

## Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the first trimester of 2014

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### 1. Reviews

#### **MAGNETIC FIELDS EXPOSURE AND CHILDHOOD LEUKEMIA RISK: A META-ANALYSIS BASED ON 11,699 CASES AND 13,194 CONTROLS.**

Zhao L, Liu X, Wang C, Yan K, Lin X, Li S, Bao H, Liu X.  
*Leuk Res.* 2014; 38(3):269-274.

The objective of this study was to observe the association between childhood leukemia and magnetic field exposure. The literature was searched by PubMed, ProQuest, Web of Science (SCI) and Medline databases during 1997-2013. Heterogeneity in several studies was weighted by I-squared value. Publication bias was tested by funnel plot and Egger's test. Odds ratio (OR) and 95% CI were used to evaluate the association strength. The statistical analyses in present study were carried out by STATA software package (version 12.0, College Station, TX).

A total of 11,699 cases and 13,194 controls in 9 studies were stratified by different exposure cut-off points. On condition of the reference  $<0.1 \mu\text{T}$ , statistical association between magnetic field intensity  $\geq 0.4 \mu\text{T}$  and childhood leukemia was exhibited (for total leukemia: OR = 1.57, 95% CI = 1.03-2.40; for acute lymphocytic leukemia: OR=2.43, 95% CI = 1.30-4.55). On condition of the reference level of  $<0.2 \mu\text{T}$ , the positive association between magnetic field intensity  $\geq 0.2 \mu\text{T}$  and childhood leukemia was found (OR = 1.31, 95% CI = 1.06-1.61).

Conclusions: The result in this meta-analysis indicated that magnetic field exposure level may be associated with childhood leukemia.

#### **POTENTIAL HEALTH IMPACTS OF RESIDENTIAL EXPOSURES TO EXTREMELY LOW FREQUENCY MAGNETIC FIELDS IN EUROPE.**

Grellier J<sup>1</sup>, Ravazzani P, Cardis E.  
*Environ Int.* 2014; 62:55-63.

Over the last two decades residential exposure to extremely low frequency magnetic fields (ELF MF) has been associated with childhood leukaemia relatively consistently in epidemiological studies, though causality is still under investigation. The authors aimed to estimate the cases of childhood leukaemia that might be attributable to exposure to ELF MF in the European Union (EU27), if the associations seen in epidemiological studies were causal. They estimated distributions of ELF MF exposure using studies identified in the existing literature. Individual distributions of exposure were integrated using a probabilistic mixture distribution approach. Exposure-response functions were estimated from the most recently published pooled analysis of epidemiological data. Probabilistic simulation was used to estimate population attributable fractions (AFP) and attributable cases of childhood leukaemia in the EU27. By assigning the literature review-based exposure distribution to all EU27 countries, the total annual number of cases of leukaemia attributable to ELF MF at between ~50 (95% CIs: -14, 132) and ~60

(95% CIs: -9, 610) was estimated, depending on whether exposure-response was modelled categorically or continuously, respectively, for a non-threshold effect.

Conclusions: The total annual number of cases of leukaemia attributable to ELF MF was estimated between ~1.5% and ~2.0% of all incident cases of childhood leukaemia occurring annually in the EU27. Considerable uncertainties are due to scarce data on exposure and the choice of exposure-response model, demonstrating the importance of further research into better understanding mechanisms of the potential association between ELF MF exposure and childhood leukaemia and the need for improved monitoring of residential exposures to ELF MF in Europe.

## **2. Residential exposure**

### **RESIDENTIAL DISTANCE AT BIRTH FROM OVERHEAD HIGH-VOLTAGE POWERLINES: CHILDHOOD CANCER RISK IN BRITAIN 1962-2008.**

Bunch KJ, Keegan TJ, Swanson J, Vincent TJ, Murphy MF.

