

Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the first trimester of 2021.

Dr. Maurits De Ridder and dr. Els de Waegeneer
Public Health Department
Ghent University

1. Reviews

Occupational Exposure to Extremely Low-Frequency Magnetic Fields and Risk of Amyotrophic Lateral Sclerosis: Results of a Feasibility Study for a Pooled Analysis of Original Data. Dan Baaken, Dagmar Dechent, Maria Blettner, Sarah Drießen, Hiltrud Merzenich. *Bioelectromagnetics*. 2021 Mar 25.

Previous meta-analyses have suggested an increased risk of amyotrophic lateral sclerosis (ALS) associated with occupational exposure to extremely low-frequency magnetic fields (ELF-MF). However, results should be interpreted with caution since studies were methodologically heterogeneous. Here, the authors assessed the feasibility of a pooling study to harmonize and re-analyze available original data. A systematic literature search was conducted. Published epidemiological studies were identified in PubMed and EMF-Portal from literature databases' inception dates until January 2019. The characteristics of all studies were described, including exposure metrics, exposure categories, and confounders. A survey among the principal investigators (PI) was carried out to assess their willingness to provide their original data. The statistical power of a pooling study was evaluated. 15 articles published between 1997 and 2019 were identified. Studies differed in terms of outcome, study population, exposure assessment, and exposure metrics. Most studies assessed ELF-MF as average magnetic flux density per working day; however, exposure categories varied widely. The pattern of adjustment for confounders was heterogeneous between studies, with age, sex, and socioeconomic status being most frequent. Eight PI expressed their willingness to provide original data.

Conclusions: A relative risk of ≥ 1.14 for ALS and occupational exposure to ELF-MF can be detected with a power of more than 80% in a pooled study. The pooling of original data is recommended and could contribute to a better understanding of ELF-MF in the etiology of ALS based on a large database and reduced heterogeneity due to a standardized analysis protocol with harmonized exposure metrics and exposure categories.

The role of magnetic fields in neurodegenerative diseases. Riancho J, Sanchez de la Torre JR, Paz-Fajardo L, Limia C, Santurtun A, Cifra M, Kourtidis K, Fdez-Arroyabe P. *Int J Biometeorol*. 2021 Jan;65(1):107-117.

The term neurodegenerative diseases include a long list of diseases affecting the nervous system that are characterized by the degeneration of different neurological structures. Among them, Alzheimer disease (AD), Parkinson disease (PD), and amyotrophic lateral sclerosis (ALS) are the most representative ones. The vast majority of cases are sporadic and results from the interaction of genes and environmental factors in genetically predisposed individuals. Among environmental conditions, electromagnetic field exposure has begun to be assessed as a potential risk factor for neurodegeneration. In this review, the authors discuss the existing literature regarding

electromagnetic fields and neurodegenerative diseases. Epidemiological studies in AD, PD, and ALS have shown discordant results. In addition, the authors discuss the role of electromagnetic radiation as a potential non-invasive therapeutic strategy for some neurodegenerative diseases, particularly for PD and AD.

Conclusions: A clear correlation between electromagnetic exposure and neurodegeneration has not been demonstrated.

2. Residential exposure

A cohort study on adult hematological malignancies and brain tumors in relation to magnetic fields from indoor transformer stations. Khan MW, Juutilainen J, Auvinen A, Naarala J, Pukkala E, Roivainen P. *Int J Hyg Environ Health.* 2021 Feb 15;233:113712.

Extremely low frequency (ELF) magnetic fields (MF) have been classified as possibly carcinogenic. This classification was mainly based on studies indicating increased risk of leukemia in children living near power lines. Increased risks of adult hematological malignancies and brain tumors have also been reported, but the results are mixed. The authors assessed incidence of adult hematological malignancies and brain tumors associated with residential MF exposure. All cohort members had lived in buildings with indoor transformer stations (TS). MF exposure was assessed based on apartment location. Out of the 256,372 individuals, 9,636 (165,000 person-years of follow-up) living in apartments next to TSs were considered as exposed. Associations between MF exposure and neoplasms were examined using Cox proportional hazard models. The hazard ratio (HR) for MF exposure ≥ 1 month was below one for most hematological neoplasms (HR for any hematological neoplasm: 0.75; 95% CI: 0.54-1.03), and decreased with increasing duration of exposure (HR for exposure ≥ 10 years: 0.47; 95% CI: 0.22-0.99). However, the HR for acute lymphocytic leukemia (ALL) was 2.86 (95% CI: 1.00-8.15), based on 4 exposed cases; the risk increased with duration of exposure (HR for exposure ≥ 3 years: 3.61; 95% CI: 1.05-12.4) and was particularly associated with childhood exposure (2 exposed cases, HR for exposure during the first two years of life: 11.5; 95% CI: 1.92-68.9). The HR for meningioma was 0.46 (95% CI: 0.19-1.11), with no evidence of exposure-response gradient with increasing duration of exposure. The HR for glioma was 1.47 (95% CI: 0.84-2.57).

