Biological Effects of Low-intensity Radiofrequency Electromagnetic Radiation
Time for a Paradigm Shift in Regulation of Public Exposure

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Oceania Radiofrequency Scientific Advisory Association (ORSAA)
RF-EMR Exposure has Skyrocketed!

Natural background RF-EMR: 
\(<10^{-15} \text{ W/m}^2\)

100 – 200 m from Mobile Phone Base Station: 
7.5 \times 10^{-2} \text{ W/m}^2

At 0.3m from a WiFi laptop: 
4.7 \times 10^{-2} \text{ W/m}^2

ARPANSA standard: 
2 -10 \text{ W/m}^2

Bioinitiative recommendation: 
3 \times 10^{-5} \text{ W/m}^2

Raines, J. K. Electromagnetic field interactions with the human body: observed effects and theories. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, Greenbelt, Maryland 20771 (1981), Fig. 3, pp 9.
RF exposure (μW/m²) at Stockholm Central Station, Sweden. Mean exposure 2,817 μW/m² (2.8 x 10⁻³ W/m²).
Red line: exposure limit of 30 μW/m² suggested by the Bioinitiative Report. 9 November 2015.

At the World Health Organization, Geneva, Switzerland. Mean 21.5 μW/m² (2.1 x 10⁻⁵ W/m²).
3 March 2017.
EME Spy 200 exposimeter (88-5,850 MHz) used.

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has set exposure standards (RPS3 - 2002)
• Based on 1998 guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP)
• Based on short-term thermal (heating) effects
• 6 minutes
The FCC’s current exposure guidelines, as well as those of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection, are thermally based, and do not apply to chronic, nonthermal exposure situations.

...that results from an increase in body temperature. The FCC’s exposure guideline is considered protective of effects arising from a thermal mechanism but not from all possible mechanisms. Therefore, the generalization by many that the guidelines protect human beings from harm by any or all mechanisms is not justified.

Sincerely,

Norbert Hankin
Center for Science and Risk Assessment
Radiation Protection Division
No Scientific Consensus on “Safe Limits” of RF-EMR

- Exposure standards/guidelines vary between countries by up to 1000 times

- 225 EMF scientists from 41 countries have appealed to the WHO and the UN for biologically-based exposure guidelines – International EMF Scientist Appeal
Mobile phone radiation alters brain glucose metabolism

NIH USA study
47 healthy participants. “on”: 50 min mobile phone exposure on right side

Brain Glucose Metabolic Images Showing Axial Planes at the Level of the Orbitofrontal Cortex. Glucose metabolism in right orbitofrontal cortex was higher for the “on” than for the “off” condition (Volkow N et al., JAMA. 2011; 305(8): 808–813).
Investigating RF-EMR Effects at Cellular and Subcellular Level

Image credit: Pearson Education Inc, Benjamin Cummings.
Biological Effects Occur at “low intensity” Exposures

- Increase cellular Oxidative Stress
- Change membrane voltage-gated ion channels
- Alter gene expression - mRNA, protein
- Genotoxic effects (DNA damage)
- Cell membrane damage - blood brain barrier
- Metabolic, immune, hormonal disruption
- Sperm damage
- Neuro-behavioural problems
- Cancer initiation/promotion
Low-intensity RF-EMR Causes Oxidative Stress in Cells

Emeritus Prof. Frank Barnes, Uni of Colorado, former Chair of Electronic Devices Society of IEEE, Vice President of IEEE publication activities.
Emeritus Prof. Ben Greenebaum, Uni of Wisconsin-Parkside, former long-serving Editor-in-Chief of Bioelectromagnetics

Some Effects of Weak Magnetic Fields on Biological Systems

RF fields can change radical concentrations and cancer cell growth rates

Our Review of Oxidative Stress Studies

- Our database contains over 2400 studies at present (http://www.orsaa.org/resources.html)
- Analysed studies with endpoints related to oxidative stress – 25 July 2017
Oxidative Stress Studies

