Overview of the epidemiologic studies on the health effects of ELF magnetic and electric fields published in the third trimester of 2012

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1. Reviews

IMPACT OF HIGH ELECTROMAGNETIC FIELD LEVELS ON CHILDHOOD LEUKEMIA INCIDENCE.

Teepen JC, van Dijck JA.

Int J Cancer. 2012; 131: 769-778.

The increasing exposure to electromagnetic fields (EMFs) has raised concern, as increased exposure may result in an increased risk of childhood leukemia (CL). Besides a short introduction of CL and EMF, this article gives an evaluation of the evidence of a causal relation between EMF and CL by critically appraising the epidemiological and biological evidence. The potential impact is also estimated by the population attributable risk. The etiology of CL is largely unknown, but is probably multifactorial. EMF may be one of the environmental exposures involved. Three pooled analyses of case-control studies showed a 1.4 - to 1.7-fold increased CL risk for extremely low-frequency EMF (ELF-EMF) exposure levels above 0.3 μT. Several biases may have played a role in these studies, but are unlikely to fully explain the increased risk. For effects of radiofrequency ELF evidence is lacking. None of the proposed biological mechanisms by which ELF-EMF might cause CL have been confirmed. The estimated overall population attributable risk was 1.9%, with the highest estimates in Northern America and Brazil (4.2% and 4.1%, respectively).

Conclusion: The potential impact of EMF exposure on public health is probably limited, although in some countries exposure might be relatively high and thus might have a more substantial impact. The authors recommend nationwide surveys to gain more insight into the contemporary exposure levels among children. Reducing exposure from power lines near densely populated areas and schools is advised. Future epidemiological studies should focus on limiting bias.

2. Residential exposure

MATERNAL EXPOSURE TO MAGNETIC FIELDS FROM HIGH-VOLTAGE POWER LINES AND THE RISK OF BIRTH DEFECTS.

Malagoli C, Crespi CM, Rodolfi R, Signorelli C, Poli M, Zanichelli P, Fabbi S, Teggi S, Garavelli L, Astolfi G, Calzolari E, Lucenti C, Vinceti M.

Bioelectromagnetics. 2012; 33: 405-409.

The authors conducted a population-based, case-control study to examine the risk of congenital anomalies associated with maternal exposure to magnetic fields (MF) from high-voltage power lines during pregnancy in a community in northern Italy. They identified 228 cases of congenital malformations diagnosed in live births, stillbirths, and induced abortions among women living in the municipality of Reggio Emilia during the period 1998-2006, and a reference group of healthy newborns was matched for year of birth, maternal age, and hospital of birth. The authors identified maternal residence during early pregnancy and used Geographic Information System to determine whether the residences were within geocoded corridors with MF ≥0.1 μT near high-voltage power lines, then calculated the relative

risk (RR) of congenital anomalies associated with maternal exposure. One case and 5 control mothers were classified as exposed, and the RR associated with MF ≥0.1 μT was 0.2 (95% CI: 0.0-2.0) after adjusting for maternal education.

Conclusion: While small or moderate effects may have gone undetected due to low statistical power, the results of this study overall do not provide support for major effects of a teratogenic risk due to exposure to MF during early pregnancy.

3. Occupational exposure

EVALUATION OF CHROMOSOMAL ALTERATION IN ELECTRICAL WORKERS OCCUPATIONALLY EXPOSED TO LOW FREQUENCY OF ELECTRO MAGNETIC FIELD (EMFs) IN COIMBATORE POPULATION, INDIA.

Balamuralikrishnan B, Balachandar V, Kumar SS, Stalin N, Varsha P, Devi SM, Arun M, Manikantan P, Venkatesan C, Sasikala K, Dharwadkar SN.

Asian Pac J