To: U.S. Dpt. Health and Human ServicePreambles (HHS)

From: International Commission for ElectroMagnetic Safety (ICEMS)

INTRODUCTION

ICEMS is an independent organisation of scientists from several countries who are experts in the interactions between electromagnetic fields and living systems. Founded in 2003, it is headquartered in Venice (Viale Venezia 7) and maintains a website (icems.eu), where visitors can find, inter alia, references to the resolutions adopted by ICEMS and the monographs published following its international meetings: the first, edited by A. R. Liboff, in Electromagnetic Biology and Medicine, Vol. 25, Issue 4 (2006), and the second, edited by L. Giuliani and M. Soffritti, entitled Non-Thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields (EMFs) and Living Matter, published in the European Journal of Oncology Library, Vol. 5 (2010), and available for free download from icems.eu.

ICEMS has been recognised by the Parliamentary Assembly of the Council of Europe (PACE) as an independent association composed of "top scientists and researchers", capable of supporting the 47 member states in the risk assessment and risk management of non-ionising radiation, including the development of standards (PACE Resolution, 11 May 2011, Annex DOC 12608).

ICEMS is ready to collaborate with HHS to improve EMF risk management by providing the EMF/RF information requested by HHS, with reference to the first two questions set out in the press release of 21 September 2026.

HEALTH EXPERIENCES AND CLINICAL OBSERVATIONS

Members of ICEMS have conducted in vivo studies on experimental animals as part of the Istituto B. Ramazzini research programme, funded, inter alia, by ISPESL (an institute under the Italian Ministry of Health) and the Emilia-Romagna Region, producing preliminary results (published in the second Monograph) and subsequently publishing their findings in the following paper: Soffritti M, Giuliani L. *The carcinogenic potential of non-ionizing radiations: The cases of S-50 Hz MF and 1.8 GHz GSM radiofrequency radiation*. Basic Clin Pharmacol Toxicol. 2019 Aug;125 Suppl 3:58-69. https://doi.org/10.1111/bcpt.13215. Epub 2019 Mar 25. PMID: 30801980.

Quote from Abstract: "… *A second project of two large life-span carcinogenic bioassays was conducted on over 3000 Sprague Dawley rats* [the main project on 2450 rats, editors' note] *exposed from prenatal life until natural death to 1.8 GHz GSM of mobile phone radio base station [in far field, editors' note], alone or combined with acute exposure to gamma radiation. Early results from the experiment on 1.8 GHz GSM alone show a statistically significant increase in the incidence of heart malignant schwannoma among males exposed at the highest dose* [50.0 V/m, i. e. 6.63 W/sq.m, to be compared with the U.S. exposure limits at 1.8 GHz, 58.34 V/m i.e. 9.0 W/sq.m, *editors' note*]

This result is complementary to and integrative of the result found in the main study of the U.S. National Toxicology Program (NTP), published in 2017 and assessed in 2018, summarised by the NTP itself as "clear evidence" of carcinogenicity for heart schwannomas in humans. Integrative, since the NTP study was designed to study the effect of radiation in the "near field" – the condition of temporary exposure to mobile phones at distances between 0.5 and 1.5 cm – while the Ramazzini Institute study was designed for the "far field" – the usual exposure condition of people within the range of irradiation from an RBS.

EXPOSURE STANDARDS AND RISK ASSESSMENT

While several scientists, starting with A. Albhom and M. Feychting in Sweden (Epidemiology 2004), as well as the WHO's Interphone Study (2012, Interphone.iarc.fr) and several lawsuits in several countries, assessed or respectively recognised (e.g. Italian Supreme Court, Judgment No. 17438/2012, available for free download from icems.eu) the causal nexus (or a high likelihood of a nexus) between people's exposure (in the near field) to mobile phones, mainly involving heavy ipsilateral head exposure, the assessment of global human exposure to SRBs (in the far field) does not establish a causal nexus with diagnoses of tumours. It could be related to the fact that global exposure rarely reaches values near the exposure limits established in the USA or the EU (although it has increased in recent decades, exposure has not yet reached the exposure limits of 9 W/sq.m at 1.8 GHz due to 2G or 4G services, and 10 W/sq.m at 2.1 GHz or higher for 3G, 4G and 5G services), while the partial exposure level of the head is frequently close to the exposure limit.

