

# Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the fourth trimester of 2010

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## 1. Reviews

### **POOLED ANALYSIS OF RECENT STUDIES ON MAGNETIC FIELDS AND CHILDHOOD LEUKAEMIA.**

Kheifets L, Ahlbom A, Crespi CM, Draper G, Hagihara J, Lowenthal RM, Mezei G, Oksuzyan S, Schüz J, Swanson J, Tittarelli A, Vinceti M, Wunsch Filho V. *Br J Cancer*. 2010; 103(7): 931-932.

Previous pooled analyses have reported an association between magnetic fields and childhood leukaemia. The authors present a pooled analysis based on primary data from studies on residential magnetic fields and childhood leukaemia published after 2000. Seven studies with a total of 10,865 cases and 12,853 controls were included. The main analysis focused on 24-h magnetic field measurements or calculated fields in residences.

In the combined results, risk increased with increase in exposure, but the estimates were imprecise. The odds ratios for exposure categories of 0.1-0.2  $\mu\text{T}$ , 0.2-0.3  $\mu\text{T}$  and  $\geq 0.3$   $\mu\text{T}$ , compared with  $<0.1$   $\mu\text{T}$ , were 1.07 (95% CI 0.81-1.41), 1.16 (0.69-1.93) and 1.44 (0.88-2.36), respectively. Without the most influential study from Brazil, the odds ratios increased somewhat. An increasing trend was also suggested by a nonparametric analysis conducted using a generalised additive model.

Conclusion: These results are in line with previous pooled analyses showing an association between magnetic fields and childhood leukaemia. Overall, the association is weaker in the most recently conducted studies, but these studies are small and lack methodological improvements needed to resolve the apparent association. The authors conclude that recent studies on magnetic fields and childhood leukaemia do not alter the previous assessment that magnetic fields are possibly carcinogenic.

### **A POOLED ANALYSIS OF EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS AND CHILDHOOD BRAIN TUMORS.**

Kheifets L, Ahlbom A, Crespi CM, Feychting M, Johansen C, Monroe J, Murphy MF, Oksuzyan S, Preston-Martin S, Roman E, Saito T, Savitz D, Schüz J, Simpson J, Swanson J, Tynes T, Verkasalo P, Mezei G. *Am J Epidemiol*. 2010; 172(7): 752-761.

Pooled analyses may provide etiologic insight about associations between exposure and disease. In contrast to childhood leukemia, no pooled analyses of childhood brain tumors and exposure to extremely low-frequency magnetic fields (ELF-MFs) have been conducted. The authors carried out a pooled analysis based on primary data (1960-2001) from 10 studies of ELF-MF exposure and childhood brain tumors to assess whether the combined results, adjusted for potential confounding, indicated an association. The odds ratios for childhood brain tumors in ELF-MF exposure categories of 0.1- $<0.2$   $\mu\text{T}$ , 0.2- $<0.4$   $\mu\text{T}$ , and  $\geq 0.4$   $\mu\text{T}$  were 0.95 (95% confidence interval: 0.65, 1.41), 0.70 (95% CI: 0.40, 1.22), and 1.14 (95% CI: 0.61, 2.13),

respectively, in comparison with exposure of <0.1 µT. Other analyses employing alternate cutpoints, further adjustment for confounders, exclusion of particular studies, stratification by type of measurement or type of residence, and a nonparametric estimate of the exposure-response relation did not reveal consistent evidence of increased childhood brain tumor risk associated with ELF-MF exposure.

Conclusion: These results provide little evidence for an association between ELF-MF exposure and childhood brain tumors.

