

Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2013

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1. Meta-analysis

A META-ANALYSIS ON THE RELATIONSHIP BETWEEN EXPOSURE TO ELF-EMFS AND THE RISK OF FEMALE BREAST CANCER.

Chen Q, Lang L, Wu W, Xu G, Zhang X, Li T, Huang H.
PLoS One. 2013;8(7):e69272.

The objective of this study is to comprehensively analyze the relationship between exposure to extremely low frequency electromagnetic fields (ELF-EMFs) and the development of female breast cancer.

Reports of case-control studies published from 1990 to 2010 were analyzed. The quality effect model was chosen to calculate total odds ratio (OR) depending on the data in studies and quality scores. Subgroup analyses were also performed by the situation of menopause, estrogenic receptor and exposure assessment respectively.

For all 23 studies the OR was 1.07, 95% CI=1.02-1.13, for estrogen receptor positive subgroup, OR=1.11, 95% CI=1.03-1.20; for premenopausal subgroup, OR=1.11, 95% CI=1.00-1.23. The results of other subgroups showed no significant association between ELF-EMF and female breast cancer.

Conclusion: ELF-EMFs might be related to an increased risk for female breast cancer, especially for premenopausal and ER+ females. However, it's necessary to undertake better epidemiologic researches to verify the association between ELF-EMF and female breast cancer due to the limits of current study, especially the one on exposure assessment.

A CONSENSUS PANEL REVIEW OF CENTRAL NERVOUS SYSTEM EFFECTS OF THE EXPOSURE TO LOW-INTENSITY EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS.

Di Lazzaro V, Capone F, Apollonio F, Borea PA, Cadossi R, Fassina L, Grassi C, Liberti M, Paffi A, Parazzini M, Varani K, Ravazzani P.
Brain Stimul. 2013;6(4):469-476.

A large number of studies explored the biological effects of extremely low-frequency (0-300 Hz) magnetic fields (ELF-MFs) on nervous system both at cellular and at system level in the intact human brain reporting several functional changes. However, the results of different studies are quite variable and the mechanisms of action of ELF-MFs are still poorly defined. The aim of this paper is to provide a comprehensive review of the effects of ELF-MFs on nervous system.

The authors convened a workgroup of researchers in the field to review and discuss the available data about the nervous system effects produced by the exposure to ELF-MFs.

The authors reviewed several methodological, experimental and clinical studies and discussed the findings in five sections. The first section analyses the devices used for

ELF-MF exposure. The second section reviews the contribution of the computational methods and models for investigating the interaction between ELF-MFs and neuronal systems. The third section analyses the experimental data at cellular and tissue level showing the effects on cell membrane receptors and intracellular signaling and their correlation with neural stem cell proliferation and differentiation. The fourth section reviews the studies performed in the intact human brain evaluating the changes produced by ELF-MFs using neurophysiological and neuropsychological methods. The last section shows the limits and shortcomings of the available data, evidences the key challenges in the field and tracks directions for future research.

2. Residential exposure

ASSOCIATION BETWEEN EXPOSURE TO ELECTROMAGNETIC FIELDS FROM HIGH VOLTAGE TRANSMISSION LINES AND NEUROBEHAVIORAL FUNCTION IN CHILDREN.

Huang J, Tang T, Hu G, Zheng J, Wang Y, Wang Q, Su J, Zou Y, Peng X.

PLoS One. 2013;8(7):e67284.

Evidence for a possible causal relationship between exposure to electromagnetic fields (EMF) emitted by high voltage transmission (HVT) lines and neurobehavioral dysfunction in children is insufficient. The present study aims to investigate the association between EMF exposure from HVT lines and neurobehavioral function in children.

Two primary schools were chosen based on monitoring data of ambient electromagnetic radiation. A cross-sectional study with 437 children (9 to 13 years old) was conducted. Exposure to EMF from HVT lines was monitored at each school. Information was collected on possible confounders and relevant exposure predictors using standardized questionnaires. Neurobehavioral function in children was evaluated using established computerized neurobehavioral tests. Data was analyzed using multivariable regression models adjusted for relevant confounders.

After controlling for potential confounding factors, multivariable regression revealed that children attending a school near 500 kV HVT lines had poorer performance on the computerized neurobehavioral tests for Visual Retention and Pursuit Aiming compared to children attending a school that was not in close proximity to HVT lines.

