University of BRISTOL

H H Wills Physics Laboratory
Royal Fort, Tyndall Avenue, Bristol, BS8 1TL
Tel: (0117) 9260353
Fax: (0117) 9251723
E-mail: D.L.Henshaw@bristol.ac.uk

Denis L Henshaw
Professor of Physics

TO WHOM IT MAY CONCERN

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Dear Sir

Adverse health effects of exposure to power frequency electric and magnetic fields (EMFs)

I am writing in response to enquiries I have received on the above issue.

It is indeed unfortunate that the question of health effects of exposure to EMFs well below current exposure guidelines has not received the highest level of scientific or public health attention that it deserves. The evidence of adverse health effects from EMFs associated with the electricity supply, in particular magnetic field (MF) exposures around or below 1 microtesla (μT), is huge and it is quite clear across a range of outcomes. We have long passed the stage where application of the Precautionary Principle and of appropriate legislation against undue exposure is warranted, including a substantial lowering of permitted MF exposure limits, currently 100 μT. In the case of high voltage overhead powerlines, these should not be built close to houses or farms where cattle and poultry are housed.

The available evidence on adverse health effects of MF exposure speaks for itself. No longer can we talk of differing opinions of whether or not there are such adverse health effects: the question is not about what people think, rather it is about what the evidence says.

Official review bodies are usually constrained by their Terms of Reference and have not been in a position to access the bulk of our scientific knowledge of MF interactions with biological systems. As I will explain below, I estimate that such bodies have at most addressed only 10% of the available evidence/data.

I will deal in turn with some aspects of the available scientific evidence/data.

1. Epidemiological evidence

The epidemiological evidence of adverse health effects from EMFs from human population studies has emerged continuously in recent years and it continues to do so. Particular emphasis has been placed on MF exposures, although electric field, EF effects continue to be researched. It may be useful to consider what recent official reports have said concerning MF health effect in particular – see summary table attached.

Internationally, the first major report of note was the US NIEHS report of 1999 (see list of acronyms below). This concluded that both adult and childhood leukaemia was associated with EMF exposure. However, the 2002 IARC report (part of WHO) without apparent reference to the NIEHS

conclusions, concluded that childhood leukaemia was the only cancer associated with EMF (note that IARC is only concerned with non-cancer health outcomes). However, the California Department of Health Sciences report, also published in 2002 concluded that increased risk of five health outcomes was associated with MF exposures: (i) childhood leukaemia; (ii) adult leukaemia; (iii) adult brain cancer; (iv) amyotrophic lateral sclerosis, ALS (or motor neurone disease) and (v) miscarriage. More recently the EU SCENIHR report has associated childhood leukaemia and Alzheimer's disease to MF exposures. The 2007 WHO EHC Report appears to prevaricate on a range of health outcomes, admitting to the existence of evidence but saying simply that this is 'not as strong' as for childhood leukaemia. It is noteworthy that the various reported adverse health effects are associated with average MF exposures around or below 1 μT. In the specific case of childhood leukaemia, a doubling of risk is seen with average exposures above 0.4 μT.

The 2002 IARC and California Reports are now a little historic, but their findings have set the trend of perceived MF health effects in recent years. Given that these two reports were published at about the same time, a number of commentators have asked why two major reports using presumably the same available data came to quite different conclusions with respect to the many studies of adult leukaemia and adult brain cancer. This led my colleague Professor Mike O'Carroll and me to study what was said in both reports and to publish our findings in a learned peer-reviewed journal (O'Carroll & Henshaw 2007). We focused on adult leukaemia and adult brain cancer. We found that whereas the California report had looked at each individual study and at the overall findings of the studies in aggregate, the IARC report had made no attempt to look at the aggregate data. This was strange because IARC had listed in tables the findings from 33 studies of adult leukaemia and 43 studies of adult brain cancer. It was quite clear from inspection of these tables that there was a clear dominance of studies reporting a positive association with MF exposure. In the case of adult leukaemia, the association was, if anything, stronger than that for childhood leukaemia. In O'Carroll & Henshaw we concluded: *"IARC shows no evidence of considering the aggregation of results other than subjectively. It considered individual studies but this led to a tendency to fragment and dismiss evidence that is intrinsically highly significant".*

