

## **Chronic Exposures to Low-Level, Nonionizing Radiation A Literature Review Compiled by Roger Mattson**

### **A. Critics of Standards that Do Not Account for Chronic, Low-Level Exposures**

**These are organizations from around the world that have expressed concern that small doses of nonionizing radiation accumulating over a long period of time will eventually lead to harmful effects. Note that the Federal Communications Commission of the United States is one of those organizations.**

1. US National Council on Radiation Protection and Measurements (1986)
2. US Environmental Protection Agency (1993,1996, 1999)
3. Swedish National Board of Occupational Safety and Health; National Board of Housing, Building and Planning; National Electric Safety Board; National Board of Health and Welfare; and Radiation Protection Institute (The Precautionary Principle for Low Frequency Electrical and Magnetic Fields 1996)
4. US National Institute of Environmental Health Sciences of the National Institutes of Health (NIEHS Working Group Report, August 1998)
5. Switzerland Agency for Public Health (For "prudent avoidance" adopted  $2 \mu\text{W}/\text{cm}^2$  for the frequency range 10-400 MHz, 1999)
6. US Federal Radiofrequency Interagency Working Group (*Guidelines Statement*, June 1999)
  - National Institute of Occupational Safety
  - Federal Communications Commission
  - Environmental Protection Agency
  - National Telecommunication and Information Agency
  - Food and Drug Administration
7. US Food and Drug Administration (*Epidemiology*, Owen, March 2000)
8. US National Institutes of Health, National Institute for Environmental Health Sciences, National Toxicology Program (Recommendation from FDA, February 2000)
9. Colorado Department of Health (Testimony of Dr. Hoffman to Jefferson County Commissioners, 1999)
10. Independent Expert Group of the Parliament of the United Kingdom (Stewart Report, May 2000)

11. Scottish Parliament Inquiry on Telecommunications Development (Guidelines, 2000)
12. World Health Organization, International Agency on Research for Cancer (International Electromagnetic Fields Project, 2001)
13. Italian Institute for Prevention and Work Safety, International Conference on State of Research on Electromagnetic Fields (2002)
14. California EMF Risk Evaluation (2002)

## **B. Evidence of Chronic, Low-Level Exposure to Nonionizing Radiation Causing Biological Effects**

**These are researchers who have observed but cannot yet fully describe the causal relationship between nonionizing radiation and biological effects in living organisms.**

1. De Pomerai (2002) reports in *Enzyme Microbial Tech* prolonged exposure to weak microwave fields (750–1000 MHz, 0.5 W) induces a heat-shock response in worms.
2. Michelozzi (2002) in *American Journal of Epidemiology* reports epidemiologic studies suggesting an association between lymphatic and hematopoietic cancers in humans exposed within 10 km of high-frequency electromagnetic fields (100 kHz to 300 GHz) generated by radio and television transmitters.<sup>1</sup>
3. Boscolo (2001) in *Science of Total Environment* reports Radiofrequency Radiation (RFR) from radio/television towers affects the immune system in women at levels as low as 5  $\mu\text{W}/\text{cm}^2$ .
4. Santini (2001) reports in *Pathological Biology* that there is a range of effects observed in humans from wireless antenna sites out to 300 meters.
5. Stang (2001) reported in *Epidemiology* on the possible role of radiofrequency radiation in development of uveal melanoma.
6. De Pomerai (2000) reports in *Nature* that low-intensity levels of 750 MHz RFR cause heat shock proteins to be produced in absence of cell heating.
7. Hocking (2000) reported to *Australian College of Physicians* decreased survivability of children with leukemia in continuing exposure to TV towers at 0.2 to 8  $\mu\text{W}/\text{cm}^2$ .
8. Colorado Department of Health (1999) study of residents near the Lookout Mountain antenna farm concluded that scientific literature indicates a correlation of RFR with childhood leukemia. Also, there is a statistically significantly elevated incidence of female and male brain cancer in study blocks closest to the towers.
9. Fesenko & Novoselova (1999) in *Bioelectrochemistry Bioenergy* report irradiation of mice with 8.15-18 GHz at power density of 1  $\mu\text{W}/\text{cm}^2$  interfered with cell immunity.

