

## **Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the second trimester of 2009.**

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*Dr. Maurits De Ridder  
Occupational and Environmental Health Section  
Ghent University*

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### **1. Residential exposure**

#### **MORBIDITY EXPERIENCE IN POPULATIONS RESIDENTIALLY EXPOSED TO 50 HZ MAGNETIC FIELDS: METHODOLOGY AND PRELIMINARY FINDINGS OF A COHORT STUDY.**

Fazzo L, Tancioni V, Polichetti A, Iavarone I, Vanacore N, Papini P, Farchi S, Bruno C, Pasetto R, Borgia P, Comba P.

*Int J Occup Environ Health. 2009;15(2):133-142.*

A morbidity study of the population of a district of Rome built in part under a 60 kV electric distribution line, included 345 subjects resident in the study area in any period between 1954 and 2003, excluding those deceased before 1998. Residential magnetic field levels were estimated based on current load, line characteristics, and distance of the dwellings from the power line, and the study area was divided into sub-areas with differing magnetic field levels. Standardized morbidity ratios were computed from hospital discharge records dated 1998-2003. Non statistically significant increases were observed for all and primary cancers; primary cancers were significantly increased among subjects with > 30 years' residence and latency. A significant increase for all, primary, and secondary cancers, and a two-fold increase for ischaemic diseases, was observed in subjects in the sub-area with the highest exposure. No increase was seen in neoplastic haematological diseases.

#### **BLOOD LABORATORY FINDINGS IN PATIENTS SUFFERING FROM SELF-PERCEIVED ELECTROMAGNETIC HYPERSENSITIVITY (EHS).**

Dahmen N, Ghezel-Ahmadi D, Engel A.

*Bioelectromagnetics. 2009;30(4):299-306.*

Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. The authors hypothesized that some electrosensitive individuals are suffering from common somatic health problems. Toward this end they analysed clinical laboratory parameters including thyroid-stimulating hormone (TSH), alanine transaminase (ALT), aspartate transaminase (AST), creatinine, hemoglobine, hematocrit and c-reactive protein (CRP) in subjects suffering from EHS and in controls that are routinely used in clinical medicine to identify or screen for common somatic disorders. One hundred thirty-two patients (n = 42 males and n = 90 females) and 101 controls (n = 34 males and n = 67 females) were recruited. The results identified laboratory signs of thyroid dysfunction, liver dysfunction and chronic inflammatory processes in small but remarkable fractions of EHS sufferers as potential sources of symptoms that merit further investigation in future studies. In the cases of TSH and ALT/AST there were significant differences between cases and controls. The hypotheses of anaemia or kidney dysfunction playing a major role in EHS could be unambiguously refuted.

Conclusion: Clinically it is recommended to check for signs of treatable somatic conditions when caring for individuals suffering from self-proclaimed EHS.

## **2. Occupational exposure**

### **OCCUPATIONAL EXPOSURE TO MAGNETIC FIELDS AND THE RISK OF BRAIN TUMORS.**

Coble JB, Dosemeci M, Stewart PA, Blair A, Bowman J, Fine HA, Shapiro WR, Selker RG, Loeffler JS, Black PM, Linet MS, Inskip PD.

*Neuro Oncol.* 2009;11(3):242-249.

The authors investigated the association between occupational exposure to extremely low-frequency magnetic fields (MFs) and the risk of glioma and meningioma. Occupational exposure to MF was assessed for 489 glioma cases, 197 meningioma cases, and 799 controls enrolled in a hospital-based case-control study. Lifetime occupational history questionnaires were administered to all subjects; for 24% of jobs, these were supplemented with job-specific questionnaires, or "job modules," to obtain information on the use of electrically powered tools or equipment at work. Job-specific quantitative estimates for exposure to MF in milligauss were assigned using a previously published job exposure matrix (JEM) with modification based on the job modules. Jobs were categorized as  $< \text{or } = 1.5 \text{ mG}$ ,  $> 1.5 \text{ to } < 3.0 \text{ mG}$ , and  $> \text{ or } = 3.0 \text{ mG}$ . Four exposure metrics were evaluated: (1) maximum exposed job; (2) total years of exposure  $> 1.5 \text{ mG}$ ; (3) cumulative lifetime exposure; and (4) average lifetime exposure. Odds ratios (ORs) were calculated using unconditional logistic regression with adjustment for the age, gender, and hospital site. The job modules increased the number of jobs with exposure  $> \text{ or } = 3.0 \text{ mG}$  from 4% to 7% relative to the JEM. No statistically significant elevation in ORs or trends in ORs across exposure categories was observed using four different exposure metrics for the three tumor types analyzed.

