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Letter to the Editor

Comment on "Developing Policy in the Face of Scientific Uncertainty: Interpreting 0.3 μT or 0.4 μT Cutpoints from EMF Epidemiologic Studies" by Kheifets *et al.* in *Risk Analysis, 25*(4), 927–935

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The above article (Kheifets *et al.*, 2006a) has led to an exchange of correspondence between Kundi (2006) and the authors (Kheifets *et al.*, 2006b). Developing policy on the avoidance of exposure to power frequency electric and magnetic fields (PF EMFs) based solely on the possible increased risk of childhood leukemia may materially underestimate the possible adverse health effects of such exposures and therefore significantly distort any cost-benefit considerations for such avoidance.

Kundi (2006) claimed: "Some evidence exists for a relationship to cardiovascular diseases, Alzheimer's disease, amyotrophic lateral sclerosis, childhood and adult brain cancer, male and female breast cancer, and adverse pregnancy outcomes." Kheifets *et al.* (2006b) replied that this statement "is not supported by current scientific knowledge." That of course begs the question of how "evidence" and "supported" are defined but Kundi's mild claim was only that some evidence exists. In fact there is a mixed picture and widely differing views have been expressed concerning the extent of adverse health effects resulting from PF EMF exposures.

Table I summarizes the findings from three review bodies, the U.S. National Institute of Environmental Sciences (NIEHS, 1999), the International Agency for Research on Cancer (IARC, 2002), and the California Health Department of Health Services Report on PF EMFs (CDHS, 2002). In addition to childhood leukemia, CDHS (2002) classifies adult leukemia, adult brain cancer, amyotrophic lateral sclerosis (ALS), and miscarriage as Class 2B—the IARC classification that a possible causal relationship exists.

To understand why CDHS (2002) differs from the other reviews, we need to consider how the evidence of adverse effects was assessed. The CDHS report does discuss differences in the working terms of reference and methodology. We would further note that the CDHS report systematically assesses the aggregate weight of available epidemiological studies for each health outcome, along with its systematic assessment of biological evidence. Where there are several epidemiological studies that might be dismissed individually, we think it is important to assess their aggregate weight before dismissing them in totality.

CDHS cites Kheifets herself for "meta-analytic summaries" for adult leukemia and for brain cancer. For the present purpose, the studies do not need to be consistent enough for a full meta-analysis nor even for a meta-analytic summary. Considering p-values will serve the purpose of telling us if we would be throwing away something significant. CDHS gives some exact binomial p-values for numbers of positive studies. We have added those for numbers of significant studies.

To illustrate and extend the CDHS findings, Table II gives the number of epidemiological studies they considered, the number with positive odds ratio, and the number with statistically significant positive odds ratio. The probability of obtaining this set of results purely by chance is then given. For the five health outcomes classed by CDHS as 2B, the corresponding p-values are such that this is most unlikely to be a chance finding.

While the risk assessment of the WHO ELF Task Group remains unpublished at this time (WHO,

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Table I. Review Bodies' Assessments of PF EMF Causation of Various Diseases: *Yes* Indicates a 2B Classification

Disease	NIEHS 1999	IARC 2001	CDHS (2002)
1. Childhood leukemia	Yes	Yes	Yes
2. Adult leukemia	Yes		Yes
3. Adult brain cancer			Yes
4. Miscarriage			Yes
5. ALS			Yes

in press), it will be interesting to see how their conclusions, stated in Kheifets (2006b), are justified. Meanwhile, it should be pointed out that advances in understanding have been made recently as to how PF EMFs may cause increased health risk. Plausible hypotheses have been put forward for this. For example, careful analysis of populations exposed to neighborhood PF EMFs show clear evidence of disruption of the nocturnal production of the hormone melatonin in the pineal gland (Henshaw & Reiter, 2005; Davies *et al.*, 2006)—reduced nocturnal melatonin perhaps being a common factor in increased risk of the five illnesses identified in CDHS (2002). Of added interest is that a similar range of adverse health outcomes is also associated with extremely low frequency fluctuations in solar and geomagnetic fields (Palmer *et al.*, 2006) and that the detailed mechanisms by which many animal species detect and exploit tiny changes in the Earth's static magnetic field for the purposes of navigation are starting to be elucidated (Wiltschko & Wiltschko, 2006).

