

# Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the fourth trimester of 2020.

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## 1. Reviews

None

## 2. Residential exposure

### **Association of personal exposure to power-frequency magnetic fields with pregnancy outcomes among women seeking fertility treatment in a longitudinal cohort study.**

Mary E Ingle, Lidia Mínguez-Alarcón, Ryan C Lewis, Paige L Williams, Jennifer B Ford, Ramace Dadd, Russ Hauser, John D Meeker, EARTH Study Team. *Fertil Steril* 2020 Oct 6;S0015-0282(20)30535-5.

The objective of the study was to assess for the first time the potential relationships of personal exposure to magnetic fields (MF) with pregnancy outcomes among a cohort of women from a fertility clinic, addressing, through study design (longitudinal preconception prospective cohort), some of the primary limitations of previous studies on this topic. The analysis included 119 women recruited from 2012 to 2018, who underwent in vitro fertilization (IVF) (n = 163 cycles) and/or intrauterine insemination (IUI) (n = 123 cycles). Women wore personal exposure monitors continuously for up to three consecutive 24-hour time periods separated by several weeks. The median and maximum of the overall daily mean (daily peak) MF exposure levels were 1.10 mG (2.14 mG) and 15.54 mG (58.73 mG), respectively. MF exposure metrics were highest among women who changed environments four or more times per day. Overall, no statistically significant associations between MF exposure metrics and fertility treatment or pregnancy outcomes were observed in crude or adjusted models. Effect estimates, both positive and negative, varied by outcome and the exposure metric, including the way in which exposure was modeled.

Conclusions: Personal MF exposures were not associated with fertility treatment outcomes or pregnancy outcomes. Despite its limited size, strengths of the study include a longitudinal repeated-measures design, the collection of personal MF exposure data across multiple days, and carefully documented outcome and covariate information among a potentially susceptible study population.

### **3. Occupational exposure**

**Occupational Exposure to Electric Shocks and Extremely Low-Frequency Magnetic Fields and Motor Neurone Disease.** Grace X Chen, Andrea't Mannetje, Jeroen Douwes, Leonard H Berg, Neil Pearce, Hans Kromhout, Bill Glass, Naomi Brewer, Dave J McLean. *Am J Epidemiol.* 2020 Oct 9;kwaa214.

In a New Zealand population-based case-control study the authors assessed associations with occupational exposure to electric shocks, extremely low-frequency magnetic fields (ELF-MF) and motor neurone disease using job-exposure matrices to assess exposure. Participants were recruited between 2013 and 2016. Associations with ever/never, duration, and cumulative exposure were assessed using logistic regression adjusted for age, sex, ethnicity, socioeconomic status, education, smoking, alcohol consumption, sports, head or spine injury and solvents, and mutually adjusted for the other exposure. All analyses were repeated stratified by sex. An elevated risk was observed for having ever worked in a job with potential for electric shocks (odds ratio (OR)=1.35, 95% confidence interval (CI): 0.98, 1.86), with the strongest association for the highest level of exposure (OR=2.01, 95%CI: 1.31, 3.09). Analysis by duration suggested a non-linear association: risk was increased for both short-duration (<3 years) (OR= 4.69, 95%CI: 2.25, 9.77) and long-duration in a job with high level of electric shock exposure (>24 years; OR=1.88; 95%CI: 1.05, 3.36), with less pronounced associations for intermediate durations. No association with ELF-MF was found.

Conclusions: These findings provide support for an association between occupational exposure to electric shocks and motor neurone disease but did not show associations with exposure to work-related ELF-MF.

**Relationship between exposure to Extremely Low-Frequency (ELF) magnetic field and the level of some reproductive hormones among power plant workers.** Sheari Suri, Somayeh F Dehghan, Ali S Sahlabadi, Soheila K Ardakani, Nariman Moradi, Maryam Rahmati, Fahimeh R Tehrani. *J Occup Health.* 2020 Jan;62(1):e12173.

