

Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2009

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1. Reviews

A LITERATURE REVIEW: THE CARDIOVASCULAR EFFECTS OF EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS.

McNamee DA, Legros AG, Krewski DR, Wisenberg G, Prato FS, Thomas AW.
Int Arch Occup Environ Health. 2009; 82(8):919-933.

The effects of exposure to extremely low frequency (ELF) electromagnetic fields (EMFs) on human cardiovascular parameters remain undetermined. Epidemiological studies have utilized dosimetry estimations of employee workplace exposure using altered heart rate variability (HRV) as predictive of certain cardiovascular pathologies. Laboratory studies have focused on macrocirculatory indicators including heart rate, HRV and blood pressure. Few studies have been conducted on the response of the microcirculatory system to EMF exposure. Attempts to replicate both epidemiological and laboratory studies have been mostly unsuccessful as study design, small sample populations and confounding variables have hampered progress to date. Identification of these problems, in the current context of international exposure guideline re-evaluation, is essential for future EMF studies. These studies should address the possible deleterious health effects of EMFs as well as the detection and characterization of subtle physiological changes they may induce. Recommendations for future work include investigating the macro- and microcirculatory relationship and the use of laboratory geomagnetic shielding.

2. Occupational exposure

MATERNAL OCCUPATIONAL EXPOSURE TO EXTREMELY LOW FREQUENCY MAGNETIC FIELDS AND THE RISK OF BRAIN CANCER IN THE OFFSPRING.

Li P, McLaughlin J, Infante-Rivard C.
Cancer Causes Control. 2009; 20(6):945-955.

The objective of the study is to examine the contribution of maternal occupational exposure to extremely low frequency magnetic fields (ELF-MF) shortly before and during pregnancy on the incidence of childhood brain tumors. A total of 548 incident cases and 760 healthy controls recruited between 1980 and 2002 from two Canadian provinces (Québec and Ontario) were included in this study, and their mothers were interviewed. Quantitative occupational ELF-MF exposure in microTesla units was estimated using individual exposure estimations or a job exposure matrix. Three metrics to analyze exposure were used: cumulative, average, and maximum level attained. Using the average exposure metric measured before conception, an increased risk was observed for astroglial tumors (OR = 1.5, 95% CI = 1.0-2.4). During the entire pregnancy period, a significantly increased risk was observed for astroglial tumors as well as for all childhood brain tumors with the average metric (OR = 1.6, 95% CI = 1.1-2.5 and OR = 1.5, 95% CI = 1.1-2.2, respectively). Based on job titles, a twofold risk increase was observed for astroglial tumors (OR = 2.3, 95% CI = 0.8-6.3)

and for all childhood brain tumors (OR = 2.3, 95% CI = 1.0-5.4) among sewing machine operators.

Conclusions: Results are suggestive of a possible association between maternal occupational ELF-MF exposure and certain brain tumors in their offspring.

3. Human experimental research

ALTERATIONS OF HUMAN ELECTROENCEPHALOGRAPHIC ACTIVITY CAUSED BY MULTIPLE EXTREMELY LOW FREQUENCY MAGNETIC FIELD EXPOSURES.

Cvetkovic D, Cosic I.

Med Biol Eng Comput. 2009; 47(10):1063-1073.

In the past, many studies have claimed that extremely low frequency (ELF) magnetic field (MF) exposures could alter the human electroencephalographic (EEG) activity. This study aims at extending our ELF pilot study to investigate whether MF exposures at ELF in series from 50, 16.66, 13, 10, 8.33 to 4 Hz could alter relative power within the corresponding EEG bands. 33 human subjects were tested under a double-blind and counter-balanced conditions. The multiple repeated three-way analysis of variance (ANOVA) mixed design (within and between-subject) analysis was employed followed by post-hoc t-tests and Bonferroni alpha-correction. The results from this study have shown that narrow alpha1 (7.5-9.5 Hz) and alpha2 (9-11 Hz) bands, associated with 8.33 and 10 Hz MF exposures, were significantly ($p < 0.0005$) lower than control over the temporal and parietal regions within the 10-16 min of first MF exposure session and the MF exposures were significantly higher than control of the second session MF exposure (60-65 min from the commencement of testing). Also, it was found that the beta1 (12-14 Hz) band exhibited a significant increase from before to after 13-Hz first MF exposure session at frontal region. The final outcome of our result has shown that it is possible to alter the human EEG activity of alpha and beta bands when exposed to MF at frequencies corresponding to those same bands, depending on the order and period of MF conditions. This type of EEG synchronisation of driving alpha and beta EEG by alpha and beta sinusoidal MF stimulation, demonstrated in this study, could possibly be applied as therapeutic treatment(s) of particular neurophysiological abnormalities such as sleep and psychiatric disorders.

