

# Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the fourth trimester of 2017

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## 1. Reviews

### **OCCUPATIONAL EXPOSURE TO EXTREMELY LOW FREQUENCY MAGNETIC FIELD AND RISK OF ALZHEIMER DISEASE: A SYSTEMATIC REVIEW AND META-ANALYSIS.**

Jalilian H, Teshnizi SH, Rössli M, Neghab M.

*Neurotoxicology. 2017 Dec 23. pii: S0161-813X(17)30239-5.*

Occupational exposure to extremely low frequency magnetic fields (ELF-MF) occurs in many occupations such as welders, electric utility workers, train drivers and sewing machine operators. There is some evidence suggesting ELF-MF exposure to be a risk factor for Alzheimer's disease (AD). The current study aims at systematically reviewing the literature and conducting a meta-analysis to evaluate the risk of AD amongst workers exposed to ELF-MF.

Bibliographic databases were searched including PubMed, EMBASE, Cochrane Library, and Web of Science in November 2017. Risk of bias was assessed in the all included studies. Pooled estimates were obtained using random-effects meta-analysis. In addition, sources of heterogeneity between studies and publication bias were explored.

In total, 20 articles met the inclusion criteria. The pooled results suggest an increased risk of AD (RR: 1.63; 95% CI: 1.35, 1.96). Higher risk estimates were obtained from case-control studies (OR: 1.80; 95% CI: 1.40, 2.32) than from cohort studies (RR: 1.42; 95% CI: 1.08, 1.87). A moderate to high heterogeneity ( $I^2 = 61.0\%$ ) and indication for publication bias (Egger test:  $p < .001$ ) were found.

Conclusions: The results suggested that occupational exposure to ELF-MF might increase the risk of AD. However, this suggestion should be interpreted with caution given the moderate to high heterogeneity and indication for publication bias.

## 2. Residential exposure

### **EXPOSURE TO MAGNETIC FIELD NON-IONIZING RADIATION AND THE RISK OF MISCARRIAGE: A PROSPECTIVE COHORT STUDY.**

Li DK, Chen H, Ferber JR, Odouli R2 Quesenberry C.

*Sci Rep. 2017 Dec 13;7(1):17541.*

Magnetic field (MF) non-ionizing radiation is widespread and everyone is exposed to some degree. This prospective cohort study of 913 pregnant women examined the association between high MF exposure and miscarriage risk. Cox (proportional hazards) regression was used to examine the association. After controlling for multiple other factors, women who were exposed to higher MF levels had 2.72 times the risk of miscarriage (hazard ratio = 2.72, 95% CI: 1.42-5.19) than those with lower MF exposure. The increased risk of miscarriage associated with high MF was consistently observed regardless of the sources of high MF. The association was much stronger if

MF was measured on a typical day of participants' pregnancies. The finding also demonstrated that accurate measurement of MF exposure is vital for examining MF health effects.

Conclusions: This study provides fresh evidence, directly from a human population, that MF non-ionizing radiation could have adverse biological impacts on human health.

**MATERNAL CUMULATIVE EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS AND PREGNANCY OUTCOMES IN THE ELFE COHORT.**

Migault L, Piel C, Carles C, Delva F, Lacourt A, Cardis E, Zaros C, de Seze R, Baldi I, Bouvier G.

*Environ Int.* 2017 Dec 20;112:165-173.

The objective of this study was to study the relations between maternal cumulative exposure to extremely low frequency electromagnetic fields (ELF EMF) and the risk of moderate prematurity and small for gestational age within the Elfe cohort.

The Elfe study included 18,329 infants born at 33 weeks of gestation or more in France in 2011 and was designed to follow the children until 20 years of age. Gestational age and anthropometric data at birth were collected in medical records and small for gestational age was defined according to a French customized growth standard. During interviews, mothers were asked to report their job status during pregnancy. If employed, their occupation was coded according to the International Standard Classification of Occupations 1988 and the date on which they stopped their work was recorded. Cumulative exposure to ELF EMF during pregnancy was assessed, for both mothers who worked and those who did not during pregnancy, using a recently-updated job-exposure matrix (JEM). Cumulative exposure was considered as a categorical variable (<17.5, 17.5-23.8, 23.8-36.2, 36.2-61.6 or  $\geq 61.6 \mu\text{T-days}$ ), a binary variable (<44.1 and  $\geq 44.1 \mu\text{T-days}$ ) and a continuous variable. Associations were analyzed by logistic regression, adjusting for the mother's lifestyle factors, sociodemographic characteristics and some mother's medical history during and before pregnancy. Analyses were restricted to single births and to complete values for the pregnancy outcomes (n=16,733).

