progress and the activities of agencies and competent bodies for EMF risk assessment (WHO, IARC, EU, ICNIRP ; US National Toxicology Program, etc.).
- At the same time, the competent authorities (Ministries of Energy, Tourism, Digital Agenda and Health, Social Services and Equality) should coordinate their activities and enhance cooperation to optimize and monetize the results of public and private research projects on EMF (Mobi kid, COSMOS, Geronimo, WHO EMF Project, Lexnet, etc.).
- Greater collaboration and coordination should be encouraged between the sectors involved (industry, telecommunications operators, professional associations, scientific associations, consumers, etc.) and State, regional and local authorities in the assessment, management and communication of the effects of EMF and RF.

- This collaboration should promote an open and transparent dialogue that facilitates organized implementation and development of new telecommunications technologies.
- The competent authorities should carry out information campaigns and education about EMF, its uses, applications and effects. This information must be objective and based on the best evidence scientific contributed by national and international organizations and agencies with accredited experience, responsibility and competence.
- These informational activities should encourage reasonable use of new technologies especially during childhood and adolescence (middle school, problematic and excessive use, security in Internet and social networks, etc.), use respectful toward other citizens (privacy, public transportation, places of leisure, etc.) and safe use (driving vehicles).
- All exposure level studies and surveillance systems used in our country and in Europe confirm repeatedly that they are hundreds or thousands of times below those recommended by the EU, WHO and the ICNIRP and national legislation (RD1066/2001). Therefore, it is not recommended to invest resources in new surveillance systems that do not provide significant innovation regarding levels of exposure already known.