

Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2014

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1. Residential exposure

DISTANCE TO HIGH-VOLTAGE POWER LINES AND RISK OF CHILDHOOD LEUKEMIA - AN ANALYSIS OF CONFOUNDING BY AND INTERACTION WITH OTHER POTENTIAL RISK FACTORS.

Pedersen C, Bräuner EV, Rod NH, Albieri V, Andersen CE, Ulbak K, Hertel O, Johansen C, Schüz J, Raaschou-Nielsen O.

PLoS One. 2014; 9(9):e107096.

The authors investigated whether there is an interaction between distance from residence at birth to nearest power line and domestic radon and traffic-related air pollution, respectively, in relation to childhood leukemia risk. Further, they investigated whether adjusting for potential confounders alters the association between distance to nearest power line and childhood leukemia. They included 1024 cases aged <15, diagnosed with leukemia during 1968-1991, from the Danish Cancer Registry and 2048 controls randomly selected from the Danish childhood population and individually matched by gender and year of birth. Geographical information systems were used to determine the distance between residence at birth and the nearest 132-400 kV overhead power line. Concentrations of domestic radon and traffic-related air pollution (NO_x at the front door) were estimated using validated models.

A statistically significant interaction between distance to nearest power line and domestic radon regarding risk of childhood leukemia ($p = 0.01$) was found when using the median radon level as cut-off point but not when using the 75th percentile ($p = 0.90$). No evidence was found of an interaction between distance to nearest power line and traffic-related air pollution ($p = 0.73$). Almost no change in the estimated association between distance to power line and risk of childhood leukemia was found when adjusting for socioeconomic status of the municipality, urbanization, maternal age, birth order, domestic radon and traffic-related air pollution.

Conclusions: The statistically significant interaction between distance to nearest power line and domestic radon was based on few exposed cases and controls and sensitive to the choice of exposure categorization and might, therefore, be due to chance.

RESIDENTIAL PROXIMITY TO ELECTROMAGNETIC FIELD SOURCES AND BIRTH WEIGHT: MINIMIZING RESIDUAL CONFOUNDING USING MULTIPLE IMPUTATION AND PROPENSITY SCORE MATCHING.

de Vocht F, Lee B.

Environ Int. 2014; 69:51-57.

Studies have suggested that residential exposure to extremely low frequency (50 Hz) electromagnetic fields (ELF-EMF) from high voltage cables, overhead power lines, electricity substations or towers are associated with reduced birth weight and may be associated with adverse birth outcomes or even miscarriages. The authors previously conducted a study of 140,356 singleton live births between 2004 and 2008 in Northwest England, which suggested that close residential proximity (≤ 50 m) to ELF-EMF sources was associated with reduced average birth weight of 212 g (95%CI: -395 to -29 g) but not

with statistically significant increased risks for other adverse perinatal outcomes. However, the cohort was limited by missing data for most potentially confounding variables including maternal smoking during pregnancy, which was only available for a small subgroup, while also residual confounding could not be excluded. This study, using the same cohort, was conducted to minimize the effects of these problems using multiple imputation to address missing data and propensity score matching to minimize residual confounding. Missing data were imputed using multiple imputation using chained equations to generate five datasets. For each dataset 115 exposed women (residing \leq 50 m from a residential ELF-EMF source) were propensity score matched to 1150 unexposed women. After doubly robust confounder adjustment, close proximity to a residential ELF-EMF source remained associated with a reduction in birth weight of -116 g (95% confidence interval: -224:-7 g). No effect was found for proximity \leq 100 m compared to women living further away.

Conclusions: These results indicate that although the effect size was about half of the effect previously reported, close maternal residential proximity to sources of ELF-EMF remained associated with suboptimal fetal growth.

2. Occupational exposure

OCCUPATIONAL EXPOSURE TO EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS AND BRAIN TUMOR RISKS IN THE INTEROCC STUDY.

Turner MC, Benke G, Bowman JD, Figuerola J, Fleming S, Hours M, Kincl L, Krewski D, McLean D, Parent ME, Richardson L, Sadetzki S, Schlaefer K, Schlehofer B, Schüz J, Siemiatycki J, van Tongeren M, Cardis E.
Cancer Epidemiol Biomarkers Prev. 2014; 23(9):1863-1872.