*Br J Cancer. 2014; 110(5):1402-1408.*

The authors extended their previous study of childhood leukaemia and proximity to high-voltage powerlines by including more recent data and cases and controls from Scotland, by considering 132-kV powerlines as well as 275 and 400 kV and by looking at greater distances from the powerlines. A case-control study using 53 515 children from the National Registry of Childhood Tumours 1962-2008, matched controls, and calculated distances of mother's address at child's birth to powerlines at 132, 275, and 400 kV in England, Wales and Scotland was carried out. The previous finding of an excess risk for leukaemia at distances out to 600 m declines over time. Relative risk and 95% confidence interval for leukaemia, 0-199 m compared with >1000 m, all voltages: 1960s 4.50 (0.97-20.83), 2000s 0.71 (0.49-1.03), aggregate over whole period is 1.12 (0.90-1.38). Increased risk, albeit less strong, may also be present for 132-kV lines. Increased risk does not extend beyond 600 m for lines of any voltage.

Conclusions: A risk declining over time is unlikely to arise from any physical effect of the powerlines and is more likely to be the result of changing population characteristics among those living near powerlines.

### **DISTANCE FROM RESIDENCE TO POWER LINE AND RISK OF CHILDHOOD LEUKEMIA: A POPULATION-BASED CASE-CONTROL STUDY IN DENMARK.**

Pedersen C, Raaschou-Nielsen O, Rod NH, Frei P, Poulsen AH, Johansen C, Schüz J.

*Cancer Causes Control. 2014; 25(2):171-177.*

Epidemiological studies have found an association between exposure to extremely low-frequency magnetic fields (ELF-MF) and childhood leukemia. In 2005, a large British study showed an association between proximity of residence to high-voltage power lines and the risk of childhood leukemia. The association extended beyond distances at which the 'power line'-induced magnetic fields exceed background levels, suggesting that the association was not explained by the magnetic field, but might be due to chance, bias, or other risk factors associated with proximity to power lines. The aim of the authors was to conduct a comparable study in an independent setting (Denmark).

They included 1,698 cases aged <15, diagnosed with leukemia during 1968-2006, from the Danish Cancer Registry and 3,396 controls randomly selected from the

Danish childhood population and individually matched by gender and year of birth. Geographical information system was used to determine the distance between residence at birth and the nearest 132-400 kV overhead power line.

Odds ratios (ORs) were 0.76 [95 % confidence interval (CI) 0.40-1.45] for children who lived 0-199 m from the nearest power line and 0.92 (95 % CI 0.67-1.25) for those who lived 200-599 m away when compared with children who lived  $\geq$ 600 m away. When restricting the analysis to 220 and 400 kV overhead power lines, the OR for children who lived 200-599 m from a power line was 1.76 (95 % CI 0.82-3.77) compared to children who lived  $\geq$ 600 m away. However, chance is a likely explanation for this finding as the result was not significant, numbers were small, and there were no indications of an higher risk closer to the lines since no cases were observed within 200 m of these.

Conclusions: This study does not find a higher risk of leukemia for children living 0-199 m or for children living 200-599 m of a 132-400 kV overhead power line. A slightly elevated OR for children living between 200 and 599 m of a 220-400 kV overhead power line is likely to be a chance finding.

### **3. Occupational exposure**

#### **OCCUPATIONAL EXTREMELY LOW-FREQUENCY MAGNETIC FIELD EXPOSURE AND SELECTED CANCER OUTCOMES IN A PROSPECTIVE DUTCH COHORT.**

Koeman T, van den Brandt PA, Slottje P, Schouten LJ, Goldbohm RA, Kromhout H, Vermeulen R.

*Cancer Causes Control. 2014; 25(2):203-214.*

The purpose to this study is to investigate the association between exposure to occupational extremely low-frequency magnetic fields (ELF-MF) and the risk of a priori selected cancer outcomes within the prospective Netherlands Cohort Study.

120,852 men and women aged 55-69 years at time of enrollment in 1986 were followed up (17.3 years) for incident lung, breast and brain cancer, and hematolymphoproliferative malignancies. Information on occupational history and potential confounders such as sex, age, smoking, alcohol use, and attained educational level were collected at baseline through a self-administered questionnaire. Occupational ELF-MF exposure was assigned with a job-exposure matrix. Using a case-cohort approach, associations with cancer incidence were analyzed with Cox regression stratified by sex, using three exposure metrics: (1) ever had a job with low or high exposure to ELF-MF versus background, (2) duration of exposure, and (3) cumulative exposure.