Conclusion: The results suggest long-term low-level exposure to EMF from HVT lines might have a negative impact on neurobehavioral function in children. However, because of differences in results only for two of four tests achieved statistical significance and potential limitations, more studies are needed to explore the effects of exposure to extremely low frequency EMF on neurobehavioral function and development in children.

EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS DURING PREGNANCY AND THE RISK OF SPONTANEOUS ABORTION: A CASE-CONTROL STUDY.
Shamsi Mahmoudabadi F, Ziaei S, Firoozabadi M, Kazemnejad A.
J Res Health Sci. 2013;13(2):131-134.

Exposure to extremely low frequency electromagnetic fields is increasingly common, but the potential influence on pregnant women has not been thoroughly investigated.

In this case-control study, 58 women who had an unexplained spontaneous abortion at < 14 weeks gestation and 58 matched pregnant women >14 weeks gestation were enrolled in 2012. The women completed the questionnaire, which was used to collect data about socioeconomic and obstetric characteristics, medical and reproductive histories. Then, to evaluate the extremely low frequency electromagnetic fields, the authors determined the magnitude of electromagnetic fields in the participants' houses by an exposure level tester (3D EMF tester/ Model: ELF-828; Taiwan). The instrument covers a limited frequency range (30 HZ to 3 KHZ).

The magnitude of extremely low frequency electromagnetic fields in the participants' houses was significantly different between the two groups ($P < 0.001$).

Conclusions: Extremely low frequency electromagnetic fields exposure is probably related to early spontaneous abortions.

3. Occupational exposure

CASE-CONTROL STUDY OF SEMICIRCULAR LIPOATROPHY, A NEW OCCUPATIONAL DISEASE IN OFFICE WORKERS.

Reinoso-Barbero L, González-Gómez MF, Bélanger-Quintana D, Piñaga-Solé M, Fernández-Fernández M, Garrido-Astray MC, Capapé-Aguilar A, Mota-Olmeda A, Díaz-Garrido R, Gómez-Gallego F, Bandrés-Moya F, Sanz-González J.
J Occup Health. 2013;55(3):149-157.

Semicircular lipoatrophy (SL) is an emerging occupational pathology. Its etiology is poorly understood. The authors intend to establish the probable risk factors and estimate the relative risk. A case-control study was performed. The studied company had 55 diagnosed cases. As controls, the 3 closest healthy coworkers to each case were used. The chi square, odds ratio and logistic regression were calculated for different exposures, during the 3 years from September 2007 to August 2010. There was 100% participation for the cases and 70.9% for the controls (ratio 1 : 2.1 case-control). The only risk variables found were female gender ($p < 0.02$) and exposure to leaning on the edge of a table ($p < 0.01$). In addition, a breakdown by sex objectifies a much stronger association with leaning on the edge of a table in women ($p < 0.01$) than men ($p 0.67$). Conclusions: Female gender and leaning on the edge of a table (repeated microtrauma), especially in women, are risk factors for development of SL. Other variables seem to be confounding factors associated with female gender. There were no SL cases showing statistically significant relations with history of cancer or autoimmune diseases. There was also no significance with regard to wearing jeans. Conclusion: There is a new risk for office staff in addition to the more traditional disorders (musculoskeletal, ocular, and psychosocial). Further studies are necessary to evaluate what can be considered as an underdiagnosed condition, since there is a large percentage of people that are potentially exposed and very little information was found in the literature on the matter.

4. Human experiment studies

TESTING OF COMMON ELECTROMAGNETIC ENVIRONMENTS FOR RISK OF INTERFERENCE WITH CARDIAC PACEMAKER FUNCTION.

Maria Tiikkaja, Aapo L. Aro, Tommi Alanko, Harri Lindholm, Heli Sistone, Juha E.K. Hartikainen, Lauri Toivonen, Jukka Juutilainen, Maila Hietanen.
Safety and Health at Work 2013;4(1):156-159.

Cardiac pacemakers are known to be susceptible to strong electromagnetic fields (EMFs). This in vivo study investigated occurrence of electromagnetic interference with pacemakers caused by common environmental sources of EMFs.

Eleven volunteers with a pacemaker were exposed to EMFs produced by two mobile phone base stations, an electrically powered commuter train, and an overhead high voltage transmission lines. All the pacemakers were programmed in normal clinically selected settings with bipolar sensing and pacing configurations.

None of the pacemakers experienced interference in any of these exposure situations. However, often it is not clear whether or not strong EMFs exist in various work environments, and hence an individual risk assessment is needed.