Occupational exposure to extremely low-frequency magnetic fields (ELF) is a suspected risk factor for brain tumors, however the literature is inconsistent. Few studies have assessed whether ELF in different time windows of exposure may be associated with specific histologic types of brain tumors. This study examines the association between ELF and brain tumors in the large-scale INTEROCC study.

Cases of adult primary glioma and meningioma were recruited in seven countries (Australia, Canada, France, Germany, Israel, New Zealand, and the United Kingdom) between 2000 and 2004. Estimates of mean workday ELF exposure based on a job exposure matrix were assigned. Estimates of cumulative exposure, average exposure, maximum exposure, and exposure duration were calculated for the lifetime, and 1 to 4, 5 to 9, and 10+ years before the diagnosis/reference date. There were 3,761 included brain tumor cases (1,939 glioma and 1,822 meningioma) and 5,404 population controls. There was no association between lifetime cumulative ELF exposure and glioma or meningioma risk. However, there were positive associations between cumulative ELF 1 to 4 years before the diagnosis/reference date and glioma [odds ratio (OR) \geq 90th percentile vs. $<$ 25th percentile, 1.67; 95% confidence interval (CI), 1.36-2.07; PLinear trend $<$ 0.0001], and, somewhat weaker associations with meningioma (OR \geq 90th percentile vs. $<$ 25th percentile, 1.23; 95% CI, 0.97-1.57; PLinear trend = 0.02).

Conclusions: Results showed positive associations between ELF in the recent past and glioma. Occupational ELF exposure may play a role in the later stages (promotion and progression) of brain tumorigenesis.

NEURODEGENERATIVE DISEASE AND MAGNETIC FIELD EXPOSURE IN UK ELECTRICITY SUPPLY WORKERS.

Sorahan T, Mohammed N.

Occup Med. 2014; 64(6):454-460.

Previous research has suggested a possible link between neurodegenerative disease and exposure to extremely low-frequency electric and magnetic fields. The aim of this study was to investigate whether risks of Alzheimer's, motor neurone or Parkinson's disease are related to occupational exposure to magnetic fields.

The mortality experienced by a cohort of 73051 employees of the former Central Electricity Generating Board of England and Wales was investigated for the period 1973-2010. All employees were hired in the period 1952-82, were employed for at least 6 months and had some employment after 1 January 1973. Detailed calculations had been performed by others to enable an assessment to be made of exposures to magnetic fields. Poisson regression was used to calculate relative risks (rate ratios) of developing any of the three diseases under investigation for categories of lifetime, distant (lagged) and recent (lugged) exposure.

No statistically significant trends were shown for risks of any of these diseases to increase with estimates of lifetime, recent or distant exposure to magnetic fields.

Conclusions: There is no convincing evidence that UK electricity generation and transmission workers have suffered elevated risks from neurodegenerative diseases as a consequence of exposure to magnetic fields.

3. Human experiment

INFLUENCE OF ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS ON THE CIRCADIAN SYSTEM: CURRENT STAGE OF KNOWLEDGE.

Lewczuk B, Redlarski g, Zak A, Ziolkowska N, Przybylska-Gornowicz B, Krawczuk M.

Biomed Res Int. 2014:169459

The results of studies on the effects of electric, magnetic, and electromagnetic fields on melatonin and cortisol secretion as well as on sleep are largely contradictory. The adverse data related to the influence of these physical factors on secretion of both "circadian" hormones were obtained in all groups of investigations including the epidemiological studies, the studies on volunteers, and the studies on animals. Moreover, in vitro investigations on rodent pineals have also brought inconsistent results. The sources of discrepancies remain unknown; however such factors as an inappropriate estimation of exposure level, interferences with other factors like light and medication, differences in a phase of the circadian rhythm during exposure, and interindividual variability in the sensitivity to electromagnetic fields seem to be particularly worth of attention. The idea that some individuals are more sensitive to the electromagnetic field than others, due to genetic background or/and current health status, appears very attractive and should be a subject of further studies. It is worth to note that inconsistent results have been also obtained in the studies dealing with other effects of electrical, magnetic, and electromagnetic fields on organism, including their tumor-promoting action.

