Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2006 .

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1. **Reviews**

PUBLIC HEALTH IMPACT OF EXTREMELY LOW-FREQUENCY ELECTROMAGNETIC FIELDS.
Kheifets L., Afifi A.A., Shimkhada R.
Environ Health Perspect. 2006 ;114 :1532-1537.

The association between exposure to extremely low-frequency electric and magnetic fields (ELF) and childhood leukemia has led to the classification of magnetic fields by the International Agency for Research on Cancer as a "possible human carcinogen." This association is regarded as the critical effect in risk assessment. Creating effective policy in light of widespread exposure and the undisputed value of safe, reliable, and economic electricity to society is difficult and requires estimates of the potential public health impact and associated uncertainties.
Although a causal relationship between magnetic fields and childhood leukemia has not been established, the authors present estimates of the possible pubic health impact using attributable fractions to provide a potentially useful input into policy analysis under different scenarios.
Using ELF exposure distributions from various countries and dose-response functions from two pooled analyses, they calculate country-specific and worldwide estimates of attributable fractions (AFs) and attributable cases.
Even given a wide range of assumptions, they find that the AF remains < 10%, with point estimates ranging from < 1% to about 4%. For small countries with low exposure, the number of attributable cases is less than one extra case per year. Worldwide the range is from 100 to 2,400 cases possibly attributable to ELF exposure.
Conclusion: The fraction of childhood leukemia cases possibly attributable to ELF exposure across the globe appears to be small. There remain, however, a number of uncertainties in these AF estimates, particularly in the exposure distributions.

DEVELOPING POLICY IN THE FACE OF SCIENTIFIC UNCERTAINTY: INTERPRETING 0.3 MICROTESLA OR 0.4 MICROTESLA CUTPOINTS FROM EMF EPIDEMIOLOGIC STUDIES.
Kheifets L., Sahl J.D., Shimkhada R., Repacholi M.H.
Risk Anal. 2005 ;25 : 927-935.

There has been considerable scientific effort to understand the potential link between exposures to power-frequency electric and magnetic fields (EMF) and the occurrence of cancer and other diseases. The combination of widespread exposures, established biological effects from acute, high-level exposures, and the possibility of leukemia in children from low-level, chronic exposures has made it both necessary and difficult to develop consistent public health policies. In this article the authors review the basis of both numeric standards and precautionary-based approaches. While they believe that policies regarding EMF should indeed be precautionary, this does not require or imply adoption of numeric exposure

standards. They argue that cutpoints from epidemiologic studies, which are arbitrarily chosen, should not be used as the basis for making exposure limits due to a number of uncertainties. Establishment of arbitrary numeric exposure limits undermines the value of both the science-based numeric EMF exposure standards for acute exposures and precautionary approaches. The World Health Organization's draft Precautionary Framework provides guidance for establishing appropriate public health policies for power-frequency EMF.

2. Residential exposure

CHILDHOOD LEUKEMIA, ELECTRIC AND MAGNETIC FIELDS, AND TEMPORAL TRENDS.
Kheifets L., Swanson J., Greenland S.
Bioelectromagnetics. 2006; 27 : 545-552.

During the past 25 years concern has been raised about the possible health effects of extremely low frequency (ELF) electric and magnetic fields (EMFs), particularly regarding childhood leukemia. Comparison of changes in electricity consumption (a surrogate for exposure) to changes in childhood-leukemia rates, known as ecologic correlation, have been used to argue both for and against the association between magnetic fields and childhood leukemia. In this paper we explore what can be learned from such an ecologic approach. We first examine separately the evidence on trends in exposure to EMFs and on trends in leukemia rates, and then compare the two. Both incidence rates and exposures have increased, but there are so many approximations and assumptions involved in connecting the two trends that we cannot regard the ecologic evidence as providing any meaningful evidence for or against a causal link.

ASSOCIATION BETWEEN HIGH VOLTAGE OVERHEAD TRANSMISSION LINES AND MENTAL HEALTH: A CROSS-SECTIONAL STUDY.
Yamazaki S., Sokejima S., Mizoue T., Eboshida A., Kabuto M., Yamaguchi N., Akiba S., Fukuhara S., Nitta H.
Bioelectromagnetics. 2006; 27 : 473-478.