Conclusion: Modern pacemakers are well shielded against external EMFs, and workers with a pacemaker can most often return to their previous work after having a pacemaker implanted. However, an appropriate risk assessment is still necessary after the implantation of a pacemaker, a change of its generator, or major modification of its programming settings.

ARE MEDIA WARNINGS ABOUT THE ADVERSE HEALTH EFFECTS OF MODERN LIFE SELF-FULFILLING? AN EXPERIMENTAL STUDY ON IDIOPATHIC ENVIRONMENTAL INTOLERANCE ATTRIBUTED TO ELECTROMAGNETIC FIELDS (IEI-EMF).

Witthöft M, Rubin GJ.
J Psychosom Res. 2013;74(3):206-212.

Medically unsubstantiated 'intolerances' to foods, chemicals and environmental toxins are common and are frequently discussed in the media. Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) is one such condition and is characterized by symptoms that are attributed to exposure to electromagnetic fields (EMF). In this experiment, the authors tested whether media reports promote the development of this condition.

Participants (N=147) were randomly assigned to watch a television report about the adverse health effects of WiFi (n=76) or a control film (n=71). After watching their film, participants received a sham exposure to a WiFi signal (15 min). The principal outcome measure was symptom reports following the sham exposure. Secondary outcomes included worries about the health effects of EMF, attributing symptoms to the sham exposure and increases in perceived sensitivity to EMF.

82 (54%) of the 147 participants reported symptoms which they attributed to the sham exposure. The experimental film increased: EMF related worries ($\beta=0.19$; $P=.019$); post sham exposure symptoms among participants with high pre-existing anxiety ($\beta=0.22$; $P=.008$); the likelihood of symptoms being attributed to the sham exposure among people with high anxiety ($\beta=.31$; $P=.001$); and the likelihood of people who

attributed their symptoms to the sham exposure believing themselves to be sensitive to EMF ($\beta=0.16$; $P=.049$).

Conclusion: Media reports about the adverse effects of supposedly hazardous substances can increase the likelihood of experiencing symptoms following sham exposure and developing an apparent sensitivity to it. Greater engagement between journalists and scientists is required to counter these negative effects.

5. Exposure assessment

DOES APARTMENT'S DISTANCE TO AN IN-BUILT TRANSFORMER ROOM PREDICT MAGNETIC FIELD EXPOSURE LEVELS?

Huss A, Goris K, Vermeulen R, Kromhout H.

J Expo Sci Environ Epidemiol. 2013;23(5):554-558.

It has been shown that magnetic field exposure in apartments located directly on top or adjacent to transformer rooms is higher compared with exposure in apartments located further away from the transformer rooms. It is unclear whether this also translates into exposure contrast among individuals living in these apartments. The authors performed spot measurements of magnetic fields in 35 apartments in 14 apartment buildings with an in-built transformer and additionally performed 24-h personal measurements in a subsample of 24 individuals. Apartments placed directly on top of or adjacent to a transformer room had on average exposures of $0.42 \mu\text{T}$, apartments on the second floor on top of a transformer room, or sharing a corner or edge with the transformer room had $0.11 \mu\text{T}$, and apartments located further away from the transformer room had levels of $0.06 \mu\text{T}$. Personal exposure levels were approximately a factor 2 lower compared with apartment averages, but still showed exposure contrasts, but only for those individuals who live in the apartments directly on top or adjacent to a transformer room compared with those living further away, with 0.23 versus $0.06 \mu\text{T}$ for personal exposure when indoors, respectively. Conclusion: A classification of individuals into 'high' and 'low' exposed based on the location of their apartment within a building with an in-built transformer is possible and could be applied in future epidemiological studies.

METHODS USED TO ESTIMATE RESIDENTIAL EXPOSURE TO 50 HZ MAGNETIC FIELDS FROM OVERHEAD POWER LINES IN AN EPIDEMIOLOGICAL STUDY IN FRANCE.

Bessou J, Deschamps F, Figueroa L, Cougnaud D.

J Radiol Prot. 2013;33(2):349-365.