Cumulative exposure was obtained for 96.0% of the mothers. Among them, 37.5% were classified in the 23.8-36.2  $\mu\text{T-days}$  category, but high exposures were rare: 1.3% in the  $\geq 61.6 \mu\text{T-days}$  category and 5.5% in the  $\geq 44.1 \mu\text{T-days}$  category. No significant association was observed between maternal cumulative exposure and moderate prematurity and small for gestational age in this exposure range.

Conclusions: This large population-based study does not suggest that maternal exposure to ELF EMF during pregnancy is highly associated with risks of moderate prematurity or small for gestational age.

**ASSOCIATION BETWEEN MEDIA COVERAGE AND PREVALENCE OF IDIOPATHIC ENVIRONMENTAL INTOLERANCE ATTRIBUTED TO ELECTROMAGNETIC FIELD IN TAIWAN.**

Huang PC, Li KH, Guo HR.

*Environ Res.* 2018 Feb;161:329-335.

Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) describes symptoms sufferers attribute to exposure to electromagnetic fields (EMF). In Taiwan, the prevalence rate of IEI-EMF was 13.3% in 2007, but a survey using the same method found the rate declined to 4.6% in 2012. Because media reports may encourage readers to attribute their symptoms to EMF, the change might be related to

media coverage. The authors searched articles indexed in the largest newspaper database in Taiwan to evaluate the association between media coverage and the prevalence of IEI-EMF. They also assessed the effects of other potential affecting factors. The number of newspaper articles related to EMF and IEI-EMF increased from 2005 to 2007 and then has been decreasing until 2012, which is compatible with the change in the prevalence of IEI-EMF. However, from 2007 to 2012, the other potential affecting factors such as density of mobile phone base stations, number of mobile phone users, total mobile phone calling time, and number of text messages sent through mobile phones all increased in Taiwan.

Conclusions: This finding indicated a positive association between media coverage and the prevalence of IEI-EMF in Taiwan, which might also be true in other countries.

### **3. Occupational exposure**

None

### **4. Human experimental studies**

#### **THE EFFECT OF LOCAL EXTREMELY LOW FREQUENCY MAGNETIC FIELD ON STUDENT SLEEPINESS.**

Ayoobi F, Shamsizadeh A, Shafiei SA.

*Neurol Res.* 2017 Dec;39(12):1080-1085.

The current study aimed to investigate the impact of local extremely low frequency magnetic field (ELF-MF) on sleep and drowsiness in healthy young adults. Sixty-five young adults (32 males and 31 females, aged 18-24, participated voluntarily in this randomized crossover clinical trial. 200 microTesla MF (3 minutes duration) at three frequencies (10, 14 and 18 Hz) was applied to the skull in areas C3, Cz and C4, respectively. The Stanford Sleepiness Scale (SSS) or Consciousness Test (CT), Epworth Sleepiness Scale (ESS) and Peabody Picture Vocabulary Test were used to evaluate drowsiness, sleepiness, and reaction time. These tests were done both before and after application of ELF-MF or sham operation.

Minimum reaction time after exposure to ELF-MF increased compared to that before exposure ( $P = 0.03$ ), while it was not significant for the sham group ( $P = 0.63$ ). From the ESS questionnaire, the results indicated that there was no significant difference for males or females between the exposure and sham groups. The mean of the SSS scores was no different compared to that before exposure.

Conclusions: The results of this study demonstrated that exposure to ELF-MF may influence reaction time in young healthy people. However, as the results of ESS and SSS were not different between exposure and non-exposure groups, further studies using larger sample sizes are recommended in order to reach better interpretations of the effects of ELF-MF on sleepiness in young people.