All this can have implications for precautionary risk analysis and public health policy with respect to exposure from electric and magnetic fields from the electricity supply. Childhood leukemia is relatively rare, while some of the other implicated diseases are much more common. As with exposures from telecommunications, there can be a dilemma of ubiquity versus uncertainty. If statistically significant aggregate evidence for a range of adverse health outcomes is not to be discarded, it could substantially increase precautionary action supported by cost-benefit analysis.

Drawing from WHO, Kheifets *et al.* (2006b) says: "Given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukemia and the limited impact on public health, the benefits of exposure reduction on health are unclear and thus the costs to reduce exposure should be very low." If other implicated diseases are not to be dismissed, the argument of "limited impact on public health" no longer applies, and so a different view may be taken about proportionate precautionary costs.

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REFERENCES

CDHS (California Department of Health Services). (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, &

Disease	Number of Studies	Positive Studies		Significant Positives	
		Number	*p* Value*	Number	*p* Value*
1. Childhood leukemia	19	16	0.0014	3	0.01
2. Adult leukemia	43	32	0.0007	11.5	<<0.00001
3. Adult brain cancer	32	25	0.0007	6	0.0001
4. Miscarriage	37	27.5	0.0015	9	<<0.00001
5. ALS	7	6	0.06	3	0.0004
6. Childhood brain cancer	12	6	>0.5	2	0.04
7. Female breast cancer	24	17.5	0.012	5.5	0.0001
8. Male breast cancer	16	11.5	0.04	–	
9. Alzheimer's disease	6	4	0.34	2.5	0.001
10. Suicide	8	6.5	0.02	3	0.0007
11. Heart disease	8	6.5	0.02	5.5	<<0.00001

*Null hypothesis, result occurs by chance.

Table II. Epidemiological Studies Reviewed by CDHS (2002) and the Corresponding Number of Odds Ratios >1.0, Number that Were Statistically Significant, and *p* Value for Each Set

Lee). Oakland, CA: California EMF Program. Available at http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html.

Davis, S., Mirick, D. K., Chen, C., & Stanczyk, F. Z. (2006). Effects of 60-Hz magnetic field exposure on nocturnal 6-Sulfatoxymelatonin, estrogens, luteinizing hormone, and follicle-stimulating hormone in healthy reproductive age women: Results of a crossover trial. *Annals of Epidemiology*, *16*, 622–631.

Henshaw, D. L., & Reiter, R. J. (2005). Do magnetic fields cause increased risk of childhood leukaemia via melatonin disruption? *Bioelectromagnetics,* 7(Suppl.), S86–S97.

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. Lyon, France: IARC Press.

Kheifets, L., Sahl, J. D., Shimkhada, R., & Repacholi, M. H. (2006a). Developing policy in the face of scientific uncertainty: Interpreting 0.3 μT or 0.4 μT cutpoints from EMF epidemiologic studies. *Risk Analysis*, *25*(4), 927–935.

Kheifets, L., Sahl, J. D., Shimkhada, R., & Repacholi, M. H. (2006b). Epidemiological data and standards: Response to Kundi. *Risk Analysis*, *26*(3), 583–584.

Kundi, M. (2006). Comment on "Developing policy in the face of scientific uncertainty: Interpreting 0.3 μT or 0.4 μT cutpoints from EMF epidemiologic studies" by Kheifets *el al*. *Risk Analysis*, *26*(3), 579–581.

National Institute of Environmental Health Sciences (NIEHS). (1999). *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic fields*. Research Triangle Park, NC: NIEHS.

Palmer, S. J., Rycroft, M. J., & Cermack, M. (2006). Solar and geomagnetic activity, extremely low frequency magnetic and electric fields and human health at the earth's surface. *Surveys in Geophysics*, *27*(5), 557–595.

Wiltschko, R., & Wiltschko, W. (2006). Magnetoreception. *BioEssays*, *28*(2), 157–168.

World Health Organisation. (In press). *Extremely Low Frequency Fields. Environmental Health Criteria XXX*. Geneva: WHO.