#### **EXPOSURE TO ELECTROMAGNETIC FIELDS AND HUMAN REPRODUCTION: THE EPIDEMIOLOGIC EVIDENCE.**

Figa-Talamanca I, Nardone P, Giliberti C

*Eur. J. Oncol.* 2010 nov - Library Vol. 5: 387-402. (<http://www.icems.eu/papers.htm>)

Several studies have examined the reproductive effects of occupational and environmental exposures to electromagnetic fields (EMF) using in vitro, in vivo and epidemiologic methods. The present paper reviews the main results of the epidemiologic literature on the effects of exposure to EMF on male and female reproduction, indexed in the PubMed data bank after 1990. Studies on male reproductive effects have mainly focused on the possible association between occupational exposure to EMF and infertility or congenital defects in the offspring. Studies on possible female reproductive effects have examined the association between exposures during pregnancy to EMF (VDTs, residential exposure to ELF magnetic fields, electric blankets, heated water beds, mobile phones) and spontaneous abortion and congenital defects in the offspring. For each study, the authors paid particular attention to the study design (cohort, correlational, case-control, prospective follow-up, experimental), the population and outcomes studied, the method of exposure assessment to EMF and the results obtained.

Conclusion: Overall, the results obtained to date through the epidemiological approach, do not raise strong concern for human reproductive health from the usual occupational and environmental EMF exposure levels. However there is also some evidence that subjects with unusually high exposures, show some increase in reproductive risk. In discussing the evidence the authors point out to numerous limitations of most epidemiologic studies: confounding factors such as age, smoking, occupational exposures to male and female reproductive chemical toxicants, sedentary life style etc. are often not taken into account. In addition, exposure of the subjects to EMF has been frequently determined only on the basis of interviews and self reports on the part of the subjects involved. These limitations are also discussed, together with the possible mechanisms of action of hypothesized/suspected reproductive effects of EMF on male and female reproduction as suggested by the literature of animal studies.

## **2. Residential exposure**

#### **CHILDHOOD CANCER AND MAGNETIC FIELDS FROM HIGH-VOLTAGE POWER LINES IN ENGLAND AND WALES: A CASE-CONTROL STUDY.**

Kroll ME, Swanson J, Vincent TJ, Draper GJ.

*Br J Cancer.* 2010; 103(7): 931-2.

Epidemiological evidence suggests that chronic low-intensity extremely-low-frequency magnetic-field exposure is associated with increased risk of childhood leukaemia; it is not certain the association is causal.

The authors report a national case-control study relating childhood cancer risk to the average magnetic field from high-voltage overhead power lines at the child's home address at birth during the year of birth, estimated using National Grid records. From the National Registry of Childhood Tumours, they obtained records of 28,968 children born in England and Wales during 1962-1995 and diagnosed in Britain under age 15. Controls were selected from birth registers, matching individually by sex, period of birth, and birth registration district. No participation by cases or controls was required.

The estimated relative risk for each 0.2  $\mu$ T increase in magnetic field was 1.14 (95% confidence interval 0.57 to 2.32) for leukaemia, 0.80 (0.43-1.51) for CNS/brain tumours, and 1.34 (0.84-2.15) for other cancers.

Conclusion: Although not statistically significant, the estimate for childhood leukaemia resembles results of comparable studies. Assuming causality, the estimated attributable risk is below one case per year. Magnetic-field exposure during the year of birth is unlikely to be the whole cause of the association with distance from overhead power lines that the authors previously reported.

### **3. Occupational exposure**

#### **OCCUPATIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS AND SEX-DIFFERENTIAL RISK OF UVEAL MELANOMA.**

Behrens T, Lynge E, Cree I, Sabroe S, Lutz JM, Afonso N, Eriksson M, Guénel P, Merletti F, Morales-Suarez-Varela M, Stengrevics A, Févotte J, Llopis-González A, Gorini G, Sharkova G, Hardell L, Ahrens W.  
*Occup Environ Med.* 2010; 67(11): 751-759. .

The association between occupational exposure to electromagnetic fields (EMF) and the risk of uveal melanoma was investigated in a case-control study in nine European countries.

Incident cases of uveal melanoma and population as well as hospital controls were included and frequency matched by country, 5-year birth cohort and sex. Subjects were asked whether they had worked close to high-voltage electrical transmission installations, computer screens and various electrical machines, or in complex electrical environments. Measurements of two Scandinavian job-exposure matrices were applied to estimate lifelong cumulative EMF exposure. Unconditional logistic regression analyses, stratified by sex and eye colour were calculated, adjusting for several potential confounders.