4. Exposure assessment

OCCUPATIONAL EXPOSURE OF UK ADULTS TO EXTREMELY LOW FREQUENCY MAGNETIC FIELDS.

Mee T, Whatmough P, Broad L, Dunn C, Maslanyj M, Allen S, Muir K, McKinney PA, van Tongeren M.

Occup Environ Med. 2009; 66(9):619-627.

Occupational exposure to extremely low frequency (ELF) magnetic fields (MF) in the UK general population is poorly documented. The aim of this study is to assess levels of occupational exposure to ELF MF in the UK and evaluate the use of a rigid job-exposure matrix (JEM) to assign exposures to subjects in the UK Adult Brain Tumour Study (UKABTS). Personal ELF MF measurements were carried out. Exposure traces were divided into occupational, travel and elsewhere periods, under differing exposure metrics. Exposure was classified by Standard Occupational Classification (2000), Standard Industrial Classification (1997), and a combined occupation-industry classification. Statistical analyses (mixed effects model) determined the contribution of occupational exposure to the 24 h cumulative exposure and the contribution of occupation and industry to total variance. Data were obtained from 317 individuals,

comprising UKABTS subjects (n = 192), occupational proxies for UKABTS subjects (n=101) and "interest" readings (n = 24). 236 individuals provided occupational data covering 117 different occupations. Average exposure was significantly higher at work than at home. Elevated average occupational exposure was found for welding trades, printers, telephonists and filing and other records assistants. The discrimination of a rigid JEM based on occupation can be improved by linking the classification with industry and by the use of contextual information.

Conclusions: This report substantially expands information on adult exposure to ELF MF in the UK. The accuracy of exposure assessments based solely on job codes is improved by linking with either industry code or contextual knowledge of equipment and of power lines or substations in the work environment.

RESIDENTIAL MAGNETIC FIELDS AND MEASURES OF NEUTRAL-TO-EARTH VOLTAGE: VARIABILITY WITHIN AND BETWEEN RESIDENCES.

Kavet R, Hooper HC.

Health Phys. 2009; 97(4):332-342.

The objectives of this study were to characterize temporal patterns of magnetic fields (Bavg) and two measures of neutral-to-earth voltage: the voltage between the water line and earth (VW-E), and the voltage between bathtub plumbing fixtures and the drain (Vbath). The latter is a source of exposure to contact current in bathing children that has been proposed to explain the reported association between power-frequency magnetic fields and childhood leukemia. These quantities were measured each minute in a sample of 15 single-detached residences in San Jose, CA. Generally, Bavg, VW-E, and Vbath were positively correlated with each other within residences, and displayed similar diurnal patterns. Weekday and weekend patterns displayed qualitative differences that reflect the more scheduled workday for weekdays, and a less structured pattern for weekends. When pooled with two prior measurement studies, positive associations across residences between Bavg and both VW-E and Vbath were observed. Home designs over the past 30-40 years have lead to a decreasing prevalence of Vbath as conductive drains have been swapped out for non-conductive materials. Nonetheless, the observed relationships within and across residences indicate that contact current has the characteristics of a factor that could explain the association of magnetic fields with childhood leukemia.

5. Leukaemia studies

RESIDENTIAL PROXIMITY TO AGRICULTURAL PESTICIDE APPLICATIONS AND CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA.

Rull RP, Gunier R, Von Behren J, Hertz A, Crouse V, Buffler PA, Reynolds P.

Environ Res. 2009; 109(7):891-899.