Naturally, I am critical of the 2002 IARC report for not carrying out a rather basic analysis of the overall data. However, this tendency has been repeated in later WHO Reports and by the UK NRPB (now subsumed into the HPA). In fact, these later reports fail to cite or in anyway discuss the conclusions of the California Report. I have to say that this is simply bad science and indeed it is unprofessional. Were any of these reports submitted for publication to a good scientific journal, failure to pick up these failures of citation and basic analysis would be picked up by the blind peer-review system and the reports would not be published. Instead, sadly, they enjoy a rather false sense of respectability. I am bound to say that Governments and Power Companies are being poorly advised if they seek to reply solely on advice from these sources.

Notwithstanding this situation, as mentioned above, the February 2009 update of the EU SCENIHR report has added Alzheimer's disease as associated with MF exposures, based on recent studies that were not available to the earlier review bodies. Alzheimer's disease is highly prevalent in the aging population and of considerable public health significance. Of special note is the 1.5 to 2-fold increase in risk specifically seen near powerlines in Switzerland (Huss *et al.* 2008).

2. Magnetic fields and living systems

I now expand on my above comment that official review bodies have accessed at most only 10% of the relevant scientific data. The areas where MF interactions with living systems have been extensively discussed are:

1. The known ability of birds and other animals to detect tiny changes in the Earth's magnetic field (the Geomagnetic or GM) for the purposes of navigation.

2. The ability of plants to sense magnetic fields including power frequency AC fields.

3. Health effects arising from fluctuations in GM fields

4. The use of magnetic fields, including levels below the ICNIRP limit for medical treatment in wound & bone healing.

I will refer below to the 2008 Bioinitiative Report, but here is an extract of what it says about the use of MFs for medical treatment:

> **"Another Way of Looking at EMFs: Therapeutic Uses**
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> Many people are surprised to learn that certain kinds of EMFs treatments actually can heal. These are medical treatments that use EMFs in specific ways to help in healing bone fractures, to heal wounds to the skin and underlying tissues, to reduce pain and swelling, and for other postsurgical needs. Some forms of EMFs exposure are used to treat depression. EMFs have been shown to be effective in treating conditions of disease at exposure levels far below current public exposure standards. This leads to the obvious question. How can scientists dispute the harmful effects of EMF exposures while at the same time using forms of EMF treatment that are proven to heal the body?
>
> **Medical conditions are successfully treated using EMFs at levels below current public safety standards, proving another way that the body recognizes and responds to low-intensity EMF signals. Otherwise, these medical treatments could not work. The FDA has approved EMFs medical treatment devices, so is clearly aware of this paradox.**
>
> Random exposures to EMFs, as opposed to EMFs exposures done with clinical oversight, could lead to harm just like the unsupervised use of pharmaceutical drugs. This evidence forms a strong warning that indiscriminate EMF exposure is probably a bad idea.
>
> **No one would recommend that drugs used in medical treatments and prevention of disease be randomly given to the public, especially to children. Yet, random and involuntary exposures to EMFs occur all the time in daily life.**

I would add that medical treatment is normally given for a fixed period and not continuously and chronically as for an MF exposure near powerlines.

