

# Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the second trimester of 2012

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## 1. Environmental exposure

### **CONCERN THAT "EMF" MAGNETIC FIELDS FROM POWER LINES CAUSE CANCER.**

Repacholi M.

*Sci Total Environ.* 2012; 426: 454-458.

In 2002, the International Agency for Research on Cancer (IARC, 2002) categorized extremely low frequency (ELF) (including the power frequencies of 50 and 60 Hz) magnetic fields as "possibly carcinogenic to humans." That was based on pooled analyses of epidemiological research that reported an association between exposure to low-level magnetic fields and childhood leukemia. In 2007 a task group of scientific experts convened by the World Health Organization (WHO) acknowledged the IARC categorization but found that the laboratory studies and other research results did not support the association. Taking all evidence into account WHO reported that it could not confirm the existence of any health consequences from exposure to low-level magnetic fields. There remains continuing concern by some people that exposure to power frequency magnetic fields may cause adverse health effects, particularly childhood leukemia. Public health authorities need to fully understand the reasons for that ongoing concern and effective ways to address it.

Conclusion: This paper describes what drives the concern, including how people perceive risks, how WHO and other public health authorities assess scientific research to determine whether health risks exist and the conclusions they have reached about power frequency magnetic fields. This paper also addresses the scientific basis of international exposure guidelines for power frequency magnetic fields and what precautionary measures are warranted to address the concern.

## 2. Residential exposure

### **LONG-TERM (UP TO 20 YEARS) EFFECTS OF 50-HZ MAGNETIC FIELD EXPOSURE ON BLOOD CHEMISTRY PARAMETERS IN HEALTHY MEN.**

Touitou Y, Djeridane Y, Lambrozo J, Camus F.

*Clin Biochem.* 2012; 45: 425-428.

The authors examined the nocturnal profiles and levels of the following blood parameters: electrolytes (sodium, potassium, chloride, calcium, magnesium, phosphorus), nonprotein nitrogenous compounds (uric acid, urea, creatinine), and glucose, in 15 men ( $38.0 \pm 0.9$  years) exposed chronically and daily for a period of 1-20 years, in the workplace and at home, to a 50-Hz magnetic field in search of any cumulative effect from those chronic conditions of exposure. The weekly geometric mean of individual exposures ranged from 0.1 to 2.6  $\mu\text{T}$ . The results are compared to those obtained in a control group: 15 unexposed men of similar age ( $39.4 \pm 1.2$  years), with the same synchronization and physical activity that served as controls (individual exposures ranged from 0.004 to 0.092  $\mu\text{T}$ ). Blood samples were taken hourly from 20:00 h to 08:00 h.

This work shows that subjects exposed over a long period (up to 20 years) and on a daily basis to magnetic fields experienced significant changes in serum sodium, chloride, phosphorus and glucose where an effect for field-hour interaction was noted for exposures greater than 0.3  $\mu\text{T}$ .

Conclusion: These data suggest that long-term exposure to 50-Hz magnetic fields (exposure > 0.3  $\mu\text{T}$ ) in healthy men could induce some biological modifications of certain blood parameters, though their clinical relevance needs further investigation.

### **3. Human experiment**

#### **CARDIAC PACEMAKERS IN ELECTRIC AND MAGNETIC FIELDS OF 400-KV POWER LINES.**

Korpinen L, Kuisti H, Elovaara J, Virtanen V.

*Pacing Clin Electrophysiol.* 2012; 35: 422-430.

The cardiac pacemaker (PM) implantation rate per million is high. Earlier studies have found interference to PMs by electromagnetic fields. The aim of this study is to investigate disturbances in cardiac PM 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, grounded from left or right foot, or grounded from left or right hand.

Out of the tested PMs one had such a disturbance that it set the pace 60 times per minute, when the electric field was 6.7-7.5 kV/m and the magnetic field was 2.4-2.9  $\mu\text{T}$ . The electrode configuration of the PM was unipolar. In bipolar configuration, the same PM had no disturbance. During the test period, other PMs only had minor disturbances or none at all. Some PMs do not record time information for minor disturbances. In such cases, it was impossible to link the disturbances to the exposure under the power line.

Conclusions: The electric field under a 400-kV power line may disturb a PM. However, only one type out of several tested PMs showed a major disturbance and that was only with a unipolar electrode configuration. The risk of disturbances is therefore not deemed to be high.

#### **EXPERIMENTAL STUDY ON MALFUNCTION OF PACEMAKERS DUE TO EXPOSURE TO DIFFERENT EXTERNAL MAGNETIC FIELDS.**

Tiikkaja M, Alanko T, Lindholm H, Hietanen M, Hartikainen J, Toivonen L.

*J Interv Card Electrophysiol.* 2012; 34: 19-27.

Cardiac pacemaker malfunction due to exposure to magnetic fields may cause serious problems in some work environments for workers having cardiac pacemakers. The aim of this study was to find the magnetic field interference thresholds for several commonly used pacemaker models.