Ambient exposure from residential proximity to applications of agricultural pesticides may contribute to the risk of childhood acute lymphoblastic leukemia (ALL). Using residential histories collected from the families of 213 ALL cases and 268 matched controls enrolled in the Northern California Childhood Leukemia Study, the authors assessed residential proximity within a half-mile (804.5m) of pesticide applications by linking address histories with reports of agricultural pesticide use. Proximity was ascertained during different time windows of exposure, including the first year of life and the child's lifetime through the date of diagnosis for cases or reference for controls. Agricultural pesticides were categorized a priori into groups based on similarities in toxicological effects, physicochemical properties, and target pests or

uses. The effects of moderate and high exposure for each group of pesticides were estimated using conditional logistic regression. Elevated ALL risk was associated with lifetime moderate exposure, but not high exposure, to certain physicochemical categories of pesticides, including organophosphates, chlorinated phenols, and triazines, and with pesticides classified as insecticides or fumigants. A similar pattern was also observed for several toxicological groups of pesticides.

Conclusions: These findings suggest future directions for the identification of specific pesticides that may play a role in the etiology of childhood leukemia.

ACUTE CHILDHOOD LEUKAEMIA AND RESIDENCE NEXT TO PETROL STATIONS AND AUTOMOTIVE REPAIR GARAGES: THE ESCALE STUDY (SFCE).

Brosselin P, Rudant J, Orsi L, Leverger G, Baruchel A, Bertrand Y, Nelken B, Robert A, Michel G, Margueritte G, Perel Y, Mechinaud F, Bordigoni P, Hémon D, Clavel J.
Occup Environ Med. 2009; 66(9):598-606.

The association between acute childhood leukaemia and residing next to petrol stations and automotive repair garages was analysed in a national registry-based case-control study carried out in France in 2003-2004. Population controls were frequency matched with cases on age and gender. Data were collected by standardised telephone interview with the mothers. The latter were asked to report the proximity of their homes to petrol stations, automotive repair garages and other businesses from the conception of the index child to the diagnosis (for cases) or interview (for controls). Odds ratios were estimated using unconditional regression models adjusted for age, gender, number of children under 15 years of age in the household, degree of urbanisation and type of housing. 765 cases of acute leukaemia and 1681 controls were included. Acute leukaemia was significantly associated with residence next to petrol stations or automotive repair garages (OR 1.6, 95% CI 1.2 to 2.2) and next to a petrol station (OR 1.9, 95% CI 1.2 to 3.0). The OR showed no tendency to increase with duration of exposure. The results were not modified by adjustment for potential confounding factors including urban/rural status and type of housing.

Conclusions: The results support the findings of a previous study and suggest that living next to a petrol station may be associated with acute childhood leukaemia. The results also suggest that the role of low-level exposure to benzene in acute childhood leukaemia deserves further evaluation.

CHILDHOOD LEUKEMIA AND CANCERS NEAR GERMAN NUCLEAR REACTORS: SIGNIFICANCE, CONTEXT, AND RAMIFICATIONS OF RECENT STUDIES.

Nussbaum RH.
Int J Occup Environ Health. 2009; 15(3):318-323.

A government-sponsored study of childhood cancer in the proximity of German nuclear power plants (German acronym KiKK) found that children < 5 years living < 5 km from plant exhaust stacks had twice the risk for contracting leukemia as those residing > 5 km. The researchers concluded that since "this result was not to be expected under current radiation-epidemiological knowledge" and confounders could not be identified, the observed association of leukemia incidence with residential proximity to nuclear plants "remains unexplained." This unjustified conclusion illustrates the dissonance between evidence and assumptions. There exist serious flaws and gaps in the knowledge on which accepted models for population exposure and radiation risk are based. Studies with results contradictory to those of KiKK lack statistical power to invalidate its findings. The KiKK study's

ramifications add to the urgency for a public policy debate regarding the health impact of nuclear power generation.

CHILDHOOD LEUKEMIA IN THE VICINITY OF NUCLEAR POWER PLANTS IN GERMANY.

Kaatsch P, Spix C, Jung I, Blettner M.

Dtsch Arztebl Int. 2008;105(42):725-732.