Conclusion: Occupational exposure to MFs assessed using job modules was not associated with an increase in the risk for glioma, glioblastoma, or meningioma among the subjects evaluated in this study.

### **WELDING OCCUPATIONS AND MORTALITY FROM PARKINSON'S DISEASE AND OTHER NEURODEGENERATIVE DISEASES AMONG UNITED STATES MEN, 1985-1999.**

Stampfer MJ.

*J Occup Environ Hyg.* 2009;6(5):267-272.

Metal welding produces gaseous fumes that contain manganese, resulting in potential occupational exposure to welders. It has been hypothesized that occupational exposure among welders could increase risk of Parkinson's disease and other neurodegenerative diseases. The present study examines welding occupation and mortality from neurodegenerative diseases among men in the United States using the National Cause of Death databases 1985 to 1999. Information was abstracted from death certificates for states that collected data on occupation. Of 4,252,490 men who died during the study period, 107,773 had welding-related occupations. Multivariable logistic regression models were used to calculate mortality odds ratios (MOR) and 95% confidence intervals (CI) for odds of dying from Parkinson's disease or other neurodegenerative diseases among men who were welders as compared with men of other occupations, adjusting for attained age, race, region of residence, and year of death. During the study period, 49,174 deaths were attributed to Parkinson's disease, 54,892 to Alzheimer's disease, and 19,018 to presenile dementia. There was no evidence of an increased odds of Parkinson's disease mortality among welders as compared with men with other occupations (MOR = 0.83, 95% CI 0.78-0.88). Furthermore, welding occupation was unrelated to the odds of mortality from Alzheimer's disease (MOR = 0.94, 95% CI 0.89-1.00) or presenile dementia (MOR = 0.96, 95% CI 0.87-1.06). Earlier research suggested that welding exposures could predispose individuals to earlier onset Parkinson's disease. However, there was no evidence in this data of an increased mortality odds ratio associated with welding

occupations among men younger than 65 (MOR = 1.03, 95% CI 0.74-1.44); while there was a suggestion of a lower odds Parkinson's disease death among men age 65 years and older (MOR = 0.82, 95% CI 0.77-0.88).

Conclusion: Data from this large study do not support an association between welding occupations and death from Parkinson's disease or other neurodegenerative diseases, nor that welders are at increased odds of dying from Parkinson's disease at a younger age.

#### **U.K. LINESMEN'S EXPERIENCE OF MICROSHOCKS ON HV OVERHEAD LINES.**

Ahmed Y, Rowland SM.

*J Occup Environ Hyg.* 2009;6(8):475-482.

Linesmen working on high voltage equipment occasionally report unpleasant discharges from equipment. The sensation is known as microshocks, which result from capacitive coupling of the linesmen to high voltage sources and subsequent discharging when in very close proximity to grounded objects. Often, this is just an annoyance, but the levels can become such that work has to cease. Microshocks are unpredictable, and therefore, planning maintenance work around them has not been possible. A survey has been developed to investigate and quantify different factors that may have a direct influence on the frequency and intensity of discharges. Transmission line workers (N = 102) from England and Wales participated in the survey and provided details of personal body characteristics as well as their experiences of microshocks. Survey results suggest a correlation between body mass index and certain work activities to the likelihood of a person experiencing microshocks, and their severity. Higher body mass index reduces the likelihood of experiencing painful microshocks. Climbing lattice towers adjacent to energized conductors is the area most associated with the phenomenon. Microshock incidents have increased or are occurring at the same rate as 5 years ago.

Conclusion: Results presented will aid the development of policy statements and mitigation techniques that minimize linesmen's exposure to microshocks.

### **3. Exposure assessment**

#### **POWER FREQUENCY MAGNETIC FIELDS AND RISK OF CHILDHOOD LEUKAEMIA: MISCLASSIFICATION OF EXPOSURE FROM THE USE OF THE 'DISTANCE FROM POWER LINE' EXPOSURE SURROGATE.**

Maslanyj M, Simpson J, Roman E, Schüz J.

*Bioelectromagnetics.* 2009;30(3):183-188.