The purpose of this study was to investigate the relationship between exposure to ELF magnetic field and the level of some reproductive hormones in male power plant workers. The present cross-sectional study was carried out among all male employees of different units of the selected power plant around Tehran, Iran. All participants were asked to complete demographic data sheets and General Health questionnaire, on condition of consent and meeting the inclusion criteria. Time-weighted average (TWA) exposure to magnetic field of 122 men was measured by IEEE Std C95.3.1 method using TES 1393 Gauss meter. Based on the exposure level, subjects were divided into three groups. Serum Levels of Free Testosterone, Luteinizing Hormone (LH), and Follicle stimulating hormone (FSH) in participants were determined. Data analysis was performed using ANOVA, Kruskal-Wallis tests, and the relationships between variables were assessed by linear regression and correlation using SPSS v.25 software. There was no significant statistical correlation between the level of ELF exposure and serum levels of free testosterone, LH, and FSH, ( $r = 0.158$ ). Serum levels of LH decreased significantly with age and duration of work experience ( $P < .05$ ,  $r = -.25$ ,  $P = .005$ ,  $r = -.203$ ,  $P = .025$ ).

Conclusions: There was no relationship between exposure to magnetic field in power plants and reproductive hormone levels.

#### **4. Human experimental studies**

##### **The Short-Term Effect of Occupational Levels of 50 Hz Electromagnetic Field on Human Heart Rate Variability.** Erdal Binboğa, Serdar Tok, Mustafa Munzuroğlu.

*Bioelectromagnetics. 2020 Nov 19.*

Previous studies have indicated that there is no consensus on the effects of extremely low-frequency electromagnetic (ELF-EMF) exposure on the cardiovascular system. This study aimed to explore the short-term effect of ELF-EMF exposure on heart rate (HR) and HR variability (HRV). The sample consisted of 34 healthy males aged 18-27 years. The participants were randomly assigned to the EMF (n = 17) or the Sham group (n = 17). A double-blind repeated-measures design consisting of three 5 min experimental periods was employed. The chest region of each individual in the EMF group was exposed to 50 Hz, 28  $\mu$ T, linear polarized, continuous EMF during the EMF exposure period. HR and HRV data were recorded continuously by using a photoplethysmography sensor. Within-subject statistical analysis indicated a significant HR deceleration in both the EMF and Sham groups. However, the standard deviation of the NN intervals (SDNN), root mean square of successive differences (RMSSD), low-frequency (LF), and high-frequency (HF) powers increased only in the EMF group and remained stable in the Sham group. The authors also compared the same HRV indices measured during the EMF and Sham periods between the two experimental groups. The between-subject analysis results demonstrated significantly higher SDNN, RMSSD, LF, and HF values in the EMF group than in the Sham group. The LF/HF ratio did not change significantly within and between groups.

Conclusions: On the basis of these results, the authors concluded that short-term exposure of the chest region to ELF-EMF could potentially enhance parasympathetic predominance during the resting condition.

#### **5. Exposure assessment**

##### **Safety Assessment of Electromagnetic Exposure in High-Speed Train Carriage with Full Passengers.** Rui Tian, Mai Lu. *Ann Work Expo Health. 2020 Oct 8;64(8):838-851.*

The objective of this work is to evaluate the safety of the electromagnetic environment in the carriage of high-speed trains exposed to power cables when the train is full of passengers. The electromagnetic model of a real carriage, two sets of power cables and the 84 passengers were set up by using COMSOL Multiphysics software based on CRH5. The distributions of induced electric and magnetic fields in the carriage, inside and on the surface of passengers were investigated. The results show that the induced electric and magnetic fields on the windows are greater than on the passengers and the max value of induced magnetic field is 2627.10  $\mu$ T, and the max value of induced electric field is 20 kV/m. The maximum values of the induced electric and magnetic fields in 84 passengers' brain tissues were obtained, and it was found that the maximum values occurred in the third row passengers. The distribution of induced electric and magnetic fields at the cross-section of passengers' heads in the third row was also obtained, and the authors found that the passengers at the window side were greater than those of aisle passengers. In the third row, the maximum values of the induced electric and magnetic fields in the head of two passengers near the window were 94.6 mV/m, 90.9  $\mu$ T, 96.3 mV/m, and 90.4  $\mu$ T, respectively.