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<sup>1</sup> UHF frequency band is 470-890 MHz, and FCC power density limit = (frequency in MHz)/1.5  $\mu\text{W}/\text{cm}^2$   
VHF frequency band is 54-216 MHz, and FCC power density limit = 200  $\mu\text{W}/\text{cm}^2$   
AM frequency band is 535-1705 kHz, and FCC power density limit = 100,000  $\mu\text{W}/\text{cm}^2$   
FM frequency band is 88-108 MHz, and FCC power density limit = 200  $\mu\text{W}/\text{cm}^2$

10. Magras (1999) reports in *Bioelectromagnetics* on decreased reproductive function (irreversible sterility) of mice exposed to RFR at levels of 0.168 to 1.053  $\mu\text{W}/\text{cm}^2$ .
11. Velizaroz (1999) reports in *Bioelectrochemistry and Bioenergetics* that cell proliferation changes occur from non-thermal RFR exposure: heat shock proteins are triggered in absence of cell heating.
12. Blackman (1998), US Environmental Protection Agency, in a review of the effects of electromagnetic fields on biological systems, says that "In the last 30 years there has been a growing awareness that low intensity EMF exposures, that is, exposures at intensity levels that do not cause temperature increases in biological systems, can cause biological changes."
13. Blank & Goodman (1998) discussed in *Bioelectromagnetics* the interaction of electromagnetic (EM) fields within enzymes at very much lower energy than response to heat shock.
14. Cherry (1998) of Lincoln University, New Zealand cites extensive and compelling scientific research linking RFR/Microwave exposures below 2  $\mu\text{W}/\text{cm}^2$  to severe health problems and mortality risks.
15. Hocking (1998) reports in *Occupational Medicine* on symptoms associated with use of mobile phones.
16. Liakouris (1998) in *Archives of Environmental Health* concludes RFR sickness is result of low intensity RFR exposure, relying on current data and Lilienfeld Study of US embassy irradiation at low levels in Moscow between 1953 and 1976.
17. Mann (1998) in *Neuroendocrinology* reports on effects in humans exposed to 900 MHz, pulsed with 217 Hz, at average power density of 20  $\mu\text{W}/\text{cm}^2$ . Alteration in the hypothalamo-pituitary-adrenal axis activity was found with slight elevation in cortisol serum level immediately after exposure.
18. Michelozzi (1998) reports in *Epidemiology* that leukemia mortality is higher within 6 miles of a high-power radio transmitter near the Vatican in Rome, Italy.
19. Phillips (1998) reported in *Bioelectrochemistry and Bioenergetics* on DNA breaks at cell phone frequencies at exposure levels of 2.4 and 24  $\mu\text{W}/\text{gm}$  (6 to 60  $\mu\text{W}/\text{cm}^2$ ).<sup>2</sup>
20. Rodvall (1998) in *European Journal of Epidemiology* concludes that magnetic field exposure of workers in Sweden may play a role in the development of brain tumors.

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<sup>2</sup> Current standard for public exposure is 0.08 W/Kg specific absorption rate (SAR), average whole body.

21. Wartenberg (1998) in *American Journal of Public Health* concludes there is elevated risk of leukemia for children living near power lines.
22. Blank (1997) in *Bioelectromagnetics* addresses the question of whether electromagnetic fields interact directly with DNA.
23. Cherry (1997), Lincoln University, New Zealand, describes adverse performance trends in children in Swiss and Latvian studies: RFR levels of 0.003 to 0.24  $\mu\text{W}/\text{cm}^2$ .
24. Dolk (1997) reports in the *American Journal of Epidemiology* a two-fold increase in adult leukemia near English FM and TV towers at exposure levels of 1.3-5.7 $\mu\text{W}/\text{cm}^2$ .
25. Goldsmith (1997) in *American Journal of Industrial Medicine* reviews recent data and concludes that the notion that RFR is harmless is no longer tenable.
26. Goldsmith (1997) in *Public Health Review* states that delay in protective measures for RFR is likely to lead to increases in cancer, as well as other unfavorable effects.
27. Kwee (1997) reported to the Second World Congress on Biology and Medicine of Electricity and Magnetism, in Italy, that there is an increase of cell proliferation at a SAR range of 0.000021 to 0.0021 W/kg (about 0.05 to 5  $\mu\text{W}/\text{cm}^2$ ).
28. Lai (1997) in a paper presented at Brussels conference on mobile phones concludes low intensity RFR (SAR < 2 W/Kg) can affect the nervous system.
29. Magres (1997) reported in *Bioelectromagnetics* on a decrease in reproductive function of mice at electromagnetic radiation levels in the range of 0.16 to 1.053  $\mu\text{W}/\text{cm}^2$ .
30. Repacholi (1997) reported in *Radiation Research* the incidence of tumors in mice exposed to 900 MHz pulsed electromagnetic fields was twice as high as expected in unexposed animals.
31. Repacholi (1997) of WHO in *Bioelectromagnetics* suggests that reports of increased incidence of cancer near broadcasting towers should be investigated further.
32. Salford (1997) reported to the Second World Congress on Biology and Medicine of Electricity and Magnetism, in Italy, that there are changes in the blood-brain barrier at a SAR of 0.0004 W/kg (about 1  $\mu\text{W}/\text{cm}^2$ ). The blood-brain barrier protects the brain from exogenous chemicals.
33. Hocking (1996) reports in the *Medical Journal of Australia* on increases in childhood leukemia from exposure to RF from TV towers at levels from 0.2 to 8.0  $\mu\text{W}/\text{cm}^2$ .
34. Kolodynski (1996) reports in *Science of the Total Environment* on impaired motor function, memory and performance in Latvian children at RFR of 0.16  $\mu\text{W}/\text{cm}^2$ .

