

# Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2015

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## 1. Reviews

### **ARE PATIENTS WITH CARDIAC IMPLANTS PROTECTED AGAINST ELECTROMAGNETIC INTERFERENCE IN DAILY LIFE AND OCCUPATIONAL ENVIRONMENT?**

Napp A, Stunder D, Maytin M, Kraus T, Marx N, Driessen S.  
*Eur Heart J.* 2015;36(28):1798-1804.

Utilization of cardiac implants such as pacemakers and implantable cardioverter defibrillators is now commonplace among heart disease patients. The ever-increasing technological complexity of these devices is matched by the near omnipresent exposure to electric, magnetic, and electromagnetic fields (EMFs), both in everyday life and the occupational environment. Given that electromagnetic interferences (EMIs) are associated with potential risk in device patients, physicians are increasingly confronted with managing device patients with intermittent EMI and chronic occupational exposure.

Conclusions: The current review aims to provide a contemporary overview of cardiovascular implantable electronic devices, their function and susceptibility of non-medical EMFs and provide recommendations for physicians caring for cardiac device patients presenting with EMI.

## 2. Residential exposure

### **MAGNETIC FIELDS AND CHILDHOOD CANCER: AN EPIDEMIOLOGICAL INVESTIGATION OF THE EFFECTS OF HIGH-VOLTAGE UNDERGROUND CABLES.**

Bunch KJ, Swanson J, Vincent TJ, Murphy MF.  
*J Radiol Prot.* 2015;35(3):695-705.

Epidemiological evidence of increased risks for childhood leukaemia from magnetic fields has implicated, as one source of such fields, high-voltage overhead lines. Magnetic fields are not the only factor that varies in their vicinity, complicating interpretation of any associations. Underground cables (UGCs), however, produce magnetic fields but have no other discernible effects in their vicinity. The authors report here the largest ever epidemiological study of high voltage UGCs, based on 52 525 cases occurring from 1962-2008, with matched birth controls. They calculated the distance of the mother's address at child's birth to the closest 275 or 400 kV ac or high-voltage dc UGC in England and Wales and the resulting magnetic fields. Few people are exposed to magnetic fields from UGCs limiting the statistical power. No indications of an association of risk with distance or of trend in risk with increasing magnetic field for leukaemia, and no convincing pattern of risks for any other cancer were found. Trend estimates for leukaemia as shown by the odds ratio (and 95% confidence interval) per unit increase in exposure were: reciprocal of distance 0.99 (0.95-1.03), magnetic field 1.01 (0.76-1.33).

Conclusions: The absence of risk detected in relation to UGCs tends to add to the argument that any risks from overhead lines may not be caused by magnetic fields.

### **3. Occupational exposure**

#### **OCCUPATIONAL EXPOSURE TO EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS AND ELECTRICAL SHOCKS AND ACUTE MYELOID LEUKEMIA IN FOUR NORDIC COUNTRIES.**

Talibov M, Guxens M, Pukkala E, Huss A, Kromhout H, Slottje P, Martinsen JI, Kjaerheim K, Sparén P, Weiderpass E, Tryggvadottir L, Uuksulainen S, Vermeulen R.

*Cancer Causes Control. 2015;26(8):1079-1085.*

The authors studied the association between occupational exposure to extremely low-frequency magnetic fields (ELF-MF) and electrical shocks and acute myeloid leukemia (AML) in the Nordic Occupational Cancer cohort (NOCCA).

5,409 adult AML cases diagnosed between 1961 and 2005 in Finland, Iceland, Norway, and Sweden and 27,045 controls matched by age, sex, and country were included. Lifetime occupational ELF-MF exposure and risk of electrical shocks were assigned to jobs reported in the censuses using job-exposure matrices. Hazard ratios (HRs) and 95 % confidence intervals (95 % CIs) were estimated using conditional logistic regression adjusted for concurrent occupational exposures relevant for AML risk (e.g., benzene, ionizing radiation). Sensitivity analyses with different assumptions to assess the robustness of the results were conducted.