A recent study examining the relationship between distance to nearby power lines and childhood cancer risk re-opened the debate about which exposure metrics are appropriate for power frequency magnetic field investigations. Using data from two large population-based UK and German studies the authors demonstrate that distance to power lines is a comparatively poor predictor of measured residential magnetic fields. Even at proximities of 50 m or less, the positive predictive value of having a household measurement over 0.2 microT was only 19.4%. Clearly using distance from power lines, without taking account of other variables such as load, results in a poor proxy of residential magnetic field exposure.

Conclusion: The authors conclude that such high levels of exposure misclassification render the findings from studies that rely on distance alone uninterpretable.

## **EVALUATION OF CURRENT DENSITIES AND TOTAL CONTACT CURRENTS IN OCCUPATIONAL EXPOSURE AT 400 KV SUBSTATIONS AND POWER LINES.**

Korpinen LH, Elovaara JA, Kuisti HA.

*Bioelectromagnetics. 2009;30(3):231-240.*

This investigation studied the current densities in the neck and total contact currents in occupational exposure at 400 kV substations and power lines. Eight voluntary workers simulated their normal work tasks using the helmet-mask measuring system. In all, 151 work tasks with induced current measurements were made. Work situations were: tasks in 400 kV substations, tasks in 400-110 kV towers and the cutting of vegetation under 400 kV power lines. The average current density in the neck was estimated from the current induced in the helmet. The calculated maximum average current densities in the neck varied from 1.5 to 6.4 mA/m<sup>2</sup> and the maximum total contact currents from 66.8 to 458.4 microA.

Conclusion: The study shows that the maximum average current densities and the total contact currents (caused by electric field) in occupational exposure at 400 kV substations and power lines does not exceed the limit and action values (10 mA/m<sup>2</sup>) and 1 mA) of the new EU-directive 2004/40/EC (live-line bare-hand works excluded).

## **AN INTEGRATED JOB EXPOSURE MATRIX FOR ELECTRICAL EXPOSURES OF UTILITY WORKERS.**

Bracken TD, Kavet R, Patterson RM, Fordyce TA.

*J Occup Environ Hyg. 2009;6(8):499-509.*

Electric utility workers may be exposed to any combination of magnetic fields, electric fields, nuisance shocks (from spark discharges and continuous currents), imperceptible contact currents, and electrical injuries. Collectively these exposures are referred to as EMF Factors. Previous occupational exposure assessments have mainly characterized the magnetic field, with less attention to the electric field. Nuisance shocks and electrical injuries, though palpable, have received little to no attention. This article presents a prototype job exposure matrix that addresses exposure to all EMF Factors taking into account job category, work environment, and occupied environment. Exposures for all factors were classified into three ordinal levels for 22 job categories. Electric and magnetic field exposures were classified by the geometric mean of daily average of personal exposure measurements. Although relatively sparse, survey data on nuisance shocks were adequate for exposure assignment by job category and indicate that the frequency of these exposures has diminished over time. The least information was available for imperceptible contact currents that are associated with electric field exposures and small contact voltages. Data for electrical injuries by job category were derived from the Electric Power Research Institute Occupational Health Surveillance Database, with exposure assignments based on combined injury rates for flash burn and electric shock/electrocution.

Conclusion: The highest exposures for all EMF Factors are essentially limited to four job categories that work on or close to electrical equipment: (1) cable splicers, (2) electricians, (3) line workers, and (4) substation operators.

## **4. Human experimental research**

### **CELLULAR EFFECTS OF EXTREMELY LOW FREQUENCY (ELF) ELECTROMAGNETIC FIELDS.**

Santini MT, Rainaldi G, Indovina PL.

*Int J Radiat Biol. 2009;85(4):294-313.*

The major areas of research that have characterised investigation of the impact of extremely low frequency (ELF) electromagnetic fields on living systems in the past 50

years are discussed. In particular, selected studies examining the role of these fields in cancer, their effects on immune and nerve cells, and the positive influence of these ELF fields on bone and nerve cells, wound healing and ischemia/reperfusion injury are explored.

Conclusions: The literature indicates that there is still no general agreement on the exact biological detrimental effects of ELF fields, on the physical mechanisms that may be behind these effects or on the extent to which these effects may be harmful to humans. Nonetheless, the majority of the in vitro experimental results indicate that ELF fields induce numerous types of changes in cells. Whether or not the perturbations observed at the cellular level can be directly extrapolated to negative effects in humans is still unknown. However, the myriad of effects that ELF fields have on biological systems should not be ignored when evaluating risk to humans from these fields and, consequently, in passing appropriate legislation to safeguard both the general public and professionally-exposed workers. With regard to the positive effects of these fields, the possibility of testing further their efficacy in therapeutic protocols should also not be overlooked.