293 patients with uveal melanoma and 3198 control subjects were interviewed. Women exposed to electrical transmission installations showed elevated risks (OR 5.81, 95% CI 1.72 to 19.66). Positive associations with exposure to control rooms were seen among men and women, but most risk increases were restricted to subjects with dark iris colour. Application of published EMF measurements revealed stronger risk increases among women compared to men. Again, elevated risks were restricted to subjects with dark eye colour.

Conclusion: Although based on a low prevalence of exposure to potential occupational sources of EMF, these data indicate that exposed dark-eyed women may be at particular risk for uveal melanoma.

**WORK-RELATED EXPOSURE TO EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS AND DEMENTIA: RESULTS FROM THE POPULATION-BASED STUDY OF DEMENTIA IN SWEDISH TWINS.**

Andel R, Crowe M, Feychting M, Pedersen NL, Fratiglioni L, Johansson B, Gatz M.

*J Gerontol A Biol Sci Med Sci.* 2010; 65(11): 1220-1227.

The authors examined the association between extremely low-frequency magnetic fields (EMF) and the risk of dementia and Alzheimer's disease using all 9,508 individuals from the Study of Dementia in Swedish Twins (HARMONY) with valid occupational and diagnostic data.

Dementia diagnoses were based on telephone screening followed by in-person clinical workup. Main lifetime occupation was coded according to an established EMF exposure matrix. Covariates were age, gender, education, vascular risk factors, and complexity of work. Based on previous research, data were also analyzed separately for cases with disease onset by age 75 years versus later, men versus women, and those with manual versus nonmanual main occupation. Generalized estimating equations were used with the entire sample (to adjust for the inclusion of complete twin pairs) and conditional logistic regression with complete twin pairs only.

Level of EMF exposure was not significantly associated with dementia or Alzheimer's disease. However, in stratified analyses, medium and high levels of EMF exposure were associated with increased dementia risk compared with low level in cases with onset by age 75 years (odds ratio: 1.94, 95% confidence interval: 1.07-3.65 for medium, odds ratio: 2.01, 95% confidence interval: 1.10-3.65 for high) and in participants with manual occupations (odds ratio: 1.81, 95% confidence interval: 1.06-3.09 for medium, odds ratio: 1.75, 95% confidence interval: 1.00-3.05 for high). Results with 42 twin pairs discordant for dementia did not reach statistical significance.

Conclusions: Occupational EMF exposure appears relevant primarily to dementia with an earlier onset and among former manual workers.

#### **4. Human experiment**

**ELECTROMAGNETIC FIELDS AND THE BLOOD-BRAIN BARRIER.**

Stam R.

*Brain Res Rev.* 2010; 65(1): 80-97.

The mammalian blood-brain barrier (BBB) consists of endothelial cells, linked by tight junctions, and the adjoining pericytes and extracellular matrix. It helps maintain a highly stable extracellular environment necessary for accurate synaptic transmission and protects nervous tissue from injury. An increase in its normally low permeability for hydrophilic and charged molecules could potentially be detrimental. Methods to assess the permeability of the BBB include histological staining for marker molecules in brain sections and measurement of the concentration of marker molecules in blood and brain tissue. Their advantages and disadvantages are discussed. Exposure to levels of radiofrequency electromagnetic fields (EMF) that increase brain temperature by more than 1°C can reversibly increase the permeability of the BBB for macromolecules. The balance of experimental evidence does not support an effect of 'non-thermal' radiofrequency fields with microwave and mobile phone frequencies on BBB permeability. Evidence for an effect of the EMF generated by magnetic resonance imaging on permeability is conflicting and conclusions are hampered by potential

confounders and simultaneous exposure to different types and frequencies of EMF. The literature on effects of low frequency EMF, which do not cause tissue heating, is sparse and does not yet permit any conclusions on permeability changes. Studies on the potential effect of EMF exposure on permeability of the BBB in humans are virtually absent. Future permeability studies should focus on low frequency effects and effects in humans. Care should be taken to avoid the methodological limitations of earlier studies and to determine the pathophysiological relevance of any changes found.