Conclusions: In light of the existing literature, the hypothesis pointing to the disruption of melatonin secretion, as one of the main factors responsible for cancerogenic effects of electrical, magnetic, or electromagnetic fields, is not supported by the

epidemiological and experimental data. Therefore, it should be currently considered as negatively verified.

ODOR AND NOISE INTOLERANCE IN PERSONS WITH SELF-REPORTED ELECTROMAGNETIC HYPERSENSITIVITY.

Nordin S, Neely G, Olsson D, Sandström M.

Int J Environ Res Public Health. 2014; 11(9):8794-8805.

Lack of confirmation of symptoms attributed to electromagnetic fields (EMF) and triggered by EMF exposure has highlighted the role of individual factors. Prior observations indicate intolerance to other types of environmental exposures among persons with electromagnetic hypersensitivity (EHS). This study assessed differences in odor and noise intolerance between persons with EHS and healthy controls by use of subscales and global measures of the Chemical Sensitivity Scale (CSS) and the Noise Sensitivity Scale (NSS). The EHS group scored significantly higher than the controls on all CSS and NSS scales. Correlation coefficients between CSS and NSS scores ranged from 0.60 to 0.65 across measures.

Conclusions: The findings suggest an association between EHS and odor and noise intolerance, encouraging further investigation of individual factors for understanding EMF-related symptoms.

4. Exposure assessment

CURRENT DENSITIES AND TOTAL CONTACT CURRENTS FOR 110 AND 220 KV POWER LINE TASKS.

Korpinen L, Kuisti H, Elovaara J.

Bioelectromagnetics. 2014; 35(7):531-535.

The aim of this study was to analyze all values of electric current from measured periods while performing tasks on 110 and 220 kV power lines. Additionally, the objective was to study the average current densities and average total contact currents caused by electric fields in 110 and 220 kV power line tasks. One worker simulated the following tasks: (A) tested insulation voltage at a 110 kV portal tower, (B) checked the wooden towers for rot at a 110 kV portal tower, (C) tested insulation voltage at a 220 kV portal tower, and (D) checked the wooden towers for rot at a 220 kV portal tower. The highest average current density in the neck was 2.0 mA/m² (calculated internal electric field was 19.0-38.0 mV/m), and the highest average contact current was 234 µA.

Conclusions: All measured values at 110 and 220 kV towers were lower than the basic restrictions (0.1 and 0.8 V/m) of the International Commission on Non-ionizing Radiation Protection.

CHARACTERIZATION OF INDOOR EXTREMELY LOW FREQUENCY AND LOW FREQUENCY ELECTROMAGNETIC FIELDS IN THE INMA-GRANADA COHORT.

Calvente I, Dávila-Arias C, Ocón-Hernández O, Pérez-Lobato R, Ramos R, Artacho-Cordón F, Olea N, Núñez MI, Fernández MF4.

PLoS One. 2014; 9(9):e106666.

The objective of the study was to characterize the exposure to electric fields and magnetic fields of non-ionizing radiation in the electromagnetic spectrum (15 Hz to 100 kHz) in the dwellings of children from the Spanish Environment and Childhood-"INMA" population-based birth cohort.

The study sample was drawn from the INMA-Granada cohort. Out of 300 boys participating in the 9-10 year follow-up, 123 families agreed to the exposure assessment at home and completed a specific ad hoc questionnaire gathering information on sources of non-ionizing radiation electric and magnetic fields inside the homes and on patterns of use. Long-term indoor measurements were carried out in the living room and bedroom.

Survey data showed a low exposure in the children's homes according to reference levels of the International Commission on Non-Ionizing Radiation Protection but with large differences among homes in mean and maximum values. Daytime electric and magnetic fields were below the quantification limit in 78.6% (92 dwellings) and 92.3% (108 dwellings) of houses, with an arithmetic mean value (\pm standard deviation) of 7.31 ± 9.32 V/m and 162.30 ± 91.16 nT, respectively. Mean magnetic field values were 1.6 lower during the night than the day. Nocturnal electric field values were not measured.

Conclusions: Exposure levels were influenced by the area of residence (higher values in urban/semi-urban versus rural areas), type of dwelling, age of dwelling, floor of the dwelling, and season.