Conclusions: All the all data were below the ICNIRP Reference Levels, which indicates the electromagnetic exposure caused by power cables when the train is full of passengers will not threat passengers' health.

**Exposure To Extremely Low-Frequency Magnetic Fields In Low- And Middle-Income Countries: An Overview.** Dan Baaken, Daniel Wollschläger, Theodoros Samaras, Joachim Schüz, Isabelle Deltour. *Radiat Prot Dosimetry*. 2020 Nov 24;*ncaa172*.

To compare extremely low-frequency magnetic field (ELF-MF) exposure in the general population in low- and middle-income countries (LMICs) with high-income countries (HIC), a systematic literature search resulting in 1483 potentially eligible articles was carried out; however, only 25 studies could be included in the qualitative synthesis. Studies showed large heterogeneity in design, exposure environment and exposure assessment. Exposure assessed by outdoor spot measurements ranged from 0.03 to 4 $\mu$ T. Average exposure by indoor spot measurements in homes ranged from 0.02 to 0.4 $\mu$ T. Proportions of homes exposed to a threshold of  $\geq 0.3\mu$ T were many times higher in LMICs compared to HIC.

Conclusions: Based on the limited data available, exposure to ELF-MF in LMICs appeared higher than in HIC, but a direct comparison is hampered by a lack of representative and systematic monitoring studies. Representative measurement studies on residential exposure to ELF-MF are needed in LMICs together with better standardisation in the reporting.

## **6. Leukaemia studies**

**Infections and the development of childhood acute lymphoblastic leukemia: a population-based study.** Jeremiah Hwee, Rinku Sutradhar, Jeffrey C Kwong, Lillian Sung, Stephanie Cheng, Jason D Pole. *Eur J Cancer Prev*. 2020 Nov;*29(6):538-545*.

An infectious trigger for childhood acute lymphoblastic leukemia is hypothesized. The authors assessed the association between the rate, type, and critical exposure period for infections and the development of acute lymphoblastic leukemia. They conducted a matched case-control study using administrative databases to evaluate the association between the rate of infections and childhood acute lymphoblastic leukemia diagnosed between the ages of 2-14 years from Ontario, Canada, and using a validated approach to measure infections. In 1600 cases of acute lymphoblastic leukemia, and 16 000 matched cancer-free controls aged 2-14 years, having  $>2$  infections/year increased the odds of childhood acute lymphoblastic leukemia by 43% (odds ratio = 1.43, 95% confidence interval 1.13-1.81) compared to children with  $\leq 0.25$  infections/year. Having  $>2$  respiratory infections/year increased odds of acute lymphoblastic leukemia by 28% (odds ratio =1.28, 95% confidence interval 1.05-1.57) compared to children with  $\leq 0.25$  respiratory infections/year. Having an invasive infection increased the odds of acute lymphoblastic leukemia by 72% (odds ratio =1.72, 95% confidence interval 1.31-2.26). Having an infection between the age of 1-1.5 years increased the odds of acute lymphoblastic leukemia by 20% (odds ratio = 1.20, 95% confidence interval 1.04-1.39).

Conclusions: Having more infections increased the odds of developing childhood acute lymphoblastic leukemia and having an infection between the ages of 1-1.5 years increased the odds of childhood acute lymphoblastic leukemia.

**History of Early Childhood Infections and Acute Lymphoblastic Leukemia Risk Among Children in a US Integrated Health-Care System.** Libby M Morimoto, Marilyn L Kwan, Kamala Deosaransingh, Julie R Munneke, Alice Y Kang, Charles Quesenberry, Scott Kogan, Adam J de Smith, Catherine Metayer, Joseph L Wiemels. *Am J Epidemiol.* 2020 Oct 1;189(10):1076-1085.