Approximately 40 % of the subjects were ever occupationally exposed to low levels and 7 % to high levels of ELF-MF, whereas 18 % were ever at low risk and 15 % at high risk of electrical shocks. The authors did not observe an association between occupational exposure to neither ELF-MF nor electrical shocks and AML. The HR was 0.88 (95 % CI 0.77-1.01) for subjects with high levels of ELF-MF exposure and 0.94 (95 % CI 0.85-1.05) for subjects with high risk of electrical shocks as compared to those with background-level exposure. Results remained materially unchanged in sensitivity analyses with different assumptions.

Conclusion: These results do not support an association between occupational ELF-MF or electric shock exposure and AML.

### **4. Human experimental study**

#### **EFFECTS OF A 60 HZ MAGNETIC FIELD EXPOSURE UP TO 3000 MT ON HUMAN BRAIN ACTIVATION AS MEASURED BY FUNCTIONAL MAGNETIC RESONANCE IMAGING.**

Legros A, Modolo J, Brown S, Roberston J, Thomas AW.

*PLoS One. 2015;10(7):e0132024.*

Several aspects of the human nervous system and associated motor and cognitive processes have been reported to be modulated by extremely low-frequency (ELF, < 300 Hz) time-varying Magnetic Fields (MF). Due to their worldwide prevalence, power-line frequencies (60 Hz in North America) are of particular interest. Despite intense research efforts over the last few decades, the potential effects of 60 Hz MF still need to be elucidated, and the underlying mechanisms to be understood. In this study, the authors have used functional Magnetic Resonance Imaging (fMRI) to characterize potential changes in functional brain activation following human exposure to a 60 Hz MF through motor and cognitive tasks. First, pilot results acquired in a first set of subjects (N=9) were used to demonstrate the technical feasibility of using fMRI to detect subtle changes in functional brain activation with 60 Hz MF exposure at 1800  $\mu$ T. Second, a full study involving a larger cohort of subjects tested brain activation during 1) a finger tapping task

(N=20), and 2) a mental rotation task (N=21); before and after a one-hour, 60 Hz, 3000  $\mu$ T MF exposure. The results indicate significant changes in task-induced functional brain activation as a consequence of MF exposure. However, no impact on task performance was found. These results illustrate the potential of using fMRI to identify MF-induced changes in functional brain activation, suggesting that a one-hour 60 Hz, 3000  $\mu$ T MF exposure can modulate activity in specific brain regions after the end of the exposure period (i.e., residual effects).

Conclusions: The authors discuss the possibility that MF exposure at 60 Hz, 3000  $\mu$ T may be capable of modulating cortical excitability via a modulation of synaptic plasticity processes.

## **5. Exposure assessment**

### **ESTIMATING MAGNETIC FIELDS OF HOMES NEAR TRANSMISSION LINES IN THE CALIFORNIA POWER LINE STUDY.**

Vergara XP, Kavet R, Crespi CM, Hooper C, Silva JM, Kheifets L.

*Environ Res.* 2015 ;140:514-523.

The California Power Line Study is a case-control study investigating the relation between residences near transmission lines and risk of childhood leukemia. It includes 5788 childhood leukemia cases and 5788 matched primary controls born between 1986 and 2007. The authors describe the methodology for estimating magnetic fields at study residences as well as for characterizing sources of uncertainty in these estimates. Birth residences of study subjects were geocoded and their distances to transmission lines were ascertained. 302 residences were deemed sufficiently close to transmission lines to have non-zero magnetic fields attributable to the lines. These residences were visited and detailed data, describing the physical configuration and dimensions of the lines contributing to the magnetic field at the residence, were collected. Phasing, loading, and directional load flow data for years of birth and diagnosis for each subject as well as for the day of site visit were obtained from utilities when available; when yearly average load for a particular year was not available, extrapolated values based on expert knowledge and prediction models were obtained. These data were used to estimate the magnetic fields at the center, closest and farthest point of each residence. The authors found good correlation between calculated fields and spot measurements of fields taken on site during visits. The modeling strategies yielded similar calculated field estimates, and they were in high agreement with utility extrapolations. Phasing was known for over 90% of the lines. Important sources of uncertainty included a lack of information on the precise location of residences located within apartment buildings or other complexes.