5. Childhood leukaemia studies

EPIDEMIOLOGICAL EVIDENCE OF CHILDHOOD LEUKAEMIA AROUND NUCLEAR POWER PLANTS.

Janiak MK.

Dose Response. 2014; 12(3):349-364.

A few reports of increased numbers of leukaemia cases (clusters) in children living in the vicinity of nuclear power plants (NPP) and other nuclear installations have triggered a heated debate over the possible causes of the disease. In this review the most important cases of childhood leukaemia clusters around NPPs are described and analyzed with special emphasis on the relationship between the environmental exposure to ionizing radiation and the risk of leukaemia. Since, as indicated, a lifetime residency in the proximity of an NPP does not pose any specific health risk to people and the emitted ionizing radiation is too small to cause cancer, a number of hypotheses have been proposed to explain the childhood leukaemia clusters.

Conclusions: The most likely explanation for the clusters is 'population mixing', i.e., the influx of outside workers to rural regions where nuclear installations are being set up and where local people are not immune to pathogens brought along with the incomers.

POPULATION MIXING FOR LEUKAEMIA, LYMPHOMA AND CNS TUMOURS IN TEENAGERS AND YOUNG ADULTS IN ENGLAND, 1996-2005.

van Laar M, Stark DP, McKinney P, Parslow RC, Kinsey SE, Picton SV, Feltbower RG.

BMC Cancer. 2014; 14:698.

Little aetiological epidemiological research has been undertaken for major cancers occurring in teenagers and young adults (TYA). Population mixing, as a possible proxy for infectious exposure, has been well researched for childhood malignancies. The authors aimed to investigate effects of population mixing in this older age group using an English national cancer dataset.

Cases of leukaemia, lymphoma and central nervous system (CNS) tumours amongst 15-24 year olds in England (diagnosed 1996-2005) were included in the study. Data were obtained by ward of diagnosis and linked to 1991 census variables including population mixing (Shannon index); data on person-weighted population density and deprivation

(Townsend score) were also used and considered as explanatory variables. Associations between TYA cancer incidence and census variables were investigated using negative binomial regression, and results presented as incidence rate ratios (IRR) with 95% confidence intervals (CI).

A total of 6251 cases of leukaemia (21%), lymphoma (49%) and CNS tumours (30%) were analysed. Higher levels of population mixing were associated with a significant decrease in the incidence of CNS tumours (IRR = 0.83, 95% CI = 0.75-0.91), accounted for by astrocytomas and 'other CNS tumours'; however, there was no association with leukaemia or lymphoma. Incidence of CNS tumours and lymphoma was 3% lower in more deprived areas (IRR = 0.97, 95% CI = 0.96-0.99 and IRR = 0.97, 95% CI = 0.96-0.98 respectively). Population density was not associated with the incidence of leukaemia, lymphoma or CNS tumours.

Conclusions: These results suggest a possible role for environmental risk factors with population correlates in the aetiology of CNS tumours amongst TYAs. Unlike studies of childhood cancer, associations between population mixing and the incidence of leukaemia and lymphoma were not observed.

EXPOSURE TO INFECTIONS AND RISK OF LEUKEMIA IN YOUNG CHILDREN.

Marcotte EL, Ritz B, Cockburn M, Yu F, Heck JE.

Cancer Epidemiol Biomarkers Prev. 2014; 23(7):1195-1203.

Epidemiologic studies indicate that infections in early childhood may protect against pediatric acute lymphoblastic leukaemia (ALL).

3,402 ALL cases were identified among children 0 to 5 years of age using the California Cancer Registry. From California birth records the authors randomly selected controls in a 20:1 ratio and frequency matched them to cases by birth year. They investigated markers of exposure to infections, including month of birth, timing of birth in relation to influenza and respiratory syncytial virus (RSV) seasons, and birth order based on data from California birth certificates and national infection surveillance systems.

An increased risk of ALL was observed for spring and summer births, and for those first exposed to an influenza or RSV season at nine to twelve months of age compared with those exposed during the first three months of life, and this association was stronger among first born children [odds ratios (OR), 1.44 and 95% confidence intervals (CI), 1.13-1.82, for influenza exposure at nine to twelve months of age]. Decreased risk was observed with increasing birth order among non-Hispanic whites but not Hispanics (OR, 0.76 and 95% CI, 0.59-0.96, for fourth or higher birth order among whites).