An epidemiological study of paediatric cancers in relation with various environmental factors is currently being carried out in France. One of these factors is the proximity of children's residences to high voltage overhead lines (63-400 kV). This possible influence will be studied following three criteria, namely 'distance', 'distance-voltage' and 'calculated residential exposure' to extremely low frequency magnetic field (ELF-MF). This paper describes methods for generating and characterising these three criteria of increasing complexity and characterises the influence of the input data in terms of uncertainties in the exposure to ELF-MF assigned to subjects. The method developed for the 'calculated residential exposure' criterion is based on a limited number of configurations of overhead lines, selected to have a representative sample of the French high voltage (HV) network. The calculated exposure is then fitted to each subject and

each neighbouring overhead line, taking into account the yearly mean current flowing in the line and the distance of the residence from the power line. All variability factors introduced by this simplified representation have been analysed, classified and quantified to give the best assessment and associated confidence interval of the residential ELF-MF exposure of the subjects.

Conclusion: The overall 1σ uncertainty of the calculated residential exposure excluding geo-coding uncertainties is around 8% for subjects living close to power lines with a known current load and 17% for the others.

6. Leukemia studies

EXPOSURE TO HERBICIDES IN HOUSE DUST AND RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA.

Metayer C, Colt JS, Buffler PA, Reed HD, Selvin S, Crouse V, Ward MH.
J Expo Sci Environ Epidemiol. 2013;23(4):363-370.

The authors examined the association between exposure to herbicides and childhood acute lymphoblastic leukemia (ALL). Dust samples were collected from homes of 269 ALL cases and 333 healthy controls (<8 years of age at diagnosis/reference date and residing in same home since diagnosis/reference date) in California, using a high-volume surface sampler or household vacuum bags. Amounts of agricultural or professional herbicides (alachlor, metolachlor, bromoxynil, bromoxynil octanoate, pebulate, butylate, prometryn, simazine, ethalfuralin, and pendimethalin) and residential herbicides (cyanazine, trifluralin, 2-methyl-4-chlorophenoxyacetic acid (MCPA), mecoprop, 2,4-dichlorophenoxyacetic acid (2,4-D), chlorthal, and dicamba) were measured. Odds ratios (OR) and 95% confidence intervals (CI) were estimated by logistic regression. Models included the herbicide of interest, age, sex, race/ethnicity, household income, year and season of dust sampling, neighborhood type, and residence type. The risk of childhood ALL was associated with dust levels of chlorthal; compared to homes with no detections, ORs for the first, second, and third tertiles were 1.49 (95% CI: 0.82-2.72), 1.49 (95% CI: 0.83-2.67), and 1.57 (95% CI: 0.90-2.73), respectively (P-value for linear trend=0.05). The magnitude of this association appeared to be higher in the presence of alachlor. No other herbicides were identified as risk factors of childhood ALL.

Conclusion: The data suggest that home dust levels of chlorthal, and possibly alachlor, are associated with increased risks of childhood ALL.

PREGNANCY, MATERNAL EXPOSURE TO HAIR DYES AND HAIR STRAIGHTENING COSMETICS, AND EARLY AGE LEUKEMIA.

Couto AC, Ferreira JD, Rosa AC, Pombo-de-Oliveira MS, Koifman S; Brazilian Collaborative Study Group of Infant Acute Leukemia.
Chem Biol Interact. 2013;205(1):46-52.

The objective of the study was to investigate the association between maternal exposure to hair dyes and hair straightening cosmetics (HDSC) during pregnancy and leukemia at an early age (<2yr., EAL).

A multicenter hospital-based case-control study was carried out in 13 states in Brazil between 1999 and 2007. Mothers of 176 ALL (acute lymphocytic leukemia) and 55 AML (acute myeloid leukemia) cases and 419 controls were enrolled and interviewed. Data on maternal exposure to HDSC occurring 3 months before pregnancy, during pregnancy and during breastfeeding were obtained. Data were also gathered on paternal exposure to HDSC before pregnancy. Unconditional logistic regression was performed and odds ratios (OR) on the association between HDSC use and EAL were obtained after adjustment for hormonal intake during pregnancy, maternal age, education, birth weight, and the child skin color.

An adjusted OR of 1.78 (95% C.I. 1.13-2.81) was observed between maternal exposure to HDSC in the first trimester of pregnancy and ALL. Regarding AML, an adjusted OR of 2.43 (95% C.I. 1.13-5.22) was found for maternal exposure to HDSC during breastfeeding. No association between maternal exposure to HDSC during pregnancy and ALL or AML was observed in children with MLL (Mixed Lineage Leukemia) gene rearrangement.