## **EFFECTS OF A 60 HZ MAGNETIC FIELD OF UP TO 50 MILLITESLA ON HUMAN TREMOR AND EEG: A PILOT STUDY.**

Davarpanah Jazi S, Modolo J, Baker C, Villard S, Legros A.  
*Int J Environ Res Public Health.* 2017 Nov 24;14(12).

Humans are surrounded by sources of daily exposure to power-frequency (60 Hz in North America) magnetic fields (MFs). Such time-varying MFs induce electric fields and currents in living structures which possibly lead to biological effects. The present pilot study examined possible extremely low frequency (ELF) MF effects on human neuromotor control in general, and physiological postural tremor and electroencephalography (EEG) in particular. Since the EEG cortical mu-rhythm (8-12 Hz) from the primary motor cortex and physiological tremor are related, it was hypothesized that a 60 Hz MF exposure focused on this cortical region could acutely modulate human physiological tremor. Ten healthy volunteers (age:  $23.8 \pm 4$  SD) were fitted with a MRI-compatible EEG cap while exposed to 11 MF conditions (60 Hz, 0 to 50 mTrms, 5 mTrms increments). Simultaneously, physiological tremor (recorded from the contralateral index finger) and EEG (from associated motor and somatosensory brain regions) were measured.

Results showed no significant main effect of MF exposure conditions on any of the analyzed physiological tremor characteristics. In terms of EEG, no significant effects of the MF were observed for C1, C3, C5 and CP1 electrodes. However, a significant main effect was found for CP3 and CP5 electrodes, both suggesting a decreased mu-rhythm spectral power with increasing MF flux density. This is however not confirmed by Bonferroni corrected pairwise comparisons.

Conclusions: Considering both EEG and tremor findings, no effect of the MF exposure on human motor control was observed. However, MF exposure had a subtle effect on the mu-rhythm amplitude in the brain region involved in tactile perception. Current findings are to be considered with caution due to the small size of this pilot work, but they provide preliminary insights to international agencies establishing guidelines regarding electromagnetic field exposure with new experimental data acquired in humans exposed to high mT-range MFs.

## **5. Exposure assessment**

### **EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS DURING LESSONS IN SECONDARY SCHOOLS.**

Silangam W, Yoosook W, Kongtip P, Kongtawelert A, Theppeang K.  
*Radiat Prot Dosimetry.* 2017 Dec 5:1-5.

Schools are a significant location where children are exposed to electromagnetic fields (EMFs), which may cause adverse health effects. This cross-sectional study aimed to examine exposure levels to extremely low frequency magnetic fields (ELF-MFs) with a range of 5 Hz-32 kHz, and ELF-electric fields (ELF-EFs) with a range of 5 Hz-2 kHz in secondary schools in Bangkok, Thailand. This study was conducted in 60 classrooms from three schools during class hours. Spot measurements were taken with a Narda EFA 300 field analyzer to evaluate exposure levels.

Conclusions: This study showed that ELF-EMF exposure levels are lower than ICNIRP guidelines, while 21.67% of classrooms had a magnetic field strength above  $0.2 \mu\text{T}$ , and the main sources of ELF-EMFs were electrical equipment and electrical wiring. Future studies should measure ELF-EMF levels in other areas and evaluate the effects of long term exposure to ELF-EMFs on children's health.

## 6. Leukemia studies

### **A SYSTEMATIC REVIEW AND META-ANALYSIS OF THE ASSOCIATION BETWEEN CHILDHOOD INFECTIONS AND THE RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA.**

Hwee J, Tait C, Sung L, Kwong JC, Sutradhar R, Pole JD.  
*Br J Cancer. 2017 Oct 24.*

The objective of this study was to determine whether childhood infections were associated with the development of childhood acute lymphoblastic leukemia (ALL). The authors included studies that assessed any infection in childhood prior to the diagnosis of ALL in children aged 0-19 years compared to children without cancer. The primary analysis synthesized any infection against the odds of ALL, and secondary analyses assessed the frequency, severity, timing of infections, and specific infectious agents against the odds of ALL. Subgroup analyses by data source were investigated.