It is worth remembering that the French authority ANSES suspended the sale of the Apple iPhone 12 in 2023, since ANSES measured a human partial exposure of 4.85 W/kg due to the mobile phone, compared with the current EU limit of 2.0 W/kg (EU Recommendation 1999/519/EC).

Such an example well illustrates the senseless decision of international standards organisations that provided States with regulations on people's electromagnetic exposures, which caused several cases of cancer – only those ascertained by a court in a lawsuit are known – for partial exposures, while no cancers due to global (whole-body) exposures have yet been ascertained.

It is the consequence of the practice of international standards organisations (formerly ACGIH in the USA in the 1950s, then incorporated into IEEE) of deriving human exposure limits from the thermal threshold, which experiments on mouse behaviour from the middle of the last century indicated to be 4 W/kg, corresponding to human exposure to 100 W/sq.m (the threshold above which mice were no longer able to walk). From the thermal threshold, applying a safety factor equal to 0.02, the global exposure limit has been deduced. But the result could not be applied to partial exposure of the head. Contrary to common sense, the safety factor for partial exposure of the head and trunk was established at 0.50, 25 times greater than the safety factor for global exposure.

The scheme was the same as that of Radioprotection of Ionizing Radiation (IR), but for IR the safety factor was 0.01 for global exposure and partial exposure of the head and heart, and 20 times greater for partial exposure of the arms and legs.

Safety factors for global and partial exposures to NIR were not determined according to science but according to industrial needs, as we can deduce by observing that the frameworks of restrictions on human exposure adopted by the USA and the EU diverge only in the restrictions on exposure of the head and heart: in the USA, the partial exposure limit is 1.6 W/kg (FCC OET Bulletin 65, May 1997), and in the EU it is 2.0 W/kg (Recommendation 1999/519/EC). Furthermore, the EU limit for partial exposure of the heart and head is averaged over 10 g of contiguous tissue, while the corresponding US limit has to be measured as an average over 1 gram of tissue. That "continuous" should make the difference, since otherwise it should be obvious that the US limit is more conservative.

Having disregarded the IR scheme by modifying the exposure limits for partial exposure of the heart and head, it seems due to Nemesis that carcinogenicity has repeatedly affected the heads of patients (neuromas and brain tumours), as recognised in many lawsuits, including cases confirmed by Supreme Courts in some States. Meanwhile, in vivo experiments with sufficient statistical power, namely those conducted by the US NTP and the Ramazzini Institute, have revealed that the heart is another target of cancer, for which we have clear evidence according to the assessed US NTP study, in agreement with the results of the Ramazzini study.

Based on the old postulate that the only interaction of RFs with living matter is the thermal effect – a postulate that ICEMS already called into question in its cited monograph (https://icems.eu/papers.htm) – criticism of such studies is not admissible. The most meaningless criticism, formulated by the FDA during the assessment of the US NTP in vivo study in 2018, is that such an in vivo experiment is based on an animal model that cannot be translated into a human model.

It is the usual recourse to a double standard. The current framework of restrictions on human exposure to NIR is based on experiments regarding the behaviour of mice! In the studies of the US NTP and the Ramazzini Institute, mice were merely replaced by Sprague-Dawley rats, which are recognised as a benchmark for human carcinogenesis.

Furthermore, such criticism does not imply that the non-thermal effect of NIR does not exist – as the U.S. FCC standard would imply and as was also stated by the WHO's EMF Project (see https://icems.eu, Introduction), but never by IARC, the WHO's agency for cancer research. At most, such criticism might lead to the conclusion that it has not been proven that non-thermal RF effects exist in humans, but this cannot be stated with reference to other kinds of animals and plants, suggesting that the worldwide use of wireless phones and terminals for data transfer constitutes a danger to the entire global ecosystem.

The discovery of the carcinogenicity of EMF/RF, as clearly evidenced by the US NTP and the Ramazzini Institute, calls for the adoption of Interim Guidelines, replacing the outdated FCC framework of restrictions for RFs, set out in Bulletin OET 65, in force since May 1997, thirty years ago.