The question whether leukemia rates are increased near nuclear power plants is controversial. The German Childhood Cancer Registry has published an epidemiological case-control study on childhood cancer and nuclear power plants. This study was based on the distance of children's residences from nuclear power plants and addressed the question whether children under age 5 with cancer live closer, on average, to nuclear power plants than randomly selected controls. Odds Ratios (OR) for distance categories and standardized incidence ratios (SIR) were calculated. An association was found between the nearness of residence to nuclear power plants and the risk of leukemia (593 cases, 1766 controls). Within the 5-km zone, the OR for the development of leukemia in children under 5 years of age was 2.19 compared to the rest of the region, and this elevation of the OR was statistically significant. The incidence of leukemia in the overall study region was the same as that in Germany as a whole (SIR=0.99; 95% confidence interval 0.92-1.07).

Conclusion: Based on the available information about radiation emissions from German nuclear power plants, a direct relation to radiation seems implausible. Many factors may conceivably cause leukemia, possibly operating in combination, and these factors may be present to a greater extent in the vicinity of German nuclear power plants.

FETAL GROWTH AND RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA: RESULTS FROM AN AUSTRALIAN CASE-CONTROL STUDY.

Milne E, Royle JA, de Klerk NH, Blair E, Bailey H, Cole C, Attia J, Scott RJ, Armstrong BK.

Am J Epidemiol. 2009; 170(2):221-228.

The relation between intrauterine growth and risk of childhood acute lymphoblastic leukemia was investigated in an Australian population-based case-control study that included 347 cases and 762 controls aged <15 years recruited from 2003 to 2006. Information on proportion of optimal birth weight, a measure of the appropriateness of fetal growth, was collected from mothers by questionnaire. Data were analyzed by using logistic regression. Risk of acute lymphoblastic leukemia was positively associated with proportion of optimal birth weight; the odds ratio for a 1-standard-deviation increase in proportion of optimal birth weight was 1.18 (95% confidence interval: 1.04, 1.35) after adjustment for the matching variables and potential confounders. This association was also present among children who did not have a high birth weight, suggesting that accelerated growth, rather than high birth weight per se, is associated with risk of acute lymphoblastic leukemia. Similar associations between proportion of optimal birth weight and acute lymphoblastic leukemia were observed for both sexes and across age groups and leukemia subtypes.

Conclusion: Results of this study confirm earlier findings of a positive association between rapidity of fetal growth and subsequent risk of acute lymphoblastic leukemia in childhood, and they are consistent with a role for insulin-like growth factors in the causal pathway.

BIRTH WEIGHT AND CHILDHOOD CANCER.

Samuelsen SO, Bakketeig LS, Tretli S, Johannesen TB, Magnus P.
Epidemiology. 2009; 20(4):484-487.

Leukemia incidence in childhood has been shown to increase with birth weight. The purpose of this paper is to study whether the incidence of other childhood cancers also increases with birth weight. The Norwegian Medical Birth Registry was linked to the Norwegian Cancer Registry. The data consisted of 1.65 million children, of whom 3252 had a cancer diagnosis before age 16 years. The diagnoses were divided into 1010 leukemia cases, 870 cancer cases of the central nervous system (CNS), and 1370 remaining cancers. The increase in hazard rate for all cancers with a 1 kg increase in birth weight was 1.23 (95% confidence interval = 1.14-1.32) after adjustment. For leukemia the increase was 1.29 (1.14-1.47), for CNS cancers 1.07 (0.93-1.23), and for the remaining cancer diagnoses 1.29 (1.16-1.40). Conclusions: There seems to be a general relationship between heavier birth weight and cancer incidence in childhood.

MATERNAL IMMUNOGLOBULIN E AND CHILDHOOD LEUKEMIA.

Chang JS, Buffler PA, Metayer C, Chokkalingam AP, Patoka J, Kronish D, Wiemels JL.
Cancer Epidemiol Biomarkers Prev. 2009; 18(8):2221-2227.