- 242 studies investigating OS
- Only one before the year 2000
- 55 (23%) between 2005-2009
- 173 (72%) since 2010
Low Intensity RF-EMR Causes Oxidative Stress in Cells

- We found 216 positive studies and 26 negative studies
Oxidative Stress Studies – Origin

- 242 studies done in 29 countries
- Australia only 1 study – Effect
- USA – 7 out of 8 Effect
- China all 26 Effect
- India all 35 Effect
- Turkey – 76 out of 80 Effect

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Oxidative Stress and its Implications in Health

Maintaining the Redox Homeostasis is critically important for cellular health
>> disruption in favour of pro-oxidants causes oxidative stress
>> direct damage to biomolecules and disrupt biological functions

Image of scale credit: Julia Hansen (Stock Vector)
Risk Evaluation of Potential Environmental Hazards From Low Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods

A project funded by the European Union under the programme "Quality of Life and Management of Living Resources", Key Action 4 "Environment and Health": QLK4-CT-1999-01574
RF-EMR Can Damage DNA in Brain Cells *in vivo*

DNA breaks in brain cells of rats exposed to 2 hours of 2.45 GHz non-thermal RF-EMR at 1.2W/kg whole body exposure (pulsed or continuous waves) vs. sham exposure.

Brains removed 4 hr after the exposure and DNA examined.


US National Toxicology Program confirmed DNA damage by RF in 2016.
ROS and RNS Mediate Cellular Signal Transduction AND Control Key Biological Functions

Critically important:
- concentrations
- location

Control:
- Metabolism
- Growth
- Immune functions
- Hormonal functions

RF-EMR

Multi System Dysfunction

Reduced Melatonin
Reduced antioxidant protection

Increased oxidative stress and resultant cellular damage

Immune dysfunction

Chronic Disease
RF- EMR Can Damage the Male Reproductive Cells

Mobile Phones May Cause Breast Cancer

Low Intensity RF-EMR Causes Oxidative Stress

- ARPANSA claim “the putative link between RF energy and altered ROS production remains tenuous”* is incorrect and risks public health

- ARPANSA should have assigned a team of cell biologists and clinicians experienced in oxidative stress research to conduct their review on *in vitro* and *in vivo* studies instead of relying on a single biophysicist with limited expertise.

* ARPANSA TRS-164, pp7 (2014)
Conclusion

• There are biological/health effects at currently permitted RF exposures

• ARPANSA statement “The ARPANSA Standard is based on scientific research that shows the levels at which harmful effects occur and it sets limits, based on international guidelines, well below these harmful levels.”* is not supported by the scientific evidence.

• ARPANSA should take immediate measures to:
  - Reassess the scientific evidence on biological effects of RF-EMR
  - Set a new Standard based on biological effects, discarding thermally-based ICNIRP guidelines
  - Inform the Australian public of the potential risks
  - Educate the public on exposure reduction – particularly of children
  - Advise the government to give preference to wired communication systems over wireless

* ARPANSA Fact Sheet “Mobile Phones and Health”
Additional Slides if needed for Q & A
RF-EMR Can Affect Foetal and Early Childhood Development

The age of iPads, iPotties and iTeddies
Neuro-behavioural problems are the leading cause of health burden on in young Australians

Latest data from Australian Institute for Health & Welfare (2016 release)
There is a Pandemic of Developmental Neurotoxicity

“To control the pandemic of developmental neurotoxicity, we propose a global prevention strategy”

Dr. Philippe Grandjean, MD and Dr. Philip J Landrigan, MD

Neurobehavioural effects of developmental toxicity. Lancet Neurology: 14 February 2014
DOI: http://dx.doi.org/10.1016/S1474-4422(13)70278-3
EMR Can Alter Brain Development & Behaviour

In assessing the biological effects, it was found that behavior was the most sensitive biological component to RF/MW irradiation. It was observed that behavioral effects were

- Pre/post-natal exposure to cell phones associated with behavioural problems and hyperactivity in children – Danish study on 13,000 mothers and children. (Divan HA et al., Epidemiology 2008;19:523-529)