Meanwhile, the scientific community, with HHS potentially playing a role in leading such progress, will provide a new paradigm for deriving a framework of restrictions that includes the protection of people not only from the thermal effects but also from the non-thermal effects of NIR, starting from the discovery of the ion cyclotron resonance effect in aqueous solutions – such as cellular cytoplasm – within the framework of Quantum Electrodynamics of water, which in the last two decades has reached a sufficient degree of reliability and reproducibility to be widely accepted as an explanation for the non-thermal interaction of electric and magnetic fields with living organisms (https://icems.eu/papers.htm).

Such an interaction is also the basis for explaining the non-thermal effect of NIR, due to the coupling of low- and high-frequency radiation, combined in wireless communication networks, as previously highlighted by GJ Hyland in 2000 (Hyland GJ, Physics and biology of mobile telephony. The Lancet 356(9244):1833-1836, 2000 Nov 25, https://www.thelancet.com/journals/lancet/article/PIIS0140673600032438/abstract), confirming the biophysical mechanism of the so-called Adey's window, also thanks to multiple pieces of evidence provided by the EPA in the 1980s (ex pluribus, see Blackman et al. Effects of ELF (1–120 Hz) and modulated (50 Hz) RF fields on the efflux of calcium ions from brain tissue in vitro. Bioelectromagnetics 6(1): 1-11, https://doi.org/10.1002/bem.2250060102).

Neither can we neglect the enhancement of Extremely Low Frequency (ELF) effects when they are carried by the amplitude modulation of an RF signal or are coupled with an HF ripple (Vignati M and L Giuliani. Radiofrequency exposure near High-voltage lines. Env Health Persp 105(S6):1569-1573, 1997 Dec). Nor can we overlook the mutually synergistic role of several carcinogenic pollutants and ELFs, as we may encounter (the previously cited Soffritti M and L Giuliani 2019, https://doi.org/10.1111/bcpt.13215). Such synergisms are surprisingly neglected in the standards adopted by the USA and the EU, IEEE Std. C95-2 (1992e) and ICNIRP Guidelines (1998, 2020), which do not allow people's exposure to ELFs and RFs to be summed in any way, providing two distinct sums for waves with frequencies up to 10 MHz and above 10 MHz, and not allowing their results to be summed as a measure of people's exposure to the risk due solely to electromagnetic fields.

Interim Guidelines for people protection from Non Ionizing Radiation

As interim guidelines or standards to be recognised by HHS or the FCC, as well as by the European Parliament, which was excluded from the decision on Recommendation 1999/519/EC because it was adopted only by the Council of the European Community, we recommend that the scheme derived from IR radioprotection be adopted, without tricks or pretences, assuming an updated and more accurate threshold, based on the symptomatic evidence of tumours in rats instead of failures in the behaviour of mice, as has been the case until now. Once such a threshold is established, for the interim adoption of the safety standard, a safety factor would be applied, valid for both people's global exposure and partial exposure of the head and trunk.

Interim Guidelines should follow the framework of the US standard, where the risk due to global (whole-body) exposure to RFs is expressed in terms of physical quantities measuring the electric

field, magnetic field and Poynting vector (power density), rather than SAR (Specific Absorption Rate). Indeed, SAR is related only to the thermal effect of electromagnetic fields, and it is not adequate for measuring non-thermal effects due to repeated global exposures. Moreover, SAR is not properly a physical quantity, since it is not defined at the discontinuous interfaces of human organs and is not easily measurable, as a phantom with tissues similar to human tissues is needed to take into account the conductivity and density of all the tissues in a body. Therefore, citizens' or consumers' ability to independently assess the actual extent of the electromagnetic risk to which they are exposed is not guaranteed.

Countries where SAR is not the reference quantity for measuring global (whole-body) exposure to NIR are (with the year of adoption of their standards in brackets):

Russia (2003), China (2003), Italy (1998), Switzerland (1999), Luxembourg and seven other EU countries (after 2001; some of them withdrew such precautionary standards in the 2020s, adopting Recommendation 1999/519/EC).