It is in the field of animal navigation that most progress is currently being made in elucidating the *primary* mechanism by which MFs are known to interact with biological systems. The scientific literature in this field is vast but reference to five recent publications is given below (Ritz *et al.* 2000, 2004 & 2009; Begall *et al.* 2008, Burda *et al.* 2009). Current research suggests that birds posses a magnetic compass in the eye which functions by means of a process which is deeply rooted in chemistry known as the Radical Pair Mechanism. This is the mechanism by which low intensity MFs can increase the lifetime of free radicals. In birds, magneto-reception appears to occur in biological molecules known as cryptochromes, the same molecules that have been associated with magneto-reception in plants. Crucially, cryptochromes are present in human tissues generally, so here too they could be responsible for the primary detection of magnetic fields in man (though I stress such research has not yet been carried out). Whereas in birds the MF-induced increase in lifetime of free radicals is detected for the purposes of navigation, in general such an increase results in their greater ability to cause biological damage, especially in DNA.

The way in which MFs affect biological is becoming increasingly understood. A detailed description and excellent summary may be found in the Bionitiative Report. Here are some extracts

from Section 1 (note that this report also discusses health effects from radio frequency RF exposures, principally from mobile phones. The term 'ELF' refers to power frequency EMFs):

> **Page 17: Both ELF and RF exposures can be considered genotoxic (will damage DNA) under certain conditions of exposure, including exposure levels that are lower than existing safety limits.**
>
> **Very low-level ELF and RF exposures can cause cells to produce stress proteins, meaning that the cell recognizes ELF and RF exposures as harmful. This is another important way in which scientists have documented that ELF and RF exposures can be harmful, and it happens at levels far below the existing public safety standards.**

> **Page 18: There is substantial evidence that ELF and RF can cause inflammatory reactions, allergy reactions and change normal immune function at levels allowed by current public safety standards.**

> **Page 19: Oxidative stress through the action of free radical damage to DNA is a plausible biological mechanism for cancer and diseases that involve damage from ELF to the central nervous system.**

3. The 2007 BioInitiative Report

This is an independent report on EMF health effects, which covers both power frequency MFs and radio frequency EMFs such as from mobile phones. The authors include three former Presidents of the International Bioelectromagnetics Society and it presents an authoritative view of the state of the science and the need for precaution against exposure. The report may be accessed at: http://www.bioinitiative.org/index.htm

4. Summary

It is notable that some countries took action many years ago to limit public exposure to magnetic fields associated with high voltage powerlines, for example Sweden in 1996, Switzerland and Italy in 2000. Included in the substantial literature of EMF health effects is the 2007 study by Lowenthal *et al.* of increased risk of lymphoproliferative and myeloproliferative disorders in Tasmania.

It is indeed unfortunate that power companies and some governments continue to be ill advised on the adverse health effects of EMF exposures. In the case of overhead powerlines, we really are passed the stage where we should be erecting overhead powerlines close to house and centres of population.

Yours sincerely

Denis L Henshaw

Review bodies ' assessments of EMF causation of various diseases.
- health outcomes classified as Class 2B - possible causal.

Disease	IARC[1] 2002	NIEHS 1999[2]	California 2002	EU: SCENIHR[3] February 2009
1. Childhood Leukaemia	Yes	Yes	Yes	Yes
2. Adult Leukaemia		Yes	Yes	
3. Adult brain cancer			Yes	
4. Miscariage			Yes	
5. ALS[4]			Yes	
6. Alzheimer 's disease				Yes[5]
7. Childhood brain tumours				Emerging evidence

[1] International Agency for Research on Cancer
[2] US National Institute of Environmental Sciences
[3] EU: Scientific Committee on Emerging and Newly Identified Health Ris ks: Possible effects of Electromagnetic Fields (EMF) on Human Health.
[4] Motor neurone disease
[5] Studies only recently published

Table Note. A doubling of childhood leukaemia risk is seen for average exposures above 0.4 μT. Other health risks refer generally to increased risk around or below 1 μT average exposure. The current ICNIRP exposure guidelines are set at 100 μT, 250 times higher than 0.4 μT where the doubling of childhood leukaemia risk is seen.