Conclusions: The hypothesis of a positive association between ELF MFs and adult hematological malignancies was supported only for ALL. The results suggested decreased rather than increased risk of most hematological neoplasms.

3. Occupational exposure

Assessment of sexual hormones in foundry workers exposed to heat stress and electromagnetic fields. Mohammadi H, Dehghan SF, Moradi N, Suri S, Pirposhteh EA, Ardakani SK, Golbabaie F. *Reprod Toxicol.* 2021 Feb 11:S0890-6238(20)30289-6.

The presence of hazardous agents in workplaces has raised concerns regarding their possible impacts on male reproductive system. The present study investigated the individual and combined effects of exposure to heat stress and electromagnetic fields with low-frequency characteristics on the levels of sex hormones in two foundry sections (Aluminum and Cast Iron) of an automobile parts

manufacturing plant. The level of workers' exposure (n = 110) to each of the mentioned stressors, was measured through standard methods and for each person and the time-weighted average (TWA) of exposure was calculated. The participants of each sections were classified into separate exposure groups based on the 33rd and 66th percentile of the level of to heat stress and electromagnetic fields exposure. In order to determine serum sex hormones, blood samples were taken from all participants between 7-9 am and then the blood samples were analyzed by ELISA method. In total of two sections, the lowest mean testosterone levels was observed in the third exposure group of the electromagnetic fields (magnetic field >1.40 μ T; electric field >0.42 V/m), however, the mean difference in testosterone levels between the three different groups of exposure wasn't statistically significant (P > 0.05). According to the results of Logistic Regression, the electric field had the greatest effect on testosterone levels as the main male hormone.

Conclusions: Drawing a definitive conclusion regarding the effects of each harmful physical hazards is difficult due to the existence of psychological stressors and other environmental stressors such as chemical pollution, ergonomic hazards and other physical stressors.

Heart Rate Variability and Magnetic Field Exposure Among Train Engine Drivers-A Pilot Study. Kjell Hansson Mild, Roland Bergling, Rolf Hörnsten.
Bioelectromagnetics. 2021 Apr;42(3):259-264.

Several studies have shown that magnetic field exposure can affect heart rate (HR) and heart rate variability (HRV). In this pilot study, the authors studied HRV in a group of seven male train engine drivers, occupationally exposed to an intense magnetic field over one working day. They wanted to see how the HRV was affected with simultaneous magnetic field measurement and ECG recording during 1 day.

Conclusion: The pilot study has not been able to show that HRV among locomotive drivers is affected by the magnetic field during ongoing driving of locomotive. During the day, the control group has a slightly higher HR, which is probably due to the fact that they have a lower average age and have light industrial work and move physically, unlike the train driver work, which is sedentary. As this is a pilot study, the low number of participants is a major limitation.

4. Human experimental studies

None

5. Exposure assessment

None

6. Leukaemia studies

Maternal pesticide exposure and its relation to childhood cancer: an umbrella review of meta-analyses. Iqbal S, Ali S, Ali I. *Int J Environ Health Res.* 2021 Mar 22:1-19.

This umbrella review summarizes the available meta-analyses elucidating the effects of maternal pesticide exposure on adverse health outcomes in children particularly the risk of childhood cancer. A literature search was conducted on PubMed and Scopus with 10-years temporal restriction and with search terms of ('pesticides') and ('maternal' or 'pregnancy' or 'gestational' or 'perinatal' or 'children' or 'infants' or 'birth weight' or 'gestational age' or 'cancer' or 'tumor' or 'malignancy' or 'carcinoma') and ('meta-analysis' or 'systematic review'). Using relative risk estimates, e.g., odds ratio (OR), relative risk (RR), β coefficients, and 95% confidence interval (CI) as a prerequisite for inclusion/exclusion criteria a total of 19 eligible meta-analyses were included. The results showed that maternal domestic/occupational pesticide exposure increases the risk for childhood leukaemia. The overall OR regarding the risk of pesticide exposure and leukaemia was 1.23 to 1.57 with heterogeneity I² values that varied between 12.9% and 73%. Some studies found that exposure to dichlorodipenyldichloroethylene (p,p'-DDE) and polychlorinated biphenyls (PCB-153) pesticides appears to decrease infant birth weight to some extent [p,p'-DDE ($\beta = -0.007$ to -0.008)] and [PCB-153 ($\beta = -0.15$ to -0.17)].

Conclusions: Needing more studies on this relationship, this study found that pesticide exposure is a risk factor for leukaemia in children.

Childhood leukemia near nuclear sites in Belgium: An ecological study at small geographical level. Claire Demoury, Christel Faes, Harlinde De Schutter, Sylviane Carbonnelle, Michael Rosskamp, Julie Francart, Nancy Van Damme, Lodewijk Van Bladel, An Van Nieuwenhuysse, Eva M De Clercq. *Cancer Epidemiol.* 2021 Mar 15;72:101910.