## **5. Exposure assessment**

### **METHODOLOGY OF A STUDY ON THE FRENCH POPULATION EXPOSURE TO 50 HZ MAGNETIC FIELDS.**

Bédja M, Magne I, Souques M, Lambrozo J, Le Brusquet L, Fleury G, Azoulay A, Deschamps F, Carlsberg A.

*Radiat Prot Dosimetry. 2010; 142(2-4): 146-152.*

The characterisation of population exposure to a 50-Hz magnetic field (MF) is important for assessing health effects of electromagnetic fields. With the aim of estimating and characterising the exposure of the French population to 50-Hz MFs, two representative samples of the population were made. A random selection method based on the distribution of households in different regions of France was used. The samples were carried out starting from a random polling of telephone numbers of households (listed, unlisted fixed phones and cell phones only). A total of 95,362 telephone numbers were dialed to have 2148 volunteers (1060 children and 1088 adults). They all agreed to carrying an EMDEX II meter, measuring and recording MFs, and to filling out a timetable for a 24-hour period.

Conclusion: In this article, the methodology of the sample selection and the collection of all necessary information for the realisation of this study are presented.

### **EXPOSURE TO MAGNETIC FIELDS OF RAILWAY ENGINE DRIVERS: A CASE STUDY IN ITALY.**

Contessa GM, Falsaperla R, Brugaletta V, Rossi P.

*Radiat Prot Dosimetry. 2010; 142(2-4): 160-167.*

A case study of exposure assessment of railway workers to static and extremely low frequency (ELF) magnetic fields is presented. A measurement campaign was conducted in aboard Italian main line trains. All measurements were performed on board during regular service (two engine drivers were simultaneously present), in all places potentially accessible to personnel, considering routes ranging from a few tens of kilometres to hundreds of kilometres. The measurement protocol was mostly based on broadband metres and personal metres were employed to assess individual exposure. Surveys on static and ELF magnetic fields were performed for seven different models of engine or electrified train. Traction motors were fed by alternating current (AC) current, except for two engines, where AC current fed only auxiliary services. The final result is that the average exposure to static magnetic field was a little higher than the background geomagnetic field; occasionally in few areas it could reach levels of the order of millitesla.

Conclusion: The average exposure to ELF magnetic fields was in the order of 1-2  $\mu$ T, with higher levels (few microtesla) only for one engine; occasionally in hot spots, close to wiring or specific equipment, the field values could reach several tens of microtesla.

## 6. Leukaemia studies

### **CHILDHOOD ACUTE LEUKEMIA, EARLY COMMON INFECTIONS, AND ALLERGY: THE ESCALE STUDY.**

Rudant J, Orsi L, Menegaux F, Petit A, Baruchel A, Bertrand Y, Lambilliotte A, Robert A, Michel G, Margueritte G, Tandonnet J, Mechinaud F, Bordigoni P, Hémon D, Clavel J.

*Am J Epidemiol.* 2010; 172(9): 1015-1027.

This study investigated the role of factors considered related to early stimulation of the immune system in the etiology of childhood acute leukemia. The national registry-based case-control study ESCALE was carried out in France in 2003-2004. Population controls were frequency matched to cases on age and gender. Data were obtained from structured telephone questionnaires administered to mothers. Odds ratios were estimated using unconditional regression models adjusted for potential confounders. Included were 634 acute lymphoblastic leukemia cases, 86 acute myeloblastic leukemia cases, and 1,494 controls aged  $\geq 1$  year. Negative associations were observed between acute lymphoblastic leukemia and birth order (P for trend  $< 0.0001$ ), attendance at a day-care center before age 1 year (odds ratio (OR) = 0.8, 95% confidence interval (CI): 0.6, 1.1), prolonged breastfeeding (OR = 0.7, 95% CI: 0.5, 1.0), repeated early common infections (OR = 0.7, 95% CI: 0.6, 0.9), regular contact with farm animals (OR = 0.6, 95% CI: 0.5, 0.8), frequent farm visits in early life (OR = 0.4, 95% CI: 0.3, 0.6), and history of asthma (OR = 0.7, 95% CI: 0.4, 1.0) or eczema (OR = 0.7, 95% CI: 0.6, 0.9).