35. Mann (1996) reports in *Neuropsychobiology* on effects of pulsed high frequency electromagnetic fields on human sleep.
36. Szmigielski (1996) reported in *the Science of the Total Environment* a finding of excess cancer morbidity in subjects occupationally exposed to high frequency RF and microwave electromagnetic radiation.
37. Altpeter (1995) of the University of Berne, Switzerland reports a range of effects observed in humans from RF transmitters.
38. Goldsmith (1995) reports in the *International Journal of Occupational and Environmental Health* on significantly elevated risk of adult cancers and childhood leukemia from microwave radiation at indoor levels of 0.2 to 0.5  $\mu\text{W}/\text{cm}^2$ , drawing on the Lilienfeld Study of irradiation of US embassy personnel in Moscow and other places in the USSR at levels of 5 to 18  $\mu\text{W}/\text{cm}^2$ .
39. Grayson (1995) in *American Journal of Epidemiology* reports a US Air Force study that suggests a small association between RF exposures and brain tumor risk.
40. Kheifets (1995) in the *Journal of Occupational and Environmental Medicine* reports elevation in risk of brain cancer in relation to workplace magnetic field exposure.
41. Lai and Singh (1995) in *Bioelectromagnetics* reports DNA strand breaks in rat brain cells for RFR exposure levels ranging from 0.6 to 1.2 W/Kg, whole body specific absorption rate (SAR).
42. Von Klitzing (1995) reported in *Physica Medica* on observations of brain wave alterations in humans subjected to low frequency pulsed electromagnetic fields at 0.7  $\mu\text{W}/\text{cm}^2$ .
43. Maskarinec (1994) in *Journal of Environmental Pathology, Toxicology and Oncology* found excess childhood leukemia near Oahu with high EMR from radio towers.
44. Navakatikian (1994) in Biological Effects of Electric and Magnetic Fields reports microwaves induce behavioral and endocrine changes at power densities of 10-100  $\mu\text{W}/\text{cm}^2$ .
45. Savitz (1994) in *American Journal of Epidemiology* reports a study of 138,000 electric utility workers wherein prolonged exposure to power frequency magnetic fields is shown to increase the risk of brain cancer.
46. Adey (1993) reports in *Modern Radio Science* on responses to low level microwave exposure, including Alzheimer's and Parkinson's diseases, heart disease and cancer.
47. Maes (1993) reports in *Bioelectromagnetics* on observations of increased chromosome aberrations at non-thermal levels of microwaves at 2450 MHz.

48. Chou & Guy (1992) reporting in *Bioelectromagnetics*, cited by EPA in 1993, suggested cancer may result from chronic exposure to low intensity RFR.
49. Veyret (1991) in *Bioelectromagnetics* reported immune system changes for amplitude modulated, pulsed microwaves at 9.4 GHz and 30  $\mu\text{W}/\text{cm}^2$ .
50. Ray (1990) reported in *Radiation Research* observations of decreased eating and drinking behavior of rats after exposure to microwaves with SAR of 31.7  $\mu\text{W}/\text{gm}$  or 79  $\mu\text{W}/\text{cm}^2$ .
51. Chiang (1989) in *Journal of Bioelectricity* observed in a study of 1170 subjects increased white blood cells, slowed visual reaction, lower memory function, and reduced immune function in children at exposures ranging from 2.4 to 32  $\mu\text{W}/\text{cm}^2$ .
52. Dutta (1989) reports in *Bioelectromagnetics* on measurements of calcium ion efflux from bird and cat brain tissues at very low SAR in the range of 0.005 to 0.05 W/Kg.
53. Milham (1988) reporting in the *American Journal of Epidemiology* is cited by EPA in 1993 as suggesting cancer may result from chronic exposure to low intensity RFR.
54. Milham (1985) reporting in *Lancet* is cited by EPA in 1993 as suggesting cancer may result from chronic exposure to low intensity RFR.
55. US Air Force (1985) reported four-fold, statistically significant increase in primary malignancies in rats exposed long term to 450 MHz RFR at 1000  $\mu\text{W}/\text{cm}^2$ .
56. Milham (1982) reporting in the *New England Journal of Medicine* is cited by EPA in 1993 as suggesting cancer may result from chronic exposure to low intensity RFR.
57. Szmigielski (1982) reporting in *Bioelectromagnetics* his finding of excess cancer among Polish army personnel exposed to EM radiation is cited by EPA in 1993 as suggesting cancer may result from chronic exposure to low intensity RFR.
58. Silverman (1973) reported nervous system and behavioral effects in groups of workers occupationally exposed to various intensities and frequencies of microwaves in nine clinical studies in Czechoslovakia, Poland, USSR and USA.