Acronyms

HPA: Health Protection Agency (UK)
IARC: International Agency for Research on Cancer (a branch of WHO)
ICNIRP: International Commission on Non-ionising Radiation Protection
NIEHS: National Institute of Environmental Health Sciences (USA)
NRPB: National Radiological Protection Board (UK)
SCENIHR: Scientific Committee on Emerging and Newly Identified Health Risks (EU)
WHO: World Health Organisation
WHO EHC: World Health Organisation Environmental Health Criteria

References

Begall S, Cerveny J, Neef J, Vojtech O and Burda H, 2008. Magnetic alignment in grazing and resting cattle and dear, *PNAS,* **105**(36), 13451-13455.

BioInitiative Report 2007: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELS and RF) Authors: Sage, Xu, Chen, Lai, Blank, Johansson, Hardell, Mild, Kundi, Davanipour, Sobel, Blackman, Gee and Carpenter. http://www.bioinitiative.org/index.htm

Burda H, Begall S, Cerveny J, Neef J and Nemec P. 2009. Extremely low-frequency electromagnetic fields disrupt magnetic alignment of ruminants. *PNAS*, 106(14),5708-13, 2009.

California Health Department Services (CHDS) Report, 2002. An evaluation of the possible risks from electric and magnetic fields (EMFs) from power lines, internal wiring, electrical occupations and appliances. (Eds: Neutra, DelPizzo and Lee). California EMF Program, 1515 Clay Street, 17th Floor, Oakland, CA 94612, USA.

http://www.ehib.org/emf/RiskEvaluation/riskeval.html
Garcia AM, Sisternas A, Hoyos S P.2008 Occupational exposure to extremely low frequency electric and magnetic fields and Alzheimer's dosease: a meta-analysis *Int. J. Epidemiol*. **37**, 329-340.
Huss A, Spoerri A, Egger M, Martin Rőősli M, 2008. Residence Near Power Lines and Mortality From Neurodegenerative Diseases: Longitudinal Study of the Swiss Population. *Am J Epidem* **169(2),** 167 -175.
IARC Monographs of the Evaluation of Carcinogenic Risks to Humans, 2002. Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields. Volume 80, 19-26 June 2001, IARC Press 2002, 150 Cours Albert Thomas, F-69372 Lyon Cedex 08, France.
Lowenthal, R. M., Tuck, D. M. and Bray, I. C., 2007. Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study. *Internal Medicine Journal*, **37**, 614-619.
National Institute of Environmental Health Sciences (NIEHS), 1999, NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic fields. *NIH Publication* No. 99-4493, P. O. Box 12233, Research Triangle Park, NC 27709.
O'Carroll, M. J. and Henshaw, D. L., 2008. Aggregating epidemiological evidence: comparing two seminal EMF reviews. *Risk Analysis*, **28**(1), 225-234
Ritz, T., Adem, S., and Schulten, K., 2000. A model for photoreceptor-based magnetoreception in birds. *Biophysical Journal,* **78**, 707-718.
Ritz T, Thalau P, Phillips JB, Wiltschko R, Wiltschko W. Resonance effects indicate a radical-pair mechanism for avian magnetic compass. Nature 2004; **429:**177-180.
Ritz T, Wiltschko R, Hore PJ, Rodgers CT, Stapput K, Thalau P, Timmel and Wiltschko W. 2009. Magnetic compass of birds is based on a molecule with optimal directional sensitivity. *Biophys J,* **96**, 3451-3457.
SCENIHR 2009 update: Scientific Committee on Emerging and Newly Identified Health Risks: Possible effects of Electromagnetic Fields (EMF) on Human Health. Published by the European Commission, Health & Consumer Protection DG, Directorate C: Public Health and Risk Assessment, Unit C7 – risk Assessment, Office: B232, B-1049 Brussels; weblink:
http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf
WHO: World Health Organisation Environmental Health Criteria 238: Extremely Low Frequency Fields, 2007. Available online at:
http://www.who.int/entity/peh-emf/publications/Complet_DEC_2007.pdf