None of the exposure metrics showed an effect on incidence for lung, breast, and brain cancer, nor any of the assessed subtypes in men and women. Of the hematolymphoproliferative malignancies in men, ever high exposed to ELF-MF showed a significant association with acute myeloid leukemia (AML) [hazard ratio (HR) 2.15; 95 % confidence interval (CI) 1.06-4.35] and follicular lymphoma (FL) (HR 2.78; 95 % CI 1.00-5.77). Cumulative exposure to ELF-MF showed a significant, positive association with FL but not AML among men.

Conclusions: In this large prospective cohort study, the authors found some indications of an increased risk of AML and FL among men with occupational ELF-MF exposure. These findings warrant further investigation.

#### 4. Human experiment

##### **ELECTROMAGNETIC INTERFERENCE WITH IMPLANTABLE CARDIOVERTER-DEFIBRILLATORS AT POWER FREQUENCY: AN IN VIVO STUDY.**

Napp A, Joosten S, Stunder D, Knackstedt C, Zink M, Bellmann B, Marx N, Schauerte P, Silny J.

*Circulation. 2014; 129(4):441-450.*

The number of implantable cardioverter-defibrillators (ICDs) for the prevention of sudden cardiac death is continuing to increase. Given the technological complexity of ICDs, it is of critical importance to identify and control possible harmful electromagnetic interferences between various sources of electromagnetic fields and ICDs in daily life and occupational environments.

Interference thresholds of 110 ICD patients (1-, 2-, and 3-chamber ICDs) were evaluated in a specifically developed test site. Patients were exposed to single and combined electric and magnetic 50-Hz fields with strengths of up to 30 kV·m<sup>-1</sup> and 2.55 mT. Tests were conducted considering worst-case conditions, including maximum sensitivity of the device or full inspiration. With devices being programmed to nominal sensitivity, ICDs remained unaffected in 91 patients (83%). Five of 110 devices (5%) showed transient loss of accurate right ventricular sensing, whereas 14 of 31 (45%) of the 2- and 3-chamber devices displayed impaired right atrial sensing. No interference was detected in 71 patients (65%) within the tested limits with programming to maximum sensitivity, whereas 20 of 110 subjects (18%) exhibited right ventricular disturbances and 19 of 31 (61%) subjects exhibited right atrial disturbances.

Conclusions: Extremely low-frequency daily-life electromagnetic fields do not disturb sensing capabilities of ICDs. However, strong 50-Hz electromagnetic fields, present in certain occupational environments, may cause inappropriate sensing, potentially leading to false detection of atrial/ventricular arrhythmic events. When the right atrial/right ventricular interferences are compared, the atrial lead is more susceptible to electromagnetic fields.

##### **INTERFERENCE BETWEEN ACTIVE IMPLANTED MEDICAL DEVICES AND ELECTROMAGNETIC FIELD EMITTING DEVICES IS RARE BUT REAL: RESULTS OF AN INCIDENCE STUDY IN A POPULATION OF PHYSICIANS IN FRANCE.**

Hours M, Khati I, Hamelin J.

*Pacing Clin Electrophysiol. 2014; 37(3):290-296.*

Assessing the behavior of active implanted medical devices (AIMDs) in response to electromagnetic field (EMF) transmitters is a current issue of great importance. Given the numerous telecommunication systems and our lack of knowledge as to the impact of electromagnetic effects, this study investigated the reality of possible AIMD disturbance by EMFs by interviewing health professionals.

A self-administered postal questionnaire was sent to almost 5,000 physicians in five specialties: cardiology; endocrinology; ears, nose, and throat; urology; and neurology. It collected data on the existence and annual number of incidents observed and the conditions under which they occurred, the EMF sources involved, and the means of managing the malfunctions.