Conclusion: These results support the hypothesis that infections in early childhood decrease risk of ALL. The findings implicate early life exposure to infections as protective factors for ALL in young children.

RISK OF LEUKEMIA IN RELATION TO EXPOSURE TO AMBIENT AIR TOXICS IN PREGNANCY AND EARLY CHILDHOOD.

Heck JE, Park AS, Qiu J, Cockburn M, Ritz B.

Int J Hyg Environ Health. 2014; 217(6):662-668.

There are few established causes of leukemia, the most common type of cancer in children. Studies in adults suggest a role for specific environmental agents, but little is known about any effect from exposures in pregnancy to toxics in ambient air. In this case-control study, 69 cases of acute lymphoblastic leukemia (ALL) and 46 cases of acute myeloid leukemia (AML) were ascertained from California Cancer Registry records

of children <age 6, and 19,209 controls from California birth records within 2 km (1.3 miles) (ALL) and 6 km (3.8 miles) (AML) of an air toxics monitoring station between 1990 and 2007. Information on air toxics exposures was taken from community air monitors. A logistic regression was used to estimate the risk of leukemia associated with one interquartile range increase in air toxic exposure. Risk of ALL was elevated with 3(rd) trimester exposure to polycyclic aromatic hydrocarbons (OR=1.16, 95% CI 1.04, 1.29), arsenic (OR=1.33, 95% CI 1.02, 1.73), benzene (OR=1.50, 95% CI 1.08, 2.09), and three other toxics related to fuel combustion. Risk of AML was increased with 3rd trimester exposure to chloroform (OR=1.30, 95% CI 1.00, 1.69), benzene (1.75, 95% CI 1.04, 2.93), and two other traffic-related toxics. During the child's first year, exposure to butadiene, ortho-xylene, and toluene increased risk for AML and exposure to selenium increased risk for ALL.

Conclusions: Benzene is an established cause of leukemia in adults; this study supports that ambient exposures to this and other chemicals in pregnancy and early life may also increase leukemia risk in children.

POLYCYCLIC AROMATIC HYDROCARBONS IN RESIDENTIAL DUST AND RISK OF CHILDHOOD ACUTE LYMPHOBLASTIC LEUKEMIA.

Deziel NC, Rull RP, Colt JS, Reynolds P, Whitehead TP, Gunier RB, Month SR, Taggart DR, Buffler P, Ward MH, Metayer C.

Environ Res. 2014; 133:388-395.

Several polycyclic aromatic hydrocarbons (PAHs) are known or probable human carcinogens. The authors evaluated the relationship between PAH exposure and risk of childhood acute lymphoblastic leukemia (ALL) using concentrations in residential dust as an exposure indicator. They conducted a population-based case-control study (251 ALL cases, 306 birth-certificate controls) in Northern and Central California from 2001 to 2007. Residential dust was collected using a high volume small surface sampler (HVS3) (n=185 cases, 212 controls) or by sampling from participants' household vacuum cleaners (n=66 cases, 94 controls). The authors evaluated log-transformed concentrations of 9 individual PAHs, the summed PAHs, and the summed PAHs weighted by their carcinogenic potency (the toxic equivalence). They calculated odds ratios (ORs) and 95% confidence intervals (CI) using logistic regression adjusting for demographic characteristics and duration between diagnosis/reference date and dust collection. Among participants with HVS3 dust, risk of ALL was not associated with increasing concentration of any PAHs based on OR per ln(ng/g). Among participants with vacuum dust, positive associations were observed between ALL risk and increasing concentrations of benzo[a]pyrene (OR per ln[ng/g]=1.42, 95% CI=0.95, 2.12), dibenzo[a,h]anthracene (OR=1.98, 95% CI=1.11, 3.55), benzo[k]fluoranthene (OR=1.71, 95% CI=0.91, 3.22), indeno[1,2,3-cd]pyrene (OR=1.81, 95% CI=1.04, 3.16), and the toxic equivalence (OR=2.35, 95% CI=1.18, 4.69).

Conclusions: The increased ALL risk among participants with vacuum dust suggests that PAH exposure may increase the risk of childhood ALL; however, reasons for the different results based on HVS3 dust samples deserve further study.