The authors investigated 16 pacemakers from three different manufacturers with the frequency range of 2 to 1,000 Hz, using sinusoidal, pulse, ramp, and square waveforms. The magnetic fields were produced by a computer-controlled Helmholtz coil system.

Pacemaker malfunction occurred in six of 16 pacemakers. Interaction developed almost immediately after high-intensity magnetic field exposure started. With each waveform, at least two pacemakers exhibited interference. In most exposure settings, there was no interference at magnetic field levels below the international occupational

safety limits. Nevertheless, some frequencies using ramp or square waveforms interfered with pacemakers even at levels below public exposure limits. The occurrence of interference depended greatly on the waveform, frequency, magnetic field intensity, and the sensing configuration of the pacemaker. Unipolar configurations were more susceptible for interference than the bipolar ones. In addition, magnetic fields perpendicular to the pacemaker loops were more likely to cause interference than parallel fields.

Conclusion: There is a need for further investigations on pacemaker interference caused by different external magnetic fields to ensure safe working environment to workers with a pacemaker.

**NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS OF A 60 HZ, 1,800  $\mu$ T MAGNETIC FIELD IN HUMANS.**

Legros A, Corbacio M, Beuter A, Modolo J, Goulet D, Prato FS, Thomas AW.

*Eur J Appl Physiol.* 2012; 112: 1751-1762.

The present study aimed to investigate the effects of a 60 Hz, 1,800  $\mu$ T MF exposure on neurophysiological (EEG) and neuromotor (standing balance, voluntary motor function, and physiological tremor) aspects in humans using a single experimental procedure. Though results from this study suggest a reduction of human standing balance with MF exposure, as well as an increase of physiological tremor amplitude within the frequency range associated with central nervous system contribution, no exposure effect appeared on other investigated parameters (e.g., EEG or voluntary motor control).

Conclusion: These results suggest that 1 h of 60 Hz, 1,800  $\mu$ T MF exposure may modulate human involuntary motor control without being detected in the cortical electrical activity.

**STUDY OF THE FREQUENCY PARAMETERS OF EEG INFLUENCED BY ZONE-DEPENDENT LOCAL ELF-MF EXPOSURE ON THE HUMAN HEAD.**

Shafiei SA, Firoozabadi SM, Rasoulzadeh Tabatabaie K, Ghabaee M.

*Electromagn Biol Med.* 2012; 3:112-121.

It has been reported that human subjects exposed to electromagnetic fields exhibit changes in human EEG signals at the frequency of stimulation. The aim of the present study was to expose different parts of the brain to extremely low-frequency magnetic fields locally and investigate EEG power spectrum alters at the frequency of stimulation. EEG relative power spectrum were evaluated at 3, 5, 10, 17, and 45 Hz frequencies at T4, T3, F3, Cz, and F4 points, respectively, when these points were exposed to magnetic fields with similar frequencies and 100  $\mu$ T intensity.

Conclusion: The paired t-test results showed that power value of EEG did not alter significantly at the frequency of stimulation ( $P < 0.05$ ). Further, significant changes in different EEG bands caused by locally exposing to ELF-MF in different points of brain were observed.

**ORIGINS OF ELECTROMAGNETIC HYPERSENSITIVITY TO 60HZ MAGNETIC FIELDS: A PROVOCATION STUDY.**

Kim DW, Choi JL, Nam KC, Yang DI, Kwon MK.  
*Bioelectromagnetics*. 2011; 33: 326-333.

With increasing electrical device usage, social concerns about the possible effects of 60 Hz electromagnetic fields on human health have increased. The number of people with self-attributed electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms such as headache and insomnia has also increased. However, it is unclear whether EHS results from physiological or other origins. In this double-blinded study, the authors simultaneously investigated physiological changes (heart rate, respiration rate, and heart rate variability), subjective symptoms, and perception of the magnetic field to assess origins of the subjective symptoms. Two volunteer groups of 15 self-reported EHS and 16 non-EHS individuals were tested with exposure to sham and real (60 Hz, 12.5  $\mu$ T) magnetic fields for 30 min. Magnetic field exposure did not have any effects on physiological parameters or eight subjective symptoms in either group. There was also no evidence that the EHS group perceived the magnetic field better than the non-EHS group.

Conclusion: The subjective symptoms did not result from the 60 Hz, 12.5  $\mu$ T magnetic field exposures but from other non-physiological factors.

#### **4. Exposure assessment**

**TRENDS IN RESIDENTIAL EXPOSURE TO ELECTROMAGNETIC FIELDS FROM 2006 TO 2009.**

Tomitsch J, Dechant E.  
*Radiat Prot Dosimetry*. 2012; 149 :384-391.

After measuring extremely low frequency electric and magnetic fields (ELF-EFs, ELF-MFs) and radio frequency electromagnetic fields (RF-EMFs) in 2006, a follow-up investigation was done in 2009. Overall, 130 measurements in bedrooms at identical and 83 at changed locations within the same or a neighbouring building were performed. The median of ELF-EFs decreased from 25.15 to 17.35 V m<sup>-1</sup> from 2006 to 2009. The median of all-night ELF-MFs from power supply decreased from 16.86 to 12.76 nT, whereas the arithmetic mean was almost unchanged (+0.1%). No difference in the medians of all-night ELF-MFs of railway current was observed.