- Prenatal exposure to cellphone radiation caused structural and functional deficits in the brains of mice - ADHD like behaviour (Aldad TS et al., Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice. Scientific Reports. 2012;2:312)

- Dr. Martha Herbert (Harvard Uni/Massachusetts General Hospital) shows how EMR can contribute to autism (Herbert M and Sage C. Pathophysiology. 2013 Jun;20(3):191-209)

Neuro-behavioural Symptoms Near RF-EMR Transmitters

Mobile Base Stations
- France - Santini et al., Electromag Biol Med. 2003; 22;41-49.
- Austria - Hutter et al., Occup Environ Med 2006; 63;307-313.
- Egypt - Abdel-Rassoul et al., Neurotoxicology 2007; 28;434-440.
- Germany - Blettner et al., Occup Environ Med 2009; 66;118-123.
- Germany - Eger H & Manfred J. Umwelt·Medizin·Gesellschaft, Feb 2010: 130-139.
- Iran - Shahbazi-Gahrouei et al., Electromagn Biol Med 2014;33(3):206-10

Military Radar
- Cyprus - Preece et al., Occup Environ Med 2007;64;402–408.

Broadcast Tower

All above 15 studies found increased symptoms
EMR and Neurological Symptoms/ Cognitive Effects

• Headache, lethargy, dizziness, cognitive deficits, decreased concentration, dysasthesia and other neurological symptoms  (Hocking B and Gobbo F. J Health Saf Environ 2011, 27(3): 185-195; Reeves G. “Review of Extensive workups of 34 USAF Patients Overexposed to RF.” Aviat Aero Envt Med 2000; 71(3); 206–215) and Hocking B. 2001; 72(6); 590-1. )

• Memory loss, difficulty concentrating, irritability and depression in US embassy workers in Moscow exposed to RF-EMR (outside max. 5 μW/cm2, inside <0.1 μW/cm2) Lilienfeld AM et al., Foreign service health status study - evaluation of health status of foreign service and other employees from selected eastern European posts. Final Report (Contract number 6025-619073) to the U.S. Department of State, July 31, 1978.

• Increased headaches/migraine associated with mobile phone use in 52,680 Danish 7 year olds  (Sudan M. et al., The Open Pediatric Medicine Journal, 2012, 6, 46-52).

• Neuro-behavioural effects associated with mobile/cordless phones in high school students in NZ  (Redmayne M et al., Environmental Health 2013, 12:5).

• Mobile phone use associated with faster but less accurate responses to cognitive tasks in 13 year old Australian students  (Abramson MJ et al., Bioelectromagnetics. 2009 Dec;30(8):678-86)

• Mobile phone use affects cognitive functions of adolescents, young adults and older adults  (Leung S et al., Clin Neurophysiol. 2011 Nov;122(11):2203-16; Thomas S et al., Occup Environ Med. 2010 Dec;67(12):861-6;
Cancer Deaths Near Mobile Base Stations

Cancer deaths within 500m from MBS: 6724/7191 = 93.5%
Can’t prove causality but needs to be considered with other evidence

(Dode et al., Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. Science of The Total Environment 2011;409:3649–65)
Cancer Clusters Near Radio/TV/Mobile Transmitters

**Australia** – increased childhood leukaemia incidence and mortality near radio/TV transmitters in N. Syd (Hocking B et al., Med J Aust. 1996; 165(11-12):601-5)


**Vatican City** – increased leukaemia (Micholozzi P. et al., Regional Health Authority, Ronie, Italy. Epidemiology, July 1998, Vol 9, Number 4, Supplement 354P)


**Germany** – increased cancer within 400 m of MBS (Eger et al., Umwelt Medizin Gesellschaft 2004;17(4) 1-7)

**Israel** – increased cancer (Wolf & Wolf, 2004 Int J Cancer Prevention 1(2):2-19)

**Korea** – increased cancer in women near a radio tower (Ha M et al., Arch Environ Health, 2003; 58(12) 756-62) and increased childhood leukaemia (Ha M et al., Am J Epidemiol. 2007;166(3):270-9)

**Brazil** – Increased cancer mortality near MBS (Dode et al., Science of The Total Environment 2011;409:3649–65)
RF-EMR and Cancer – animal studies

- **US govt study** found non-thermal exposure for 2 years to 2.45 GHz (WiFi and radar frequency) **caused 4 times more cancers** in exposed rats.