**GENETIC DAMAGE IN MAMMALIAN SOMATIC CELLS EXPOSED TO EXTREMELY LOW FREQUENCY ELECTRO-MAGNETIC FIELDS: A META-ANALYSIS OF DATA FROM 87 PUBLICATIONS (1990-2007).**

Vijayalaxmi, Prihoda TJ.

*Int J Radiat Biol.* 2009 Mar;85(3):196-213.

A meta-analysis was conducted to obtain a 'quantitative' estimate of the extent of genetic damage in mammalian somatic cells exposed to non-ionizing radiation emitted from extremely low frequency electro-magnetic fields (ELF-EMF) and to compare with that in unexposed control cells. The methods used for the meta-analysis were recommended in several standard text books. Three specific variables related to ELF-EMF exposure characteristics were examined in the meta-analysis: (i) frequency (Hz), (ii) flux density (mT), and (iii) in occupationally exposed individuals.

Result and conclusions: (1) The difference between ELF-EMF-exposed and control cells as well as the 'effect size' due to ELF-EMF exposure were biologically small (although statistically significant) with very few exceptions. (2) At certain ELF-EMF exposure conditions there was a statistically significant increase in genetic damage assessed from some end-points. (3) The mean indices for chromosomal aberrations and micronuclei end-points in ELF-EMF-exposed and control cells were within the spontaneous levels reported in historical database. (4) Considerable evidence for publication bias was found in the meta-analysis.

## **5. Leukaemia studies**

**BIRTH WEIGHT AND CHILDHOOD LEUKEMIA: A META-ANALYSIS AND REVIEW OF THE CURRENT EVIDENCE.**

Caughey RW, Michels KB.

*Int J Cancer.* 2009;124(11):2658-2670

A growing body of evidence suggests that childhood leukemia may be initiated in utero when lymphoid and myeloid cells are not fully differentiated and are particularly susceptible to malignant transformation. A fixed effects meta-analysis examining the association between birth weight and childhood leukemia was conducted including 32 studies and 16,501 cases of all types of leukemia (OL), 10,974 cases of acute lymphoblastic leukemia (ALL), and 1,832 cases of acute myeloid leukemia (AML). The odd ratios (OR) for the association of high birth weight with OL, ALL and AML were 1.35 (95% CI: 1.24, 1.48), 1.23 (95% CI: 1.15, 1.32), and 1.40 (95% CI: 1.11, 1.76), respectively, compared with normal birth weight. Low birth weight was not associated

with overall and ALL leukemia, but with AML (OR = 1.50; 95% CI: 1.05, 2.13). Per 1000 g increase in birth weight, the OR for OL was 1.18 (95% CI: 1.13, 1.23) and ALL 1.18 (95% CI: 1.12, 1.23).

Conclusion: The combined available evidence from observational studies suggests that high birth weight is associated with an increased risk of overall leukemia and ALL. For AML the risk may be elevated at both high and low extremes of birth weight, suggesting a U-shaped association.

**PARENTAL AGE AND RISK OF CHILDHOOD CANCER: A POOLED ANALYSIS.**

Johnson KJ, Carozza SE, Chow EJ, Fox EE, Horel S, McLaughlin CC, Mueller BA, Puumala SE, Reynolds P, Von Behren J, Spector LG.

*Epidemiology.* 2009;20(4):475-483.

The authors assessed the relationship between parental age and childhood cancer in a case-control study using pooled population-based data. The pooling was based on linked cancer and birth registry records from New York, Washington, Minnesota, Texas, and California. Subjects included 17,672 cancer cases diagnosed at ages 0-14 years during 1980-2004 and 57,966 controls born during 1970-2004. Individuals with Down syndrome were excluded. Odds ratios and 95% confidence intervals were calculated by logistic regression for the association between parental age and childhood cancer after adjustment for sex, birth weight, gestational age, birth order, plurality, maternal race, birth year, and state. Positive linear trends per 5-year maternal age increase were observed for childhood cancers overall (odds ratio = 1.08 [95% confidence interval = 1.06-1.10]) and 7 of the 10 most frequent diagnostic groups: leukemia (1.08 [1.05-1.11]), lymphoma (1.06 [1.01-1.12]), central nervous system tumors (1.07 [1.03-1.10]), neuroblastoma (1.09 [1.04-1.15]), Wilms' tumor (1.16 [1.09-1.22]), bone tumors (1.10 [1.00-1.20]), and soft tissue sarcomas (1.10 [1.04-1.17]). No maternal age effect was noted for retinoblastoma, germ cell tumors, or hepatoblastoma. Paternal age was not independently associated with most childhood cancers after adjustment for maternal age.