Conclusion: Results in this study seem to support the hypothesis that maternal exposure to HDSC during pregnancy may be involved in the etiology of leukemia in children under 2 years of age.

RISK OF CHILDHOOD LEUKAEMIA AND NON-HODGKIN'S LYMPHOMA AFTER PARENTAL OCCUPATIONAL EXPOSURE TO SOLVENTS AND OTHER AGENTS: THE SETIL STUDY.

Miligi L, Benvenuti A, Mattioli S, Salvan A, Tozzi GA, Ranucci A, Legittimo P, Rondelli R, Bisanti L, Zambon P, Cannizzaro S, Kirchmayer U, Cocco P, Celentano E, Assennato G, Merlo DF, Mosciatti P, Minelli L, Cuttini M, Torregrossa V, Lagorio S, Haupt R, Risica S, Polichetti A; SETIL Working Group, Magnani C.

Occup Environ Med. 2013;70(9):648-655.

In the context of the Italian Multicentric Epidemiological Study on Risk Factors for Childhood Leukaemia and Non-Hodgkin's Lymphoma (SETIL), the risk of childhood cancer was investigated in relation to parental occupational exposures.

All cases of childhood leukaemia and non-Hodgkin's lymphoma (NHL) in children aged 0-10 years were identified. Controls were chosen at random from the local population in each region. Parents were interviewed using a structured questionnaire. The collected data were blindly reviewed by expert industrial hygienists in order to estimate exposure to a list of agents. Statistical analyses were performed for each agent using unconditional multivariable logistic regression models, taking into account timing of exposure.

683 cases of acute childhood leukaemia, 97 cases of NHL and 1044 controls were identified. Increased risk of childhood leukaemia was found for maternal exposure to aliphatic (OR 4.3) or aromatic hydrocarbons (OR 3.8) in the preconception period, and for paternal exposure to diesel exhaust (OR 1.4), lead exposure (OR 1.4) and mineral oils (OR 1.7). Risk of NHL appeared to be related to paternal exposure to oxygenated solvents (OR 2.5) and petrol exhaust (OR 2.2).

Conclusion: The authors found increased risk for childhood leukaemia associated with maternal occupational exposure to aromatic and aliphatic hydrocarbons, particularly in the preconception period; increased risks were also observed for paternal exposure to diesel exhaust fumes, mineral oils and lead. The risk of NHL appeared to be related to paternal exposure to oxygenated solvent and petrol exhausts.

TOBACCO SMOKE EXPOSURE AND THE RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC AND MYELOID LEUKEMIAS BY CYTOGENETIC SUBTYPE.

Metayer C, Zhang L, Wiemels JL, Bartley K, Schiffman J, Ma X, Aldrich MC, Chang JS, Selvin S, Fu CH, Ducore J, Smith MT, Buffler PA.

Cancer Epidemiol Biomarkers Prev. 2013;22(9):1600-1611.

Tobacco smoke contains carcinogens known to damage somatic and germ cells. The authors investigated the effect of tobacco smoke on the risk of childhood acute lymphoblastic leukemia (ALL) and myeloid leukemia (AML), especially subtypes of prenatal origin such as ALL with translocation t(12;21) or high-hyperdiploidy (51-67 chromosomes).

The authors collected information on exposures to tobacco smoking before conception, during pregnancy, and after birth in 767 ALL cases, 135 AML cases, and 1,139 controls (1996-2008). Among cases, chromosome translocations, deletions, or aneuploidy were identified by conventional karyotype and fluorescence in situ hybridization.

Multivariable regression analyses for ALL and AML overall showed no definite evidence of associations with self-reported (yes/no) parental prenatal active smoking and child's passive smoking. However, children with history of paternal prenatal smoking combined with postnatal passive smoking had a 1.5-fold increased risk of ALL [95% confidence interval (CI), 1.01-2.23], compared to those without smoking history (ORs for pre- or postnatal smoking only were close to one). This joint effect was seen for B-cell precursor ALL with t(12;21) (OR = 2.08; 95% CI, 1.04-4.16), but not high hyperdiploid B-cell ALL. Similarly, child's passive smoking was associated with an elevated risk of AML with chromosome structural changes (OR = 2.76; 95% CI, 1.01-7.58), but not aneuploidy.

Conclusion: These data suggest that exposure to tobacco smoking was associated with increased risks of childhood ALL and AML; and risks varied by timing of exposure (before and/or after birth) and cytogenetic subtype, based on imprecise estimates.