A total of 1,188 physicians agreed to participate. Sixteen percent of participants reported cases of implant failure, three-quarters of whom, mainly in cardiology,

reported rates of at least one incident per year-amounting to more than 100 incidents per year in all. Severity appeared to be moderate (discomfort or transient symptoms), but frequently required resetting or, more rarely, replacing the device. Some serious incidents were, however, reported. The sources implicated were basically of two types: electronic security systems (antitheft and airport gates) and medical electromagnetic radiation devices. These incidents were poorly reported within the public health system, preventing follow-up and effective performance of alert and surveillance functions.

Conclusion: Although minor, the risk of interference between EMF sources and AIMDs is real and calls for vigilance. It particularly concerns antitheft and airport security gates, though other sources may also cause incidents.

#### **IMPLANTABLE CARDIOVERTER DEFIBRILLATORS IN ELECTRIC AND MAGNETIC FIELDS OF 400 KV POWER LINES.**

Korpinen L, Kuisti H, Elovaara J, Virtanen V.  
*Pacing Clin Electrophysiol.* 2014; 37(3):297-303.

Implantable cardioverter defibrillator (ICD) therapy has increased in Western countries. The aim of the study was to investigate the function of ICDs using a human-shaped phantom in electric and magnetic fields of 400 kV power lines. The phantom was used in the following manner: isolated from the ground, earthed from a foot, or earthed from a hand.

The authors performed 37 ICD tests using 10 different ICD devices. When the electric fields varied from 6.8 kV/m to 7.5 kV/m (humidity 70.5%) and the magnetic field was 2.0  $\mu$ T, one of the ICDs tested recorded 258 ventricular beats/min when a simulated heart signal was applied to ICD electrodes. When the exposure was 5.1 kV/m, the same ICD had a similar disturbance; however, in a 0.9 kV/m field, it worked correctly.

Conclusions: No effect on ICDs functioning was observed up to 0.9 kV/m, while anomalous behavior in some conditions was observed when levels exceeded 5.1 kV/m; ICD malfunctioning seems possible within 11.5 m from 400 kV power lines or in conditions inducing exposures exceeding 5 kV/m. Further development of this research field is needed.

## **5. Exposure assessment**

#### **INDOOR TRANSFORMER STATIONS AND ELF MAGNETIC FIELD EXPOSURE: USE OF TRANSFORMER STRUCTURAL CHARACTERISTICS TO IMPROVE EXPOSURE ASSESSMENT.**

Okokon EO, Roivainen P, Kheifets L, Mezei G, Juutilainen J.  
*J Expo Sci Environ Epidemiol.* 2014; 24(1):100-104.

Previous studies have shown that populations of multi-apartment buildings with indoor transformer stations may serve as a basis for improved epidemiological studies on the relationship between childhood leukaemia and extremely-low-frequency (ELF) magnetic fields (MFs). This study investigated whether classification based on structural characteristics of the transformer stations would improve ELF MF exposure assessment. The data included MF measurements in apartments directly above transformer stations ("exposed" apartments) in 30 buildings in Finland, and reference apartments in the same buildings. Transformer structural characteristics (type and location of low-voltage conductors) were used to

classify exposed apartments into high-exposure (HE) and intermediate-exposure (IE) categories. An exposure gradient was observed: both the time-average MF and time above a threshold ( $0.4 \mu\text{T}$ ) were highest in the HE apartments and lowest in the reference apartments, showing a statistically significant trend. The differences between HE and IE apartments, however, were not statistically significant.

Conclusions: A simulation exercise showed that the three-category classification did not perform better than a two-category classification (exposed and reference apartments) in detecting the existence of an increased risk. However, data on the structural characteristics of transformers is potentially useful for evaluating exposure-response relationship.

## **6. Leukaemia studie**

### **DO LONGER FORMULA FEEDING AND LATER INTRODUCTION OF SOLIDS INCREASE RISK FOR PEDIATRIC ACUTE LYMPHOBLASTIC LEUKEMIA?**

Schraw JM, Dong YQ, Okcu MF, Scheurer ME, Forman MR.

*Cancer Causes Control.* 2014; 25(1):73-80.