- **US National Toxicology Program** – **preliminary data release 2016**

  Significant increase in cancer risk in irradiated rats
RF-EMR is Associated with Cancer – Human Evidence

Use of a mobile phone >10 years increases brain cancer risk > 100%

• Interphone (13 countries): 5,117 cases
• Hardell study (Swedish): 3,439 cases
• CERENAT study (French): 447 cases

RF-EMR Can Damage DNA

Published Review - 2009

49 studies - genotoxic effects (DNA damage)
43 studies - no genotoxic effects (no DNA damage)

Ruediger, HW, "Genotoxic effects of radiofrequency electromagnetic fields"
Pathophysiology, 2009;16 (2–3): 67–69

2006 to October 2014

84 studies – genotoxic effects
41 studies - no genotoxic effects

Prof. Henry Lai (Washington University)

Over 100 peer-reviewed studies showing DNA damage

2016 – data released by US National Toxicology Program confirms DNA damage
RF- EMR Can Damage the Male Reproductive System

Review of **10 studies** (semen from **1492 men**) showed damage to sperm Adams JA et al., Effect of mobile telephones on sperm quality: A systematic review and meta-analysis. Environ Int. 2014;70:106-12

**4 hour** exposure to WiFi-enabled laptop damaged sperm Avendano C et al., Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. Fertil Steril; 2012;97(1):39-45


Review of **27 studies** investigating the effects of RF-EMR on the male reproductive system – **21 reported negative consequences** Houston BJ et al, Reproduction. 2016 Dec;152(6):R263-R276. Epub 2016 Sep 6

- **Low Fertility**
- Increased risk of genetic defects in future generations
- **Erectile dysfunction (impotence)**
- Increased risk of testicular and prostrate cancer
Evidence of RF-EMR Non-thermal Bioeffects – Key Scientific Reports

Commissioned by Governments:

- Bibliography of Reported Biological Phenomena ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-frequency Radiation, Naval Medical Research Institute, 1971 (USA).
- Biological Effects of Electromagnetic Radiation (Radiowaves and Microwaves) - Eurasian Communist Countries. Army Medical Intelligence and Information Agency - Office of the Surgeon General, 1976 (USA).

Commissioned by Telecommunications Industry:

- ECOLOG Institute Report for T-Mobil, DeTeMobil Deutsche Telekom MobilNet GmbH. 2000 (Germany)

Prepared by Independent Scientists:


The WHO’s International Agency for Research on Cancer:

Electro-hypersensitivity is Similar to Acute Radiation Syndrome

• Symptoms of ARS may include **nausea, vomiting, headache, and diarrhea**.
  - These symptoms start **within minutes to days after the exposure**, can last for minutes up to several days, and **may come and go**.
• After the initial symptoms, a person usually looks and feels healthy for a period of time, after which he or she will become sick again with **variable symptoms and severity** that vary depending on the radiation dose that he or she received.
  - These symptoms include **loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly even seizures and coma**.
  - This seriously ill stage may last from a few hours up to several months.
• People who receive a high radiation dose also can have **skin damage**. This damage can start to show **within a few hours after exposure or it may be delayed for several days**. It can **include swelling, itching, and redness of the skin (like a bad sunburn)** or may be more severe and include blisters or ulcers.
  - The skin **may heal for a short time, followed by the return of swelling, itching, and redness days or weeks later**.
  - Complete healing of the skin may take from several weeks up to a few years.
  - The time for skin to heal depends on the radiation dose the person’s skin received.
  - People who receive a high radiation dose to all or part of the body also may experience temporary hair loss. It may take several weeks for the hair to grow back.