In a primary analysis of 12 496 children with ALL and 2 356 288 children without ALL from 38 studies, the authors found that any infection was not associated with ALL (odds ratio (OR)=1.10, 95% CI: 0.95-1.28). Among studies with laboratory-confirmed infections, the presence of infections increased the odds of ALL by 2.4-fold (OR=2.42, 95% CI: 1.54-3.82). Frequency, severity, and timing of infection were not associated with ALL.

Conclusions: The hypothesis put forward by Greaves and others about an infectious etiology are neither confirmed nor refuted and the overall evidence remains inadequate for good judgement. The qualitative difference in the subgroup effects require further study, and future research will need to address the challenges in measuring infectious exposures.

### **EARLY VACCINATION PROTECTS AGAINST CHILDHOOD LEUKEMIA: A SYSTEMATIC REVIEW AND META-ANALYSIS.**

Morra ME, Kien ND, Elmaraezy A, Abdelaziz OAM, Elsayed AL, Halhouli O, Montasr AM, Vu TL, Ho C, Foly AS, Phi AP, Abdullah WM, Mikhail M, Milne E, Hirayama K, Huy NT.  
*Sci Rep. 2017 Nov 22;7(1):15986.*

Leukemia is the most commonly diagnosed childhood cancer, although its etiology is still largely unknown. Growing evidence supports a role for infection in the etiology of acute lymphocytic leukemia (ALL), and the involvement of the immune system suggests that vaccination may also play a role. However, the findings presented in the published literature are inconsistent. Therefore, the authors conducted a PRISMA systematic review and meta-analysis. 14 studies were identified and meta-analyzed. Vaccinations studied comprised Bacillus Calmette-Guérin (BCG) vaccine, Triple vaccine, Hepatitis B vaccine (HBV), Polio, Measles, Rubella, Mumps, trivalent MMR vaccine and Haemophilus influenza type B (HiB) vaccine. A protective association was observed between any vaccination in the first year of life and risk of childhood leukemia (summary odds ratio (OR) 0.58 [95% confidence interval (CI) 0.36-0.91]). When individual vaccines were analyzed, some evidence of an association was seen only for BCG (summary OR 0.73 [95% CI 0.50-1.08]).

Conclusions: Early vaccination appears to be associated with a reduced risk of childhood leukemia. This finding may be underpinned by the association observed for BCG. Given the relatively imprecise nature of the results of this meta-analysis, these findings should be interpreted cautiously and replicated in future studies.

### **PARENTAL AGE AND RISK OF INFANT LEUKAEMIA: A POOLED ANALYSIS.**

Marcotte EL, Druley TE, Johnson KJ, Richardson M, von Behren J, Mueller BA, Carozza S, McLaughlin C, Chow EJ, Reynolds P, Spector LG.

*Paediatr Perinat Epidemiol.* 2017 Nov;31(6):563-572.

Infant leukaemia (IL) is extremely rare with fewer than 150 cases occurring each year in the United States. Little is known about its causes. However, recent evidence supports a role of de novo mutations in IL etiology. Parental age has been associated with several adverse outcomes in offspring, including childhood cancers. Given the role of older parental age in de novo mutations in offspring, an analysis of parental age and IL was carried out.

The authors evaluated the relationship between parental age and IL in a case-control study using registry data from New York, Minnesota, California, Texas, and Washington. Records from 402 cases [219 acute lymphoblastic leukaemia (ALL), 131 acute myeloid leukaemia (AML), and 52 other] and 45 392 controls born during 1981-2004 were analyzed. Odds ratios (OR) and 95% confidence intervals (CI) were calculated by logistic regression. Estimates were adjusted for infant sex, birth year category, maternal race, state, and mutually adjusted for paternal or maternal age, respectively.

Infants with mothers' age  $\geq 40$  years had an increased risk of developing AML (OR 4.80, 95% CI 1.80, 12.76). In contrast, paternal age  $< 20$  was associated with increased risk of ALL (OR 3.69, 95% CI 1.62, 8.41).