We have to consider two different scenarios, each providing interim exposure limits:

1. Global Exposures to RFs in Far Field and in Propagation Zone of Near Field to RFs

    - Risk threshold: between 25 and 50 V/m (i.e. 1.66 and 6,62 W/sq.m), as has been ascertained in the large-scale carcinogenesis bioassay conducted by the Ramazzini Institute (Falcioni L et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Env Res 165:496-503, 2018, https://doi.org/10.1016/j.envres.2018.01.037).
    - Safety factor: 50 - the justification is given in the previous paragraph.
      Range of the computed exposure limits (EL), according to the assumptions:

      $$3.5\ V/m < EL < 7.1\ V/m \text{ (i.e. } 25.7 mW/sq.m < EL < 51.5\ mW/sq.m) \quad (1)$$

      This is the same range within which the exposure limits of Italy (6 V/m), Switzerland (5 V/m) and Poland (7 V/m) were established, respectively in 1998 (Regulation 1998/381, on the basis of the unanimous Parliamentary Resolution 1-00360/1999, based on Giuliani L. Proposta dell'ISPESL. Atti del XXX Congresso dell'AIRM, Cavalese 5–8 Feb 1998, Prov. Aut. Trento Copisteria Trento 1998), in 1999 (Federal Ordinance ORNI, 23 Dec 1999) and in 2002..

2. Partial Exposure of head and trunk to RFs in Reaction Zone of Near Field
   Based on the studies conducted by the US National Toxicology Program (NTP) of the NIEHS (Ron Melnick et al. 2017, also see Official NTP Technical Report 595/596), the lowest Specific Absorption Rate (SAR) at which malignant cardiac tumours were observed in male Sprague-Dawley rats was 1.5 W/kg, expressed as whole-body averaged SAR.

However, it is important to distinguish between:

- 1.5 W/kg: The lowest experimental exposure level at which malignant cardiac schwannomas were observed.
- 3 and 6 W/kg: The two higher exposure levels at which tumour incidence varied depending on the radiofrequency modulation.
- Biological threshold (cutoff): The study did not establish a definitive SAR threshold below which carcinogenic effects cannot occur.

An important technical clarification: the NTP studies used GSM and CDMA modulation.

NTP experimental results

The following table summarizes the incidence of malignant cardiac schwannomas in male Sprague-Dawley rats, as reported in NTP Technical Report 595 (2018), Tables 20 and 47.

Whole-body SAR	GSM	CDMA
0 W/kg (controls)	0/90	0/90
1.5 W/kg	2/90 (2.2%)	2/90 (2.2%)
3 W/kg	1/90 (1.1%)	3/90 (3.3%)
6 W/kg	5/90 (5.6%)	6/90 (6.7%)

Statistical interpretation

The distinction between tumor occurrence and statistical significance is essential.

At 1.5 W/kg and at 3.0 W/kg, malignant cardiac schwannomas were observed, but the increase compared with the control group was not individually statistically significant. However, the NTP reported a statistically significant positive exposure-response trend. For CDMA exposure, the increase at 6 W/kg was also statistically significant compared with controls.

Based on the overall findings, the NTP classified the occurrence of malignant cardiac schwannomas in male rats as “clear evidence of carcinogenic activity.”

Conclusive results

1.5 W/kg is the cutoff of the epidemiological study as the lowest experimentally tested whole-body averaged SAR associated with the occurrence of malignant cardiac schwannomas. However, 1.5 W/kg should not be interpreted as a scientifically established carcinogenicity threshold, nor as an exposure level at which a statistically significant increase in cardiac tumour incidence has been independently demonstrated. As a consequence, the NTP findings do not establish a safe threshold below which carcinogenic effects are impossible.

However, 3.0 W/kg whole-body averaged SAR has been considered by the NTP as the LOAEL (Lowest Observed Adverse Effect Level), above which carcinogenic effects are possible.
Thus, we can deduce the range providing the exposure limit for the head and trunk, based on the best experimental results available today:

$$3.0\ W/Kg \leq L \leq 6.0\ W/Kg \qquad (2)$$

where L represents the SAR limit, not yet the exposure limit.
To the upper range, we have to apply the usual redundancy factor in order to ensure the prudent use of mobile phones and data transmitters, since the head and trunk might not tolerate exposure levels higher than those of the whole body, as in radioprotection against ionising radiation.

