Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the second trimester of 2019

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1. Reviews

HEALTH EFFECTS RELATED TO EXPOSURE TO LOW-FREQUENCY ELECTROMAGNETIC FIELDS.
Anses, France, April 2019
https://www.anses.fr/fr/system/files/AP2013SA0038Ra.pdf

The report "Health effects related to exposure to low-frequency electromagnetic fields" published by Anses in April 2019 concluded as follows:

With regard to childhood leukemia, all of the data considered (through other reports prior to 2010 and by the analysis of the recent bibliography) lead to the conclusion that low-frequency fields may have an effect on the appearance of this pathology. It should be noted that this conclusion is based more on the results of studies prior to 2010 than on the results of recent studies, which find less frequently the link highlighted above.

With regard to breast cancer, the association highlighted by the Erren study in 2001 was not confirmed by subsequent studies. The available expert reports agree on the absence of a link between exposure to low-frequency electromagnetic fields and this pathology, and the analysis of epidemiological studies published between 2010 and 2015 agrees with this conclusion. Thus, the data set does not allow to conclude whether or not an effect of magnetic fields on breast cancer.

Regarding brain tumors, two studies suggest the possibility of a link between occupational exposure to low-frequency electromagnetic fields and the appearance of glioma or meningioma, and two studies do not find a link. At present, the data are too heterogeneous to conclude whether there is a link with exposure to low-frequency electromagnetic fields and further studies are needed in this area.

Regarding amyotrophic lateral sclerosis, despite the limitations noted during their analysis, some studies show a link between ALS and the fact of having a job related to electricity. This link could be explained by different factors of exposure: magnetic field, electric shock or synergy between physical agent and chemical, etc. Although current data do not support the conclusion that there is a link between low frequency exposure and ALS, further study in this area is a priority.

For other pathologies (other cancers of children and adults, other degenerative diseases), the data are too fragmentary to conclude whether or not there is a link with exposure to low frequency electromagnetic fields.

RESEARCH INTO POSSIBLE LONG TERM EFFECTS OF ELECTROMAGNETIC FIELDS ON THE HEALTH OF WORKERS – UPDATE 2019. RIVM REPORT 2019-0010.

Rijs K.J., Stam R.
https://www.rivm.nl/bibliotheek/rapporten/2019-0010.html

Scientific research has not yet proven any links between the exposure of workers and the occurrence of cancer, disorders of the nervous system or other illnesses in the long term. Indications have, however, again been found for a link between low-frequency electromagnetic fields and the extent to which the neurological disease ALS occurs. However, it is still not clear whether the electromagnetic fields are the actual cause, or other factors at the workplace, such as chemical substances or electric shocks. For other diseases of the nervous system, such as dementia and multiple sclerosis (MS), studies contradict one another or too few studies on the effects of electromagnetic fields have been carried out.

No links have been demonstrated between exposure to electromagnetic fields and the occurrence of various forms of cancer and cardiovascular diseases. There are still no indications for a link with breast cancer (in women).There is insufficient evidence for links between electromagnetic fields and brain tumors or leukaemia. For other forms of cancer and defects in the reproductive functions, the senses, the immune system or muscles and joints, there is a lack of well-substantiated research.

CHANGES OVER TIME IN THE REPORTED RISK FOR CHILDHOOD LEUKAEMIA AND MAGNETIC FIELDS.
Swanson J, Kheifets L, Vergara X.
J Radiol Prot. 2019 Jun;39(2):470-488.

There have been many studies from 1979 to the present, reporting raised risks for childhood leukaemia with exposure to power-frequency magnetic fields. There are also suggestions that the reported risk has been decreasing. The authors examine trends in the risk over time from all available studies. For 41 studies, They combine reported risks using inverse-variance weighting, drawing risk estimates from previous pooled analyses where possible for greater consistency. They examine the cumulative risk for studies published up to each successive calendar year for all studies and for various subsets, and test for a trend over the period. The cumulative relative risk has indeed declined, for our most rigorous analysis from a maximum 2.44 in 1997 to 1.58 in 2017, but not statistically significantly when tested as a linear trend. Suggestions of higher risks in studies looking at higher exposures and in studies with better quality exposure assessment were find.

Conclusions: There is a decline in reported risk from the mid 1990s to now, which is unlikely to be solely explained by improving study quality but may be due to chance, and an elevated risk remains.