A previous investigation of the occurrence of childhood acute leukemia around the Belgian nuclear sites has shown positive associations around one nuclear site (Mol-Dessel). In the following years, the Belgian Cancer Registry has made data available at the smallest administrative unit for which demographic information exists in Belgium, i.e. the statistical sector. This offers the advantage to reduce the potential misclassification due to large geographical scales. The current study performed for the period 2006-2016 uses Poisson models to investigate (i) the incidence of childhood acute leukemia within 20 km around the four Belgian nuclear sites, (ii) exposure-response relationships between cancer incidence and surrogate exposures from the nuclear sites (distance, wind direction frequency and exposure by hypothetical radioactive discharges taking into account historical meteorological conditions). All analyses are carried out at statistical sector level. Higher incidence rate ratios were found for children <15 years (7 cases, RR = 3.01, 95% CI: 1.43;6.35) and children <5 years (< 5 cases, RR = 3.62, 95% CI: 1.35;9.74) living less than 5 km from the site of Mol-Dessel. In addition, there was an indication for positive exposure-response relationships with the different types of surrogate exposures.

Conclusions: Results confirm an increased incidence of acute childhood leukemia around Mol-Dessel, but the number of cases remains very small. Random variation cannot be excluded and the ecological design does not allow concluding on causality. These findings emphasize the need for more in-depth

research into the risk factors of childhood leukemia, for a better understanding of the etiology of this disease.

Early life ionizing radiation exposure and cancer risks: systematic review and meta-analysis. Abalo KD, Rage E, Leuraud K, Richardson DB, Le Pointe HD, Laurier D, Bernier MO. *Pediatr Radiol.* 2021 Jan;51(1):45-56.

Ionizing radiation use for medical diagnostic purposes has substantially increased over the last three decades. Moderate to high doses of radiation are well established causes of cancer, especially for exposure at young ages. However, cancer risk from low-dose medical imaging is debated. The objectives of this study are to review the literature on cancer risks associated with prenatal and postnatal medical diagnostic ionizing radiation exposure among children and to assess this risk through a meta-analysis. A literature search of five electronic databases supplemented by a hand search was performed to retrieve relevant epidemiological studies published from 2000 to 2019, including patients younger than 22 years of age exposed to medical imaging ionizing radiation. Pooled odds ratio (OR_{pooled}) and pooled excess relative risk (ERR_{pooled}) representing the excess of risk per unit of organ dose were estimated with a random effect model. Twenty-four studies were included. For prenatal exposure (radiographs or CT), no significant increased risk was reported for all cancers, leukemia and brain tumors. For postnatal exposure, increased risk was observed only for CT, mostly for leukemia (ERR_{pooled}=26.9 Gy⁻¹; 95% confidence interval [CI]: 2.7-57.1) and brain tumors (ERR_{pooled}=9.1 Gy⁻¹; 95% CI: 5.2-13.1).

Conclusions: CT exposure in childhood appears to be associated with increased risk of cancer while no significant association was observed with diagnostic radiographs.

Maternal diabetes and risk of childhood malignancies in the offspring: a systematic review and meta-analysis of observational studies. Yan P, Wang Y, Yu X, Liu Y, Zhang ZJ. *Acta Diabetol.* 2021 Feb;58(2):153-168.

Diabetes mellitus (DM) is widely recognized as a risk factor for diverse cancers in adults. However, the association between maternal diabetes and risk of childhood cancer in the offspring has so far not been well studied. The authors conducted a meta-analysis to evaluate the role of maternal diabetes on the risk of childhood cancer. They performed a comprehensive literature search to identify eligible studies published up to June 20, 2020, including the PubMed, Web of science and Embase databases. Summary odds ratios (OR) and 95% confidence intervals (CI) were computed using a random-effects model ($I^2 \geq 25\%$) or a fixed-effect model ($I^2 < 25\%$). Totally, sixteen case-control and six cohort studies on the risk of childhood cancer associated with maternal diabetes were included. Overall, children of diabetic women had a significantly increased risk in childhood malignancy (OR, 1.30; 95% CI, 1.10-1.53). Notably, a significantly elevated risk of childhood cancer in the offspring was found for women with pre-existing diabetes (OR, 1.41; 95% CI, 1.17-1.70), but not for women with gestational diabetes mellitus (GDM) (OR, 1.10; 95% CI, 0.94-1.28). For site-specific cancers, maternal diabetes was associated with a higher risk of leukemia in offspring (OR, 1.30; 95% CI, 1.15-1.48), especially for acute lymphoblastic leukemia (OR, 1.44; 95% CI, 1.27-1.64). However, no significant associations were observed between maternal diabetes and the risk of lymphomas and retinoblastoma.

Conclusions: This meta-analysis indicates that maternal diabetes is associated with an increased risk of childhood cancer in the offspring, particularly for acute lymphoblastic leukemia. Future study should investigate the underlying biological mechanisms behind the association.