Conclusions: These results suggest that older maternal age increases risk for most common childhood cancers. Investigation into possible mechanisms for this association is warranted.

**A COHORT STUDY OF CHILDHOOD CANCER INCIDENCE AFTER POSTNATAL DIAGNOSTIC X-RAY EXPOSURE.**

Hammer GP, Seidenbusch MC, Schneider K, Regulla DF, Zeeb H, Spix C, Blettner M.

*Radiat Res.* 2009;171(4):504-512.

Ionizing radiation is an established cause of cancer, yet little is known about the health effects of doses from diagnostic examinations in children. The risk of childhood cancer was studied in a cohort of 92,957 children who had been examined with diagnostic X rays in a large German hospital during 1976-2003. Radiation doses were reconstructed using the individual dose area product and other exposure parameters, together with conversion coefficients developed specifically for the medical devices and standards used at the radiology department. Newly diagnosed cancers occurring between 1980 and 2006 were determined through record linkage to the German Childhood Cancer Registry. The median radiation dose was 7 microSv. Eight-seven incident cases were found in the cohort: 33 leukemia, 13 lymphoma, 10 central nervous system tumors, and 31 other tumors. The standardized incidence ratio (SIR) for all cancers was 0.99 (95% CI: 0.79-1.22). No trend in the incidence of total cancer, leukemia or solid tumors with increasing radiation dose was observed in the SIR

analysis or in the multivariate Poisson regression. Risk did not differ significantly in girls and boys.

Conclusion: Overall, no increase in cancer risk with diagnostic radiation was observed.

**RESIDENTIAL EXPOSURE TO POLYCHLORINATED BIPHENYLS AND ORGANOCHLORINE PESTICIDES AND RISK OF CHILDHOOD LEUKEMIA.**

Ward MH, Colt JS, Metayer C, Gunier RB, Lubin J, Crouse V, Nishioka MG, Reynolds P, Buffler PA.

*Environ Health Perspect.* 2009;117(6):1007-1013.

Incidence of childhood leukemia in industrialized countries rose significantly during 1975-2004, and the reasons for the increase are not understood. The authors used carpet dust as an exposure indicator to examine the risk of childhood leukemia in relation to residential exposure to persistent organochlorine chemicals: six polychlorinated biphenyl (PCB) congeners and the pesticides alpha- and gamma-chlordane, p,p'-DDT (dichlorodiphenyltrichloroethane), p,p'-DDE (dichlorodiphenyl-dichloroethylene), methoxychlor, and pentachlorophenol. A population-based case-control study was conducted in 35 counties in northern and central California in 2001-2006. The study included 184 acute lymphocytic leukemia (ALL) cases 0-7 years of age and 212 birth certificate controls matched to cases by birth date, sex, race, and Hispanic ethnicity. Carpet dust samples from the room where the child spent the most time before diagnosis (similar date for controls) was collected using a specialized vacuum. Detection of any PCB congener in the dust conferred a 2-fold increased risk of ALL [odds ratio (OR) = 1.97; 95% confidence interval (CI), 1.22-3.17]. Compared with those in the lowest quartile of total PCBs, the highest quartile was associated with about a 3-fold risk (OR = 2.78; 95% CI, 1.41-5.48), and the positive trend was significant ( $p = 0.017$ ). Significant positive trends in ALL risk were apparent with increasing concentrations of PCB congeners 118, 138, and 153. We observed no significant positive associations for chlordane, DDT, DDE, methoxychlor, or pentachlorophenol. The associations with PCBs were stronger among non-Hispanic whites than among Hispanics despite similar distributions of PCB levels among controls in each racial/ethnic group.

Conclusions: These findings suggest that PCBs, which are considered probable human carcinogens and cause perturbations of the immune system, may represent a previously unrecognized risk factor for childhood leukemia.