The authors examined the association between residential proximity to 60 Hz high voltage (22-500 kV) overhead transmission lines (HVOTLs) and mental health (MH). The subjects were 223 mothers with a mean age of 37 years. The distance from the subject's residence to the closest HVOTL was measured on a map. MH status was assessed by the SF-36 Health Survey, which was scored on a 0-100 point scale, and an individual with a score of 52 points or less was defined as having poor MH. Logistic regression models were used to examine the association between the distance from the subjects' residence to the closest HVOTL and MH status. The prevalence of poor MH was 15%. Among the 223 subjects, 10 lived within 100 m of a HVOTL. The adjusted odds ratios (OR) for poor MH among those who lived 101-300 m or within 100 m from HVOTL were 1.29 (95% confidence interval (CI): 0.35-10.13) and 1.87 (95% CI: 0.35-10.13), respectively, against the reference category (300+ m). MH status was not significantly associated with the distance between the subject's residence and the closest HVOTL.

3. Occupational exposure

OCCUPATIONAL EXPOSURE TO IONIZING RADIATION AND ELECTROMAGNETIC FIELDS IN RELATION TO THE RISK OF THYROID CANCER IN SWEDEN.

Lope V., Perez-Gomez B., Aragones N., Lopez-Abente G., Gustavsson P., Floderus B., Dosemeci M., Silva A., Pollan M.

Scand J Work Environ Health. 2006; 32 :276-284.

This study sought to ascertain the risk of thyroid cancer in relation to occupational exposure to ionizing radiation and extremely low-frequency magnetic fields (ELFMF) in a cohort representative of Sweden's gainfully employed population. A historical cohort of 2 992 166 gainfully employed Swedish male and female workers was followed up from 1971 through 1989. Exposure to ELFMF and ionizing radiation was assessed using three job exposure matrices based on industrial branch or occupational codes. Relative risks (RR) for male and female workers, adjusted for age and geographic area, were computed using log-linear Poisson models.

Occupational ELFMF exposure showed no effect on the risk of thyroid cancer in the study. However, female workers exposed to high intensities of ionizing radiation registered a marked excess risk [RR 1.85, 95% confidence interval (95% CI) 1.02-3.35]. This trend was not in evidence among the men.

Conclusions: While the study confirms the etiologic role of ionizing radiation, with a higher incidence of thyroid cancer being recorded for the most-exposed female workers, our results do not support the possibility of occupational exposure to ELFMF being a risk factor for the development of thyroid cancer.

4. Experimental studies

OCCUPATIONAL MAGNETIC FIELD EXPOSURE AND MELATONIN: INTERACTION WITH LIGHT-AT-NIGHT.

Juutilainen J., Kumlin T.

Bioelectromagnetics. 2006; 27 : 423-426.

The evidence of magnetic field (MF) effects on melatonin production in humans is limited and inconsistent. Part of the inconsistencies might be explained by findings suggesting interaction with light in pineal responses to MFs. To test this hypothesis, the authors reanalyzed data from a previously published study on 6-hydroxy melatonin sulfate (6-OHMS) excretion in women occupationally exposed to extremely low-frequency MFs. Based on questionnaire data on exposure to light-at-night (LAN), and measurement-based MF data, the 60 women were classified to four groups: no MF, no LAN; MF, no LAN; no MF, LAN; MF, LAN. The lowest excretion of 6-OHMS was observed in the group of women who were exposed to both MF and LAN, and the differences between the four groups were significant ($P < .0001$). The result is based on low numbers, but supports the hypothesis that daytime occupational exposure to MF enhances the effects of nighttime light exposure on melatonin production.

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.

Davis S., Mirick D.K., Chen C., Stanczyk F.Z.

Ann Epidemiol. 2006; 16 : 622-631.

Exposure to residential magnetic fields may disrupt the normal nocturnal rise in melatonin levels, resulting in increased risk for breast cancer, possibly through increased levels of reproductive hormones. The authors investigated whether exposure to a 60-Hz magnetic field under controlled conditions is associated with a decrease in urinary nocturnal 6-sulfatoxymelatonin level and increase in luteinizing hormone (LH), follicle-stimulating hormone (FSH), and estrogen levels in healthy premenopausal women.

Using a crossover design, half the participants were assigned to magnetic field exposure of 5 to 10 mG greater than ambient levels for 5 consecutive nights during the early to midluteal phase of the menstrual cycle. On the last night of exposure, a nocturnal urine sample was collected. The next month, participants were sham exposed. The other half of participants were assigned the reverse order of exposure.

Magnetic field exposure was associated with decreased 6-sulfatoxymelatonin levels, but no changes in reproductive hormone levels were observed. Participants using prescription medications and anovulatory participants had more pronounced decreases in 6-sulfatoxymelatonin levels with magnetic field exposure.

Conclusion: This study provides further evidence that exposure to magnetic fields is associated with decreased nocturnal melatonin levels, but does not support the hypothesis that such exposure results in increased urinary levels of estrogens, LH, or FSH.