Surrogate measures of infectious exposures have been consistently associated with lower childhood acute lymphoblastic leukemia (ALL) risk. However, recent reports have suggested that physician-diagnosed early-life infections increase ALL risk, thereby raising the possibility that stronger responses to infections might promote risk. The authors examined whether medically diagnosed infections were related to childhood ALL risk in an integrated health-care system in the United States. Cases of ALL (n = 435) diagnosed between 1994-2014 among children aged 0-14 years, along with matched controls (n = 2,170), were identified at Kaiser Permanente Northern California. Conditional logistic regression was used to estimate risk of ALL associated with history of infections during first year of life and across the lifetime (up to diagnosis).

Conclusions: History of infection during first year of life was not associated with ALL risk (odds ratio (OR) = 0.85, 95% confidence interval (CI): 0.60, 1.21). However, infections with at least 1 medication prescribed (i.e., more "severe" infections) were inversely associated with risk (OR = 0.42, 95% CI: 0.20, 0.88). Similar associations were observed when the exposure window was expanded to include medication-prescribed infections throughout the subjects' lifetime (OR = 0.52, 95% CI: 0.32, 0.85).

**Cesarean section and risk of childhood leukemia: a systematic review and meta-analysis.** Li-Li Jiang, Yin-Yan Gao, Wen-Bo He, Ting Gan, Hou-Qian Shan, Xue-Mei Han. *World J Pediatr.* 2020 Oct;16(5):471-479.

A large number of studies pointed that being delivered by cesarean section (CS) would affect the health outcomes of offspring, however, whether CS would affect the risk of childhood leukemia remained uncertain. This study conducted a meta-analysis to quantitatively evaluate whether being delivered by CS would influence the onset of childhood leukemia. PubMed, Embase and Web of Science databases were searched from 3rd June, 1950 to 13th October, 2019 to identify the literature, which examined the relationship between CS and childhood leukemia. This study used Newcastle-Ottawa Scale to assess the quality of literature. Subgroup analyses were conducted on region, mode of delivery, design of the study and number of confounders adjusted. Egger's test and Begg's test were performed to evaluate possible publication bias. The pooled odds ratio (OR) estimates illustrated that children delivered by CS had a higher risk of developing leukemia [OR 1.10, 95% confidence interval (CI) 1.04-1.17, P = 0.002] and lymphoblastic leukemia (OR 1.12, 95% CI 1.03-1.23, P = 0.009), while a significant association for myeloid leukemia was not observed (OR 1.05, 95% CI 0.92-1.20, P = 0.451). Results of subgroup analyses indicated that elective CS would increase the risk of childhood lymphoblastic leukemia (OR 1.16, 95% CI 1.06-1.27, P = 0.002). However, a statistical relationship between emergency CS and lymphoblastic leukemia was not observed (OR 1.07, 95% CI 0.93-1.23, P = 0.364).

Conclusions: Cesarean section would increase the risk of childhood lymphoblastic leukemia. It is worth noting that subgroup analyses shows that elective Cesarean section rather than emergency Cesarean section increases the risk of lymphoblastic leukemia in offspring.

**Is the risk of childhood leukaemia associated with socioeconomic measures in Denmark?: A nationwide register-based case-control study.** Friederike Erdmann, Ulla Arthur Hvidtfeldt, Maria Feychting, Mette Sørensen, Ole Raaschou-Nielsen. *Int J Cancer*. 2020 Nov 19.

The aetiology of childhood leukaemia is poorly understood. Knowledge about differences in risk by socioeconomic status (SES) may enhance etiologic insights. The authors conducted a nationwide register-based case-control study to evaluate socioeconomic differences in the risk of childhood leukaemia in Denmark and to assess whether associations varied by different measures of SES, time point of assessment, leukaemia type, and age at diagnosis. They identified all cases of leukaemia in children aged 0-19 years, born and diagnosed between 1980 and 2013 from the Danish Cancer Registry (N=1336) and sampled four individually matched controls per case (N=5330). Conditional logistic regression models were used for analysis. Medium and high level of parental education was associated with a higher risk of acute myeloid leukaemia (AML) in the offspring, mainly driven by children diagnosed at ages 0-4 years (OR for high maternal education = 3.07; 95% CI: 1.44-6.55). A modestly increased risk for lymphoid leukaemia (LL) was also observed in association with higher level of parental education, but only in children diagnosed at ages 5-19 years. Higher parental income was associated with an increased risk of LL but not AML among children aged 5-19 years at diagnosis (OR for high maternal income = 2.78; 95% CI: 1.32-5.89). Results for neighbourhood SES measures indicated null association.