**TIME DEPENDENCE OF 50 HZ MAGNETIC FIELDS IN APARTMENT BUILDINGS WITH INDOOR TRANSFORMER STATIONS.**

Yitzhak NM, Hareuveny R, Kandel S, Ruppin R.  
*Radiat Prot Dosimetry*. 2012; 149: 191-195.

Twenty-four hour measurements of 50 Hz magnetic fields (MFs) in apartment buildings containing transformer stations have been performed. The apartments were classified into four types, according to their location relative to the transformer room. Temporal correlation coefficients between the MF in various apartments, as well as between MF and transformer load curves, were calculated. It was found that, in addition to their high average MF, the apartments located right above the transformer room also exhibit unique temporal correlation properties.

## 5. Leukemia studies

### **IN VITRO FERTILIZATION AND RISK OF CHILDHOOD LEUKEMIA IN GREECE AND SWEDEN.**

Petridou ET, Sergentanis TN, Panagopoulou P, Moschovi M, Polychronopoulou S, Baka M, Pourtsidis A, Athanassiadou F, Kalmanti M, Sidi V, Dessypris N, Frangakis C, Matsoukis IL, Stefanadis C, Skalkidou A, Stephansson O, Adami HO, Kieler H.

*Pediatr Blood Cancer. 2012; 58: 930-936.*

Cancer risk in children born after in vitro fertilization (IVF) remains largely unknown. The authors aimed to investigate risk of leukemia and lymphoma following IVF using two nationwide datasets.

The hospital-based case-control study in Greece derived from the National Registry for Childhood Hematological Malignancies (1996-2008, 814 leukemia and 277 lymphoma incident cases with their 1:1 matched controls). The Swedish case-control study was nested in the Swedish Medical Birth Register (MBR) (1995-2007, 520 leukemia and 71 lymphoma cases with their 5,200 and 710 matched controls) with ascertainment of incident cancer cases in the National Cancer Register. Study-specific and combined odds ratios (OR) were estimated using conditional logistic regression, with adjustment for possible risk factors.

Nationwide studies pointed to similar size excess risk of leukemia following IVF, but to a null association between IVF and lymphoma. The proportion of leukemia cases conceived through IVF was 3% in Greece and 2.7% in Sweden; prevalence of IVF in matched controls was 1.8% and 1.6%, respectively. In combined multivariable analyses, the increased risk of leukemia was confined to age below 3.8 years (OR=2.21; 95% confidence interval, CI: 1.27-3.85) and to acute lymphoblastic leukemia (ALL) (OR = 1.77; 95% CI: 1.06-2.95) with no sufficient evidence of excess risk for other leukemias (OR = 1.34; 95% CI: 0.38-4.69). Following IVF, OR for ALL was 2.58 (95% CI: 1.37-4.84) before age 3.8 and 4.29 (95% CI: 1.49-12.37) before age 2 years.

Conclusions: IVF seems to be associated with increased risk of early onset ALL in the offspring.

### **Perspectives on the causes of childhood leukemia.**

Wiemels J.

*Chem Biol Interact. 2012; 196: 59-67.*

Acute leukemia is the most common cancer in children but the causes of the disease in the majority of cases are not known. About 80% are precursor-B cell in origin (CD19+, CD10+), and this immunophenotype has increased in incidence over the past several decades in the Western world. Part of this increase may be due to the introduction of new chemical exposures into the child's environment including parental smoking, pesticides, traffic fumes, paint and household chemicals. However, much of the increase in leukemia rates is likely linked to altered patterns of infection during early childhood development, mirroring causal pathways responsible for a similarly increased incidence of other childhood-diagnosed immune-related illnesses including allergy, asthma, and type 1 diabetes. Factors linked to childhood leukemia that are likely surrogates for immune stimulation include exposure to childcare settings, parity status and birth order, vaccination history, and population mixing. In case-control studies, acute lymphoblastic leukemia (ALL) is consistently inversely associated with

greater exposure to infections, via daycare and later birth order. New evidence suggests also that children who contract leukemia may harbor a congenital defect in immune responder status, as indicated by lower levels of the immunosuppressive cytokine IL-10 at birth in children who grow up to contract leukemia, as well as higher need for clinical care for infections within the first year of life despite having lower levels of exposure to infections. One manifestation of this phenomenon may be leukemia clusters which tend to appear as a leukemia "outbreak" among populations with low herd immunity to a new infection.

Conclusion: Critical answers to the etiology of childhood leukemia will require incorporating new tools into traditional epidemiologic approaches - including the classification of leukemia at a molecular scale, better exposure assessments at all points in a child's life, a comprehensive understanding of genetic risk factors, and an appraisal of the interplay between infectious exposures and the status of immune response in individuals.