2. Residential exposure

THE SENSITIVITY OF REPORTED EFFECTS OF ELECTROMAGNETIC FIELDS ON CHILDHOOD LEUKEMIA TO UNCONTROLLED CONFOUNDING BY RESIDENTIAL MOBILITY: A HYBRID SIMULATION STUDY AND AN EMPIRICAL ANALYSIS USING CAPS DATA.
Amoon AT, Arah OA, Kheifets L.
Cancer Causes Control. 2019 Aug;30(8):901-908.

Residential mobility is considered as a potential source of confounding in studies assessing environmental exposures, including in studies of electromagnetic field (EMF) exposures and childhood leukemia. The authors present a hybrid simulation study where they simulate a synthetic dataset based on an existing study and use it to assess the sensitivity of EMF-leukemia associations to different scenarios of uncontrolled confounding by mobility under two major hypotheses of the infectious etiology of childhood leukemia. Then they used the findings to conduct sensitivity analysis and empirically offset the potential bias due to unmeasured mobility in the California Power Line Study dataset. As expected, the stronger the assumed relationship between mobility and exposure and outcome, the greater the potential bias. However, no scenario created a bias strong enough to completely explain away previously observed associations.

Conclusions: Uncontrolled confounding by residential mobility had some impact on the estimated effect of EMF exposures on childhood leukemia, but that it was unlikely to be the primary explanation behind previously observed largely consistent, but unexplained associations.

MATERNAL PROXIMITY TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS AND RISK OF BIRTH DEFECTS.

Auger N, Arbour L Luo W, Lee GE, Bilodeau-Bertrand M, Kosatsky T.

Eur J Epidemiol. 2019 Jul;34(7):689-697.

Causes of birth defects are unclear, and the association with electromagnetic fields is inconclusive. The authors assessed the relationship between residential proximity to extremely low frequency electromagnetic fields from power grids and risk of birth defects. They analyzed a population-based sample of 2,164,246 infants born in Quebec, Canada between 1989 and 2016. The maternal residential postal code at delivery was geocoded and the distance to the nearest high voltage electrical transmission line or transformer station was computed. A log-binomial regression to estimate risk ratios (RR) and 95% confidence intervals (CI) for the association of residential proximity to transmission lines and transformer stations with birth defects was used, adjusting for maternal and infant characteristics. The prevalence of birth defects within 200 m of a transmission line (579.4 per 10,000 per live births) was only slightly higher compared with distances further away (568.7 per 10,000). A similar trend was seen for transformer stations. Compared with 200 m, a distance of 50 m was not associated with the risk of birth defects for transmission lines (RR 1.00, 95% CI 1.00-1.01) and transformer stations (RR 1.01, 95% CI 1.00-1.03). There was no consistent association when we examined birth defects in different organ systems.

Conclusions: The authors found no compelling evidence that residential proximity to extremely low frequency electromagnetic fields from electrical power grids increases the risk of birth defects. Women residing near electrical grids can be reassured that an effect on the risk of birth defects is unlikely.

RESIDENTIAL EXPOSURE TO ELECTROMAGNETIC FIELDS DURING PREGNANCY AND RISK OF CHILD CANCER: A LONGITUDINAL COHORT STUDY.

Auger N, Bilodeau-Bertrand M, Marcoux S, Kosatsky T.

Environ Res. 2019 Jun 7;176:108524.

The authors assessed whether exposure to electromagnetic fields during pregnancy increases the risk of childhood cancer. They studied a retrospective cohort of 784,944 newborns in Quebec, Canada between 2006 and 2016 who were followed for cancer one decade after birth. The exposures were residential distance to the nearest high voltage power transformer station and transmission line. The incidence of childhood cancer, and estimated hazard ratios and 95% confidence intervals (CI) were determined in Cox proportional hazards regression models adjusted for maternal and birth characteristics. There were 1114 incident cases of cancer during 4,647,472 person-years of follow-up. Residential proximity to transformer stations was associated with a somewhat greater risk of cancer, but there was no association with transmission lines. Compared with 200 m, a distance of 80 m from a transformer station was associated with a hazard ratio of 1.08 (95% CI 0.98, 1.20) for any cancer, 1.04 (95% CI 0.88, 1.23) for hematopoietic cancer, and 1.11 (95% CI 0.99, 1.25) for solid tumours.

Conclusions: Residential proximity to transformer stations is associated with a borderline risk of childhood cancer, but the absence of an association with transmission lines suggests no causal link.

3. Occupational exposure

No publications

4. Human experimental studies

BECOMING ELECTRO-HYPERSENSITIVE: A REPLICATION STUDY.
Dieudonné M.
Bioelectromagnetics. 2019 Apr;40(3):188-200.

Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) is an emerging environmental illness that is characterized by the attribution of various symptoms to electromagnetic fields (EMF). To date, research has not succeeded in objectifying the illness' semiology or etiology. IEI-EMF remains impossible to define other than in terms of the attributions of the persons affected. Yet, the genesis of these attributions is still not well understood. This study's objective is to replicate previous results relating to them, while correcting their limitations. Sixteen electro-hypersensitive (EHS) subjects lent themselves to both a sociological interview and a medical interview, and completed a set of standardized questionnaires. Three distinct types of biographical trajectories leading to persons becoming convinced of their hypersensitivity were identified, which were called the Reticent Attribution model, the Prior Attribution model, and the By Proxy Attribution model. These three models of EHS attribution process do not appear to lead to clinically distinct forms of IEI-EMF. What distinguishes them is the way in which the initial suspicion of the electromagnetic environment emerges. They demonstrate a diversification of the pathways to IEI-EMF. Nonetheless, in each model, the learning process that enables the EHS attribution to be materialized and operationalized is identical.

Conclusions: The ability to establish causation between the electromagnetic environment and their condition is the result of EHS subjects' trajectories, rather than

their starting point. This observation is not congruent with models attributing IEI-EMF to nocebo reactions, which raises the question of these models' ecological validity.

4. Exposure assessment

USE OF MACHINE LEARNING IN THE ANALYSIS OF INDOOR ELF MF EXPOSURE IN CHILDREN.

Tognola G, Bonato M, Chiaramello E, Fiocchi S, Magne I, Souques M, Parazzini M, Ravazzani P.

Int J Environ Res Public Health. 2019 Apr 6;16(7).

Characterization of children exposure to extremely low frequency (ELF) magnetic fields is an important issue because of the possible correlation of leukemia onset with ELF exposure. Cluster analysis-a Machine Learning approach-was applied on personal exposure measurements from 977 children in France to characterize real-life ELF exposure scenarios. Electric networks near the child's home or school were considered as environmental factors characterizing the exposure scenarios. The following clusters were identified: children with the highest exposure living 120 - 200 m from 225 kV/400 kV overhead lines; children with mid-to-high exposure living 70 - 100 m from 63 kV/150 kV overhead lines; children with mid-to-low exposure living 40 m from 400 V/20 kV substations and underground networks; children with the lowest exposure and the lowest number of electric networks in the vicinity. 63 - 225 kV underground networks within 20 m and 400 V/20 kV overhead lines within 40 m played a marginal role in differentiating exposure clusters.

Conclusions: Cluster analysis is a viable approach to discovering variables best characterizing the exposure scenarios and thus it might be potentially useful to better tailor epidemiological studies. The present study did not assess the impact of indoor sources of exposure, which should be addressed in a further study.

4. Leukemia studies

ASSOCIATION BETWEEN OUTDOOR AIR POLLUTION AND CHILDHOOD LEUKEMIA: A SYSTEMATIC REVIEW AND DOSE-RESPONSE META-ANALYSIS.

Filippini T, Hatch EE, Rothman KJ, Heck JE, Park AS, Crippa A, Orsini N, Vinceti M.

Environ Health Perspect. 2019 Apr;127(4):46002.

A causal link between outdoor air pollution and childhood leukemia has been proposed, but some older studies suffer from methodological drawbacks. No systematic reviews have summarized the most recently published evidence and no analyses have examined the dose-response relation. The authors investigated the extent to which outdoor air pollution, especially as resulting from traffic-related contaminants, affects the risk of childhood leukemia. They searched all case-control and cohort studies that have investigated the risk of childhood leukemia in relation to exposure either to motorized traffic and related contaminants, based on various traffic-related metrics (number of vehicles in the closest roads, road density, and distance from major roads), or to measured or modeled levels of air contaminants

such as benzene, nitrogen dioxide, 1,3-butadiene, and particulate matter. A meta-analysis of all eligible studies was carried out, including nine studies published since the last systematic review and, when possible, a dose-response curve was fitted using a restricted cubic spline regression model. 29 studies were found eligible to be included in this review. In the dose-response analysis, little association was found between disease risk and traffic indicators near the child's residence for most of the exposure range, with an indication of a possible excess risk only at the highest levels. In contrast, benzene exposure was positively and approximately linearly associated with risk of childhood leukemia, particularly for acute myeloid leukemia, among children under 6 years of age, and when exposure assessment at the time of diagnosis was used. Exposure to nitrogen dioxide showed little association with leukemia risk except at the highest levels.

Conclusions: Overall, the epidemiologic literature appears to support an association between benzene and childhood leukemia risk, with no indication of any threshold effect. A role for other measured and unmeasured pollutants from motorized traffic is also possible.