Conclusions: These findings suggest that the authors were able to achieve high specificity in exposure assessment, which is essential for examining the association between distance to or magnetic fields from power lines and childhood leukemia risk.

## 6. Leukemia studies

### **THE ASSOCIATIONS BETWEEN MATERNAL FACTORS DURING PREGNANCY AND THE RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA: A META-ANALYSIS.**

Yan K, Xu X, Liu X, Wang X, Hua S, Wang C, Liu X.

*Pediatr Blood Cancer.* 2015;62(7):1162-1170.

Although genetic and environmental factors are considered to be the main causes of acute lymphoblastic leukemia, the associations between maternal factors during pregnancy and the childhood ALL is still unclear. In this study, meta-analysis was used. Medline, PubMed, and Web of Science were searched. The result was assessed based on pooled odds ratios (ORs) with 95% confidence intervals (CIs). The pooled ORs showed that there were associations between childhood ALL and the birth order (The first vs others, OR = 1.08, 95%CI = 1.00-1.16), the education of pregnant woman (>high school vs ≤ high school, OR = 0.82, 95%CI = 0.77-0.86), smoking (Ever vs never, OR = 1.10, 95%CI = 1.02-1.19).

Conclusions: This meta-analysis showed that there were important associations between childhood ALL and the birth order, the education of pregnant woman, smoking.

### **CHILDHOOD LEUKEMIA AND RESIDENTIAL PROXIMITY TO INDUSTRIAL AND URBAN SITES.**

García-Pérez J, López-Abente G, Gómez-Barroso D, Morales-Piga A, Romaguera EP, Tamayo I, Fernández-Navarro P, Ramis R.

*Environ Res.* 2015;140:542-553.

Few risk factors for the childhood leukemia are well established. While a small fraction of cases of childhood leukemia might be partially attributable to some diseases or ionizing radiation exposure, the role of industrial and urban pollution also needs to be assessed. The objective of this study was to ascertain the possible effect of residential proximity to both industrial and urban areas on childhood leukemia, taking into account industrial groups and toxic substances released. The authors conducted a population-based case-control study of childhood leukemia in Spain, covering 638 incident cases gathered from the Spanish Registry of Childhood Tumors and for those Autonomous Regions with 100% coverage (period 1990-2011), and 13,188 controls, individually matched by year of birth, sex, and autonomous region of residence. Distances were computed from the respective subject's residences to the 1068 industries and the 157 urban areas with ≥10,000 inhabitants, located in the study area. Using logistic regression, odds ratios (ORs) and 95% confidence intervals (95%CIs) for categories of distance to industrial and urban pollution sources were calculated, with adjustment for matching variables.

An excess risk of childhood leukemia was observed for children living near (≤2.5 km) industries (OR=1.31; 95%CI=1.03-1.67) - particularly glass and mineral fibers (OR=2.42; 95%CI=1.49-3.92), surface treatment using organic solvents (OR=1.87; 95% CI=1.24-2.83), galvanization (OR=1.86; 95%CI=1.07-3.21), production and processing of metals (OR=1.69; 95%CI=1.22-2.34), and surface treatment of metals (OR=1.62; 95%CI=1.22-2.15) - , and urban areas (OR=1.36; 95%CI=1.02-1.80).

Conclusions: This study furnishes some evidence that living in the proximity of industrial and urban sites may be a risk factor for childhood leukemia.