Childhood leukemia, particularly acute lymphoblastic leukemia (ALL), has long been hypothesized to be affected by abnormal immune responses to microbial challenges stemming from a lack of immune modulation in early childhood. Studies of allergies suggest that a child's immune development may be modulated by maternal immune status. We conducted a study to explore the relationship between maternal immunoglobulin E (IgE) and childhood leukemia and to investigate whether maternal immune status can influence childhood leukemia risk. Serum total and specific IgE (respiratory and food) were measured in biological mothers of 352 children (193 healthy controls and 159 leukemia cases, including 139 ALL cases) ages <8 years who were enrolled in the Northern California Childhood Leukemia Study. Odds ratios associated with maternal IgE were calculated using unconditional logistic regression adjusted for child's age, sex, race/ethnicity, and annual household income. A positive association between childhood leukemia or ALL and elevated levels of maternal serum total IgE was observed, especially among Hispanics. In addition, a positive association was observed between childhood leukemia or ALL and maternal respiratory or food IgE status. These results suggest that maternal immune function may play a crucial role in the etiology of childhood leukemia, although additional studies need to be conducted to confirm the results of this study and provide a perspective on mechanisms.

MATERNAL DIET AND RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA.

Kwan ML, Jensen CD, Block G, Hudes ML, Chu LW, Buffler PA.
Public Health Rep. 2009; 124(4):503-514.

Intrauterine environmental factors, including maternal diet, may play an etiologic role in acute lymphoblastic leukemia (ALL), a common childhood cancer. Expanding on previous findings from phase 1 of the Northern California Childhood Leukemia Study (NCCLS), a population-based case-control study, we sought to further elucidate and replicate the relationships between maternal diet and ALL risk. The authors matched 282 case-control sets of children (205 pairs and 77 triplets) from phases 1 and 2 of the NCCLS on sex, date of birth, mother's race, Hispanic racial/ethnic status, and county of residence at birth. We used an interviewer-administered food frequency questionnaire to obtain information on maternal dietary

intake in the 12 months prior to pregnancy. Risk of ALL was inversely associated with maternal consumption of vegetable (adjusted odds ratio [AOR] = 0.65, 95% confidence interval [CI] 0.50, 0.84); protein sources (AOR = 0.55, 95% CI 0.32, 0.96); fruit (AOR = 0.81, 95% CI 0.65, 1.00); and legume food groups (AOR = 0.75, 95% CI 0.59, 0.95). The risk reduction was strongest for consumption of the protein sources and vegetable food groups, independent of the child's diet up to age 2 years, and consistent across phases 1 and 2 of data collection for vegetable consumption.

Conclusions: These data suggest that it may be prudent for women to consume a diet rich in vegetables and adequate in protein prior to and during pregnancy as a possible means of reducing childhood ALL risk in their offspring.

BREASTFEEDING AND EARLY INFECTION IN THE AETIOLOGY OF CHILDHOOD LEUKAEMIA IN DOWN SYNDROME.

Flores-Lujano J, Perez-Saldivar ML, Fuentes-Pananá EM, Gorodezky C, Bernaldez-Rios R, Del Campo-Martinez MA, Martinez-Avalos A, Medina-Sanson A, Paredes-Aguilera R, De Diego-Flores Chapa J, Bolea-Murga V, Rodriguez-Zepeda MC, Rivera-Luna R, Palomo-Colli MA, Romero-Guzman L, Perez-Vera P, Alvarado-Ibarra M, Salamanca-Gómez F, Fajardo-Gutierrez A, Mejía-Aranguré JM.

Br J Cancer. 2009 Sep 1;101(5):860-864.

For a child to develop acute leukaemia (AL), environmental exposure may not be sufficient: interaction with a susceptibility factor to the disease, such as Down syndrome (DS), may also be necessary. We assessed whether breastfeeding and early infection were associated with the risk of developing AL in children with DS. Children with DS in Mexico City, and either with or without AL, were the cases (N=57) and controls (N=218), respectively. Population was divided in children with AL and with acute lymphoblastic leukaemia (ALL) and also in children < or = 6 and >6 years old. Breastfeeding and early infections showed moderate (but not significant) association for AL, whereas hospitalisation by infection during the first year of life increased the risk: odds ratios (confidence interval 95%) were 0.84 (0.43-1.61), 1.70 (0.82-3.52); and 3.57 (1.59-8.05), respectively. A similar result was obtained when only ALL was analysed.

Conclusion: The authors found that breastfeeding was a protective factor for developing AL and ALL, and during the first year of life, infections requiring hospitalisation were related to a risk for developing the disease in those children with DS >6 years of age. These data do not support the Greaves's hypothesis of early infection being protective for developing ALL.