Milk formula feeding can elevate insulin-like growth factor-1 levels, possibly impacting leukemogenesis. The intent of the current study is to examine the associations between infant feeding practices and age at introduction of solids on risk of childhood acute lymphoblastic leukemia (ALL). Incident cases of infant and childhood (aged  $\leq 14$  years) ALL ( $n = 142$ ) were enrolled in a case-control study. Cases were frequency matched on age, sex, race, and ethnicity to two sets of controls ( $n = 284$  total). Multivariable logistic regression was used to determine the association between infant feeding practices and age at the introduction of solids and the odds ratio of ALL. In adjusted multivariable analyses, each additional month of formula feeding was associated with a 1.17 (1.09-1.25) odds ratio; each additional month of age at introduction of solids was associated with a 1.18 (1.07-1.30) odds ratio.

Conclusions: In this study, longer duration of formula feeding and later age at the introduction of solid foods were independently associated with increased risk of ALL. Additional studies are needed to address the factors influencing duration of formula feeding and delayed introduction of solids. The results support the potential role of energy balance in early life as a contributor to risk for pediatric acute lymphoblastic leukemia.

### **MATERNAL COFFEE CONSUMPTION DURING PREGNANCY AND RISK OF CHILDHOOD ACUTE LEUKEMIA: A META-ANALYSIS.**

Cheng J, Su H, Zhu R, Wang X, Peng M, Song J, Fan D.

*Am J Obstet Gynecol.* 2014; 210(2):151.e1-151.e10.

This study was undertaken to explore the association between maternal coffee consumption during pregnancy and childhood acute leukemia (AL).

The PubMed database was used to search studies up to May 5, 2013, and the lists of references of retrieved articles were also screened to identify additional relevant studies. Studies were included if they reported the odds ratio and corresponding 95% confidence interval (CI) of childhood AL, including childhood acute

lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML), with respect to maternal coffee consumption during pregnancy.

Compared with non/lowest drinkers, the combined odds ratio regarding the relationship of maternal coffee consumption during pregnancy and childhood AL was 1.22 (95% CI, 1.04-1.43) for ever drinkers, 1.16 (95% CI, 1.00-1.34) for low to moderate-level drinkers, and 1.72 (95% CI, 1.37-2.16) for high-level drinkers. When analysis was conducted by subtypes of childhood AL, maternal coffee consumption (high-level drinkers vs non/lowest drinkers) was statistically significantly associated with childhood ALL (1.65; 95% CI, 1.28-2.12) and childhood AML (1.58; 95% CI, 1.20-2.08). A linear dose-response relationship of coffee consumption and childhood AL ( $P$  for nonlinearity = .68) was observed, including childhood ALL and childhood AML; with increased coffee consumption, the risk of childhood AL increased.

Conclusions: The findings of the meta-analysis suggest that maternal coffee consumption during pregnancy may increase the risk of childhood AL. Because of limited studies, further prospective studies are urgently needed to explore the adverse effect of coffee consumption on childhood AL.

#### **MATERNAL FACTORS AND RISK OF CHILDHOOD LEUKEMIA.**

Kumar A, Vashist M, Rathee R.

*Asian Pac J Cancer Prev. 2014; 15(2):781-784.*

Although the cause in most cases of childhood leukemia is not known, the contribution of environmental risk factors in the context of genetic predisposition has been reported with inconsistent results. The aim of this study was to examine association of childhood leukemia with maternal factors especially during pregnancy, to help in avoiding risk factors. This case-control study included children younger than 18 years diagnosed with leukemia from 2008 to 2012. Controls were randomly selected and individually matched to cases with respect to age, sex, and residency. All variables were compared between cases and control to determine any significant association with leukemia. Statistically significant associations between risk of childhood leukemia with mother's education ( $p=0.001$ ), occupation ( $p=0.0005$ ) and pesticides exposure ( $p=0.005$ ) during pregnancy were found. However, there were no significant links with maternal age ( $p=0.090$ ), history of fetal loss (0.85), history of radiography during pregnancy ( $p=0.400$ ), history of drug intake ( $p=0.689$ ) and infection ( $p=0.696$ ) during pregnancy.

Conclusions: The results showed increased risk of leukemia in children whose mothers were working in agriculture and were exposed to pesticides during pregnancy. The further study needs to be investigated to know association of various maternal risk factors with leukemia which remained unknown in this study.