A META-ANALYSIS OF TRAFFIC-RELATED AIR POLLUTION AND RISK OF CHILDHOOD LEUKEMIA.

Gong ZH, Li J, Wang XY, Yu Y, Ren MM, Zhou J.

J Pediatr Hematol Oncol. 2019 May;41(4):267-274.

Many studies have analyzed the association between traffic-related air pollution and risk of childhood leukemia, but the results are inconsistent. Therefore, the authors performed this meta-analysis to investigate the association between traffic-related air pollution and risk of childhood leukemia. PubMed, Cochrane, and Embase databases were searched by the index words to identify eligible case-control studies, and relevant literature sources were also searched. The latest research was performed in September 2017. Odds ratio (OR) along with 95% confidence interval (95% CI) were used to analyzed the main outcomes. Twenty-one case-control studies were included in the meta-analysis. The results indicated that in the studies of overall traffic density (OR: 1.01, 95% CI: 0.98-1.04), high traffic density (OR: 1.04, 95% CI: 0.91-1.17), moderate exposure to NO2 (OR: 1.02, 95% CI: 0.93-1.10), and benzene (OR: 1.04, 95% CI: 0.71-1.37), the risks of childhood leukemia incidence were higher in the case group than the control group, but no significant difference was found. In other analysis, no significant difference was observed in the risk of childhood leukemia in the 2 groups.

Conclusions: Current evidence suggests that childhood leukemia is associated with traffic density, and moderate exposure to NO2 and benzene. However, more high-quality studies are required to confirm the conclusions.

MATERNAL RESIDENTIAL PROXIMITY TO MAJOR ROADWAYS AND THE RISK OF CHILDHOOD ACUTE LEUKEMIA: A POPULATION-BASED CASE-CONTROL STUDY IN TEXAS, 1995-2011.

Peckham-Gregory EC, Ton M, Rabin KR, Danysh HE, Scheurer ME, Lupo PJ.

Int J Environ Res Public Health. 2019 Jun 7;16(11).

Acute leukemia is the most common pediatric malignancy. Some studies suggest early-life exposures to air pollution increase risk of childhood leukemia. Therefore,

the authors explored the association between maternal residential proximity to major roadways and risk of acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML). Information on cases with acute leukemia (n = 2030) was obtained for the period 1995-2011 from the Texas Cancer Registry. Birth certificate controls were frequency matched (10:1) on birth year (n = 20,300). Three residential proximity measures were assessed: (1) distance to nearest major roadway, (2) residence within 500 meters of a major roadway, and (3) roadway density. Multivariate logistic regression was used to generate adjusted odds ratios (aOR) and 95% confidence intervals (CI). Mothers who lived ≤500 meters to a major roadway were not more likely to have a child who developed ALL (OR = 1.03; 95% CI: 0.91-1.16) or AML (OR = 0.84; 95% CI: 0.64-1.11). Mothers who lived in areas characterized by high roadway density were not more likely to have children who developed ALL (OR = 1.06, 95% CI: 0.93-1.20) or AML (OR = 0.83, 95% CI: 0.61-1.13).

Conclusions: These results do not support the hypothesis that maternal proximity to major roadways is strongly associated with childhood acute leukemia. Future assessments evaluating the role of early-life exposure to environmental factors on acute leukemia risk should explore novel methods for directly measuring exposures during relevant periods of development.

PARENTAL OCCUPATIONAL EXPOSURE TO BENZENE AND THE RISK OF CHILDHOOD AND ADOLESCENT ACUTE LYMPHOBLASTIC LEUKAEMIA: A POPULATION-BASED STUDY.

Heck JE, He D, Contreras ZA, Ritz B, Olsen J, Hansen J.

Occup Environ Med. 2019 May 28. pii: oemed-2019-105738.

The authors examined associations with acute lymphoblastic leukaemia (ALL) in a population-based study in Denmark. Benzene was largely banned from Danish workplaces after 1975, thus this case-control study focused on the immediately prior years. Paediatric cancer cases (<age 20) were ascertained from the Danish Cancer Registry among children born 1968-1974, and controls were selected from population records. Paternal occupation within the 3 months preconception and maternal pregnancy occupation were identified from nationwide pension fund records. Blinded, benzene exposure was assigned using a job-exposure matrix that had been developed for the Danish population. Risk for ALL was estimated using conditional logistic regression. In an exploratory analysis, also other cancers with at least five case parents exposed were examined. 217 employed case fathers and 169 employed case mothers were identified, of which 22 (10.1%) and 11 (6.5%), respectively, were exposed to benzene (vs 6.7% and 2.9% of control fathers and mothers). Most exposed parents worked as machine or engine mechanics, or in the shoe industry. Maternal occupational exposure to benzene in pregnancy was related to increased risk of ALL in offspring (adjusted OR=2.28, 95% CI 1.17 to 4.41), while paternal preconceptional benzene exposure was not as strongly associated (adjusted OR=1.40, 95% CI 0.88 to 2.22).