Conclusions: There are indications that in Denmark the risk of childhood leukaemia is associated with socioeconomic measures. Bias or under-ascertainment of cases among families with low income or basic education is unlikely to explain the observed socioeconomic differences. Future research addressing explicitly the underlying mechanisms of this results may help to enhance etiologic insights of the disease.

**Residential traffic exposure and lymphohematopoietic malignancies among children in the city of São Paulo, Brazil: An ecological study.** Adeylson Guimarães Ribeiro, Roel Vermeulen, Maria Regina Alves Cardoso, Maria do Rosario Dias de Oliveira Latorre, Perry Hystad, George Stanley Downward, Adelaide Cássia Nardocci. *Cancer Epidemiol*. 2020 Nov 23;70:101859.

The authors examined the role of traffic related pollution on lymphohematopoietic malignancies among under-14 s in Sao Paulo. All incident cases between 2002 and 2011 were collected from a population-based registry. Exposures were assigned on residential address at diagnosis via traffic density database (for the year 2008) and a satellite derived NO<sub>2</sub> land use regression model (averaged between 1997 and 2011). Incidence rate ratios (IRRs) were calculated via Poisson Regression adjusted by age, gender and socioeconomic status (SES), with additional stratification by SES. A positive association between traffic and NO<sub>2</sub> with some lymphohematopoietic malignancies was observed with the degree of effect differing by SES. For example, lymphoid leukemia IRRs in the lower SES group were 1.21 (95 % CI: 1.06, 1.39) for traffic density and 1.38 (95 % CI: 1.13, 1.68) for NO<sub>2</sub>. In the higher group they were 1.06 (95 % CI: 1.00, 1.14) and 1.37 (95 % CI: 1.16, 1.62).

Conclusions: NO<sub>2</sub> and traffic density were associated with Hodgkin lymphoma and lymphoid leukemia among children in São Paulo. Differing IRRs by gender and SES group indicate differences in underlying risk and/or exposure profiles.

**Indoor volatile organic compounds exposures and risk of childhood acute leukemia: a case-control study in Shanghai.** Yan Zhang, Didi Chen, Rong Shi, Michihiro Kamijima, Kiyoshi Sakai, Ying Tian, Yu Gao. *J Environ Sci Health A Tox Hazard Subst Environ Eng.* 2020 Dec 26;1-10.

A case-control study was conducted to investigate the relationship between indoor air pollution and childhood acute leukemia (AL) in Shanghai. 97 cases and 148 gender-, age-, and residence-matched controls were included. Indoor air pollution was evaluated by questionnaires and quantitative measurement including 14 volatile organic compounds (VOCs) and nitrogen dioxide (NO<sub>2</sub>) in the homes of the two groups. The levels of individual VOCs, VOC families, TVOC (sum of the concentrations of the individual VOCs) and NO<sub>2</sub> were compared between the two groups. Exposure to styrene and butyl alcohol were associated with an increased risk of childhood AL (styrene: odds ratio (OR)=2.33, 95% confidence interval (CI): 1.07-5.07; butyl alcohol: OR = 2.51, 95%CI: 1.19-5.28); 4th quartile of chlorinated hydrocarbons (OR = 2.52, 95%CI: 1.02-6.26) and 3rd quartile of TVOC (OR = 4.03, 95%CI: 1.06-6.81) had significant higher ORs for childhood AL compared with that in the lowest quartiles. Elevated levels of individual VOCs, VOC families and TVOC were also associated with self-reported risk factors.

Conclusions; These findings suggest that VOCs exposure was associated with an elevated risk of childhood AL.