Conclusion : Results support the hypothesis that repeated early infections and asthma may play a role against childhood acute leukemia.

### **DIAGNOSTIC X-RAYS AND RISK OF CHILDHOOD LEUKAEMIA.**

Bartley K, Metayer C, Selvin S, Ducore J, Buffler P.

*Int J Epidemiol.* 2010; 39(6): 1628-1637.

The association between diagnostic X-ray exposures early in life and increased risk of childhood leukaemia remains unclear. This case-control study included children aged 0 –14 years diagnosed with acute lymphoid leukaemia (ALL, n = 711) or acute myeloid leukaemia (AML, n = 116) from 1995 to 2008. Controls were randomly selected from the California birth registry and individually matched to cases with respect to date of birth, sex, Hispanic ethnicity and maternal race. Conditional logistic regression analyses were performed to assess whether ALL or AML was associated with self-reported child's X-rays after birth (post-natal), including number of X-rays, region of the body X-rayed and age at first X-ray, as well as maternal X-rays before and during pregnancy (preconception and prenatal).

After excluding X-rays in the year prior to diagnosis (reference date for matched controls), risk of ALL was elevated in children exposed to three or more post-natal X-rays (oddsratio OR = 1.85, 95% confidence interval CI 1.2 – 2.79). For B-cell ALL specifically, any exposure (one or more X-rays) conferred increased risk (OR = 1.40,

95% CI 1.06-1.86). Region of the body exposed was not an independent risk factor in multivariable analyses. No associations were observed between number of post-natal X-rays and AML (OR = 1.05, 95% CI 0.90-1.22) or T-cell ALL (OR = 0.84, 95% CI 0.59-1.19). Prevalence of exposure to prenatal and preconception X-rays was low, and no associations with ALL or AML were observed.

Conclusion: The results suggest that exposure to post-natal diagnostic X-rays is associated with increased risk of childhood ALL, specifically B-cell ALL, but not AML or T-cell ALL. Given the imprecise measures of self-reported X-ray exposure, the results of this analysis should be interpreted with caution and warrant further investigation.

**IS THERE ANY INTERACTION BETWEEN DOMESTIC RADON EXPOSURE AND AIR POLLUTION FROM TRAFFIC IN RELATION TO CHILDHOOD LEUKEMIA RISK?**

Bräuner EV, Andersen CE, Andersen HP, Gravesen P, Lind M, Ulbak K, Hertel O, Schüz J, Raaschou-Nielsen O.

*Cancer Causes Control. 2010; 21(11): 1961-1964.*

In a recent population-based case-control study using 2,400 cases of childhood cancer, the authors found a statistically significant association between residential radon and acute lymphoblastic leukemia risk. They studied the hypothesis that traffic exhaust in the air enhances the risk association between radon and childhood leukemia.

They included 985 cases of childhood leukemia and 1,969 control children and used validated models to calculate residential radon and street NO(x) concentrations for each home. Conditional logistic regression analyses were used to analyze the effect of radon on childhood leukemia risk within different strata of air pollution and traffic density.

The relative risk for childhood leukemia in association with a 10(3) Bq/m(3)-years increase in radon was 1.77 (1.11, 2.82) among those exposed to high levels of NO(x) and 1.23 (0.79, 1.91) for those exposed to low levels of NO(x) (p(interaction,) 0.17). Analyses for different morphological subtypes of leukemia and within different strata of traffic density showed a non-significant pattern of stronger associations between radon and childhood leukemia within strata of higher traffic density at the street address.

Conclusion: Air pollution from traffic may enhance the effect of radon on the risk of childhood leukemia. The observed tendency may also be attributed to chance.