Conclusions: This study demonstrates increased risk of infant ALL in relation to young paternal age. Given record linkage, there is little concern with recall or selection bias, although data are lacking on MLL gene status and other potentially important variables. Parent of origin effects, de novo mutations, and/or carcinogenic exposures may be involved in IL etiology.

### **GESTATIONAL AGE AND CHILDHOOD LEUKEMIA: A META-ANALYSIS OF EPIDEMIOLOGIC STUDIES.**

Wang YF, Wu LQ, Liu YN, Bi YY, Wang H.

*Hematology.* 2017 Nov 3:1-10.

An increasing amount of evidence shows that childhood leukemia is initiated in utero. Birth characteristics initiated in utero, such as gestational age, may play a role in leukemogenesis. The purpose of this meta-analysis is to explore the association between gestational age and childhood leukemia. Relevant studies up to 21 April 2017 were collected by searching PubMed and EMBASE databases. Subgroup analysis, sensitivity analysis and publication bias assessment were conducted.

A total of 13 studies were included. Pooled odds ratios (ORs) with 95% confidence intervals (CIs) for pre-term birth and post-term birth were 1.06 (0.98, 1.13) and 1.01 (0.90, 1.13) for childhood leukemia, 1.04 (0.97, 1.11) and 1.03 (0.95, 1.12) for acute lymphocytic leukemia (ALL), 1.20 (1.00, 1.44) and 1.20 (1.00, 1.43) for acute myeloid leukemia (AML), compared with full-term birth. Study type and study region were the reasons behind the heterogeneity. In subgroup analyses, the summary ORs with 95% CI for childhood leukemia and ALL were 1.23 (1.07, 1.41) and 1.21 (1.06, 1.39) for post-term birth in cohort studies. No significant changes in sensitivity analyses and no publication bias were observed in the analysis.

Conclusions: These results suggest that both pre-term and post-term infants have an elevated risk of developing AML. In addition, post-term birth increased the risk of childhood leukemia and ALL in cohort studies. However, more studies are warranted to

validate these results and explore the biologic mechanisms underlying these relationships.

**LIVESTOCK AND POULTRY DENSITY AND CHILDHOOD CANCER INCIDENCE IN NINE STATES IN THE USA.**

Booth BJ, Jones RR, Turyk ME, Freels S, Patel DM, Stayner LT Ward MH.

*Environ Res.* 2017 Nov;159:444-451.

Parental occupational and childhood exposures to farm animals have been positively associated with childhood brain tumors, whereas associations with childhood leukemia are equivocal. The developing immune system may be influenced by allergen, virus, or other exposures from animal sources, which may contribute to childhood cancer incidence.

Incident cancers (acute lymphoblastic leukemia [ALL], acute myeloid leukemia [AML], central nervous system [CNS], peripheral nervous system [PNS]) for children aged 0-4 diagnosed between 2003 and 2008 were obtained from nine National Cancer Institute Surveillance, Epidemiology and End Results (SEER) registries and were linked to U.S. Census of Agriculture data from 2002 and 2007 by county of diagnosis. Animal densities (animal units [AU]/km<sup>2</sup>; one animal unit is 1000 pounds of animal weight) were estimated for hogs, cattle, chickens (layers and broilers, separately), equine (horses, ponies, mules, burros, donkeys), goats, sheep, turkeys, and total animals. Animal density was examined in models as both continuous (AU per km<sup>2</sup>) and categorical variables (quartiles). Animal operation densities (per km<sup>2</sup>) by size of operation (cattle, hogs, chickens, sheep) were modeled continuously. Rate ratios and 95% confidence intervals were estimated using Poisson regression.

Positive associations were found between AML and broiler chicken densities (RRper 10AU/km<sup>2</sup> = 1.14, 95% CI = 1.02-1.26). ALL rates increased with densities of hog operations (RRper operation/100km<sup>2</sup> = 1.06, 95% CI = 1.02-1.11). PNS cancer rates were inversely associated with layer chicken density (RRper log of AU/km<sup>2</sup> = 0.94, 95% CI = 0.89-0.99). No association was found between any cancer type and densities of cattle, equine, or goats.

Conclusions: Although limited by the ecologic study design, some of these findings are novel and should be examined in epidemiological studies with individual level data.