**HOUSEHOLD PESTICIDE EXPOSURE AND THE RISK OF CHILDHOOD ACUTE LEUKEMIA IN SHANGHAI, CHINA.**

Zhang Y, Gao Y, Shi R, Chen D, Wang X, Kamijima M, Sakai K, Nakajima T, Khalequzzaman M, Zhou Y, Zheng Y, Bao P, Tian Y.

*Environ Sci Pollut Res Int.* 2015;22(15):11755-11763.

The authors investigated the relationship between household exposure to pesticides and childhood AL. Between 2009 and 2010 in Shanghai, a total of 248 newly diagnosed cases of AL and 111 gender-, age-, and hospital-matched controls were included. Five nonspecific dialkyl phosphate (DAP) metabolites of organophosphate pesticides (OPPs) [including dimethyl phosphate (DMP), diethyl phosphate (DEP), dimethyl thiophosphate (DMTP), diethyl thiophosphate (DETP), and diethyl dithiophosphate (DEDTP)] in the urine were analyzed by gas chromatography. The results showed that the median DMP, DEP, DMTP, DETP, and DEDEP levels adjusted for creatinine (Cr) in cases (13.2, 10.0, 31.3, 8.5, and 6.1  $\mu\text{g g}(-1)$ , respectively) were all significantly elevated compared with those in controls (3.6, 3.6, 13.3, 2.7, and 1.7  $\mu\text{g g}(-1)$ , respectively) ( $P < 0.05$ ). The household use of mosquito repellent was significantly associated with an increased risk of childhood AL (odds ratio (OR)=1.9; 95% confidence interval (CI) 1.2-3.1). Moreover, higher exposures were significantly associated with an elevated risk of childhood AL for DMs, DEs, and DAPs.

**Conclusions:** These findings support the notion that the household use of pesticides may play a role in the etiology of childhood AL and provide some evidence to warrant further investigation of the link between household pesticide exposures and childhood AL in Shanghai.

**RESIDENTIAL EXPOSURE TO SOLAR ULTRAVIOLET RADIATION AND INCIDENCE OF CHILDHOOD HEMATOLOGICAL MALIGNANCIES IN FRANCE.**

Coste A, Goujon S, Boniol M, Marquant F, Faure L, Doré JF, Hémon D, Clavel J.

*Cancer Causes Control.* 2015;26(9):1339-1349.

Few studies have investigated the relationship between solar ultraviolet radiation (UV) and childhood hematological malignancies (CHM). This study addresses the associations between residential UV exposure at diagnosis and the incidence of types and subtypes of CHM, by age and gender, in France, over a long period, on the fine scale of the 36,326 Communes that constitute mainland France. The 9,082 cases of acute leukemia and 3,563 cases of lymphoma diagnosed before the age of 15 years from 1990 to 2009 were provided by the French National Registry of Childhood Hematological Malignancies. The incidence of CHM was calculated by Commune, year, age and gender and expressed as the standardized incidence ratio (SIR). UV data from 1988 to 2007 were extracted from the EUROSUN database.

The annual daily average UV exposure of the children ranged from 85.5 to 137.8  $\text{J}/\text{cm}^2$ . For each additional 25  $\text{J}/\text{cm}^2$ , there was a significant increase in precursor B-cell acute lymphoblastic leukemia (PBC-ALL) in children aged less than 5 years (SIR 1.18; 95 % CI 1.10-1.27). Further analysis of PBC-ALL in the young children suggested a better fit of models with a threshold, with the risk increasing above 100  $\text{J}/\text{cm}^2$ , for which the SIR was 1.24 (95 % CI 1.14-1.36) for a 25  $\text{J}/\text{cm}^2$  increase. The results remained stable in analyses stratifying by deprivation index or degree of urbanization of the Communes.

**Conclusions:** The study suggests that higher residential UV exposure may be positively associated with a higher incidence of PBC-ALL in early childhood.