Conclusions: This study supports an increased risk for ALL with parental occupational benzene exposure.

PARENTAL OCCUPATIONAL EXPOSURE TO PESTICIDES, ANIMALS AND ORGANIC DUST AND RISK OF CHILDHOOD LEUKEMIA AND CENTRAL NERVOUS SYSTEM

TUMORS: FINDINGS FROM THE INTERNATIONAL CHILDHOOD CANCER COHORT CONSORTIUM (I4C).

Patel DM, Jones RR, Booth BJ, Olsson AC, Kromhout H, Straif K, Vermeulen R, Tikellis G, Paltiel O, Golding J, Northstone K, Stoltenberg C, Håberg SE, Schüz J, Friesen MC, Ponsonby AL, Lemeshow S, Linet MS, Magnus P, Olsen J, Olsen SF, Dwyer T, Stayner LT, Ward MH; International Childhood Cancer Cohort Consortium.

Int J Cancer. 2019 May 4.

Parental occupational exposures to pesticides, animals and organic dust have been associated with an increased risk of childhood cancer based mostly on case-control studies. The authors prospectively evaluated parental occupational exposures and risk of childhood leukemia and central nervous system (CNS) tumors in the International Childhood Cancer Cohort Consortium. They pooled data on 329,658 participants from birth cohorts in five countries (Australia, Denmark, Israel, Norway and United Kingdom). Parental occupational exposures during pregnancy were estimated by linking International Standard Classification of Occupations-1988 job codes to the ALOHA+ job exposure matrix. Risk of childhood (<15 years) acute lymphoblastic leukemia (ALL; n = 129), acute myeloid leukemia (AML; n = 31) and CNS tumors (n = 158) was estimated using Cox proportional hazards models to generate hazard ratios (HR) and 95% confidence intervals (CI). Paternal exposures to pesticides and animals were associated with increased risk of childhood AML (herbicides HR = 3.22, 95% CI = 0.97-10.68; insecticides HR = 2.86, 95% CI = 0.99-8.23; animals HR = 3.89, 95% CI = 1.18-12.90), but not ALL or CNS tumors. Paternal exposure to organic dust was positively associated with AML (HR = 2.38 95% CI = 1.12-5.07), inversely associated with ALL (HR = 0.55, 95% CI = 0.31-0.99) and not associated with CNS tumors. Low exposure prevalence precluded evaluation of maternal pesticide and animal exposures; no significant associations we observed were observed with organic dust exposure.

Conclusions: This first prospective analysis of pooled birth cohorts and parental occupational exposures provides evidence for paternal agricultural exposures as childhood AML risk factors. The different risks for childhood ALL associated with maternal and paternal organic dust exposures should be investigated further.

DOMESTIC RADON EXPOSURE AND CHILDHOOD LEUKAEMIA AND LYMPHOMA: A POPULATION-BASED STUDY IN CANADA.

Chen J, Xie L.

Radiat Prot Dosimetry. 2019 Apr 29. pii: ncz068.

In this paper, the authors revisit the possibility, first raised using a data set collected in the 1970s, that there is a link between average radon concentrations and the incidence of childhood leukaemia and lymphoma in Canada. Following the launch of the National Radon Program in 2007, Health Canada completed a long-term radon survey in 33 census metropolitan areas (CMAs), which covers about 70% of the Canadian population. The authors used this data, together with leukaemia and lymphoma incidence rates among children (0-14 years of age) in the past decade (2006-15), and tried to link the city-level average radon concentrations to the leukaemia and lymphoma incidence rates in 33 major Canadian cities. Analyses were

conducted for six subtypes (ALL, AML, CMD, HL, NHL and BL) of leukaemia and lymphoma. Estimated doses to red bone marrow from domestic radon exposure were low and the authors did not find any association between radon exposure at home and the increased risk for developing leukaemia among children under 15 years of age living in the CMAs.

Conclusions: The results indicate a slight positive association for AML among 1-4 year males in CMAs of Peer Group C and NHL among 5-9 year females in CMAs of Peer Group A; however, these should be interpreted with caution owing to the crude exposure assessment and possibilities of other confounding factors.