- Safety factor: 50

getting the following range:

$$60\ mW/Kg < L < 120\ mW/Kg \qquad (3).$$

Relationship Between SAR and Far-Field Power Density

Let us reduce to the exposure in *far field,* since mobile terminals for telephony and data transfer generally use electric antenna inside, thus we can substitute in every involved algorithm

$P=E^2/Z$, where Z is the impedance to propagation, instead of $P=E \bullet H$

(bold characters are used meaning vectors or scalar product, current font meaning scalars).

Another approximation is introduced by reducing the analysis to the case of SAR in homogeneous tissues, with given conductivity and density.

In the far field, incident electromagnetic power density, P (W/m^2), and specific absorption rate, SAR (W/kg), can be related by combining the plane-wave Poynting relation with the local energy-dissipation equation in tissue. Conversion between the two quantities depends on frequency, tissue properties, wave polarisation, and exposure geometry. It is useful to introduce the distinction between the power density of a wave touching a tissue, which will be indicated by the subscript “inc”, and that of the same wave outside the body. The same applies to other vectors or scalars. RMS indicates the average of a wave over a wavelength.

1. Fundamental far-field relationship

For a uniform plane wave in free space, the time-averaged incident power density is:

$$P_{inc} = E_{inc,RMS}^2 / Z_o \qquad (4)$$

Here $E_{inc,RMS}$ is the Root Mean Square of the incident electric-field amplitude (V/m), and $Z_o \approx 376.73\ \Omega$ is the free-space wave impedance.

The local SAR in a tissue with conductivity σ (S/m) and mass density ρ (kg/m³) is:

$$SAR = \sigma E_{tissue,RMS}^2 / \rho \qquad (5)$$

Let us define the electric-field transfer factor

$$k_E = E_{tissue,RMS} / E_{inc,RMS} \qquad (6).$$

Combining (5) and (6) we get:

$$P_{inc}=SAR\ \rho /(k^2\sigma Z_o) \qquad (7)$$

The transfer factor depends on frequency, polarization, anatomical geometry, reflection, and depth. It must be determined for the particular exposure configuration.

2. Consider normal incidence from air onto a homogeneous, isotropic, lossy tissue half-space.

The tissue intrinsic impedance and surface electric-field transmission coefficient are:

$$\eta_t = \sqrt{[j\omega\mu / (\sigma + j\omega\varepsilon)]} \qquad (8)$$

$$k_{E0} = 2\eta_t / (Z_o + \eta_t) \qquad (9)$$

With field-amplitude attenuation constant α and depth z measured into the tissue, the transmitted field magnitude decreases as $e^{-\alpha z}$. Therefore:

$$P_{inc} = SAR(z)\ \rho / (\sigma Z_o\ |2\eta_t / (Z_o + \eta_t)|^2\ e^{-2\alpha z}) \qquad (10)$$

This expression gives local SAR under the stated idealized assumptions, that are not generally suitable for computing the SAR in a human head, given the P_{inc}. 0,20 W/kg. Local SAR is not the averaged SAR on a volume of tissue, but the local value extrapolated at internal surface of a homogeneous half space, in the infinitesimal limit of z^+Thank to such an assumption $e^{-2\alpha z}=1$, in (10).

3. Numerical illustration at 900 MHz

Assume a homogeneous tissue with relative permittivity $\varepsilon_r = 45$, conductivity $\sigma = 0.9$ S/m, density $\rho = 1050$ kg/m³, and SAR(0)= 200 mW/Kg, incident power density $P_{inc} = 10$ W/m². At 900 MHz, the tissue impedance is approximately $\eta_t = (53 + j10)\ \Omega$ and the magnitude of the surface transmission factor is approximately $k_{E0} = 0.25$.

SAR(0,900 MHz) ≈ (0.9 × 376.73 / 1050) × 0.063x 0.25^2 × 10

This illustrative result is a local surface value for the half-space model. It is not a 1-g or 10-g averaged SAR and should not be treated as a prediction for an actual head or phone. Anyway, it provides a way to calculate the SAR to which a person can be exposed and, vice versa, the possibility of computing the maximum admissible P_{inc} to which that person can be exposed.

Inverse Calculation: Incident Power Density from Local SAR 900 MHz - Normal incidence on a homogeneous tissue half-space
Objective: calculate incident far-field power density starting from SAR(0) = 0.2 W/kg, using the same rounded transmission coefficient and material parameters as in the preceding example.

1. Input data

Quantity Value

Local SAR in the infinitesimal limit of z ($z = 0^+$) = 0.2034 W/kg

Frequency =900 MHz

Tissue conductivity σ(900 MHz) = 0.9 S/m

Tissue mass density ρ= 1050 kg/m³

Free-space wave impedance (Z_0) = 376.73 ohms

Squared electric-field transmission factor k_E^2= 0.063 (dimensionless)

2. Start with the local SAR equation

$SAR(0, 900\ MHz) = (\sigma \times Z_0 \times k_E^2 / \rho) \times P_{inc}$

Solving algebraically for the incident power density:

$P_{inc} = SAR(0, 900\ MHz) \times \rho] / (\sigma \times Z_0 \times k_E^2)$

3. Substitute the numerical values

$P_{inc} = (0.2034 \times 1050) / (0.9 \times 376.73 \times 0.06)\ W/m^2$

$P_{inc} = 213.57 / 21.36\ W/m^2$

$P_{inc} = 9.999\ W/m^2 \cong 10.0\ W/m^2$

4. Interpretation and limitations

The result is approximately 10 W/m². The small deviation from exactly 10 W/m² arises from rounding the SAR and transmission coefficient k_E. The 900 MHz frequency has been embodied in the assumed tissue parameters η_t and transmission factor k_E.

This is an inverse calculation for local SAR immediately inside the surface ($z = 0^+$). It is not a calculation of SAR averaged over 1 g, 10 g, or an entire organ. The factor k_E^2 = 0.063 is retained deliberately to reproduce the original approximate example, rather than recomputed from dielectric parameters.

Model assumptions: monochromatic plane wave, normal incidence, planar air–tissue interface, homogeneous semi-infinite tissue, linear response, and no additional tissue layers.

Exposure limits for partial exposure to head and trunk starting from SAR-limits

Given the linearity of the relationship between SAR(f) and P(f), we can deduce a range of partial exposure limits EL from the SAR limits in (3), using (10). Computing for a frequency of 900 MHz and a null spessor of the target, homogeneous semi-infinite tissue, we get the interval (P_1, P_2), where

$$P_1 = 0.06/0.2 * 10\ W/m^2 = 3\ W/m^2$$

$$P_2 = 0.12/0.2 * 10\ W/m^2 = 6\ W/m^2$$

i.e. the range

$$3\ W/m^2 \leq EL \leq 6\ W/m^2 \qquad (11)$$

and coming back to the electric and magnetic fields at 900 MHz

$$33.6\ V/m \leq EL_E \leq 47.5\ V/m \qquad (11')$$

$$0.089\ A/m \leq EL_H \leq 0.126\ A/m \qquad (11'').$$

(11') and (11") appear to be simultaneous exposure limits to be respected in reactive Near Field of an antenna emitting 900 MHz.

Taking in count the NTP result for the exposures at 1.5 W/Kg, we recommend the adoption of the EL close to the lowest value in the range, as a cutionary measure.

In the same way the ranges for L and EL, EL_E, EL_H depending on other frequencies between 100 MHz and 100 GHz can be deduced.

Conclusion

Since the carcinogenic bioassays of the US NTP of NIEHS and the Ramazzini Institute have proven that there are non-thermal adverse effects of NIR on humans, it is urgent to establish human exposure limits and dosimetric limits for RFs. Such limits shall be interim ceiling values until the mechanisms of interaction between electromagnetic fields and living matter are fully clarified. Every delay will cause the occurrence of tumours in several human cases, such as those that have been ascertained by courts in several countries around the world, and the occurrence not only of many diseases related to tumours but also of atypical syndromes such as Electromagnetic Hypersensitivity (EHS) worldwide.

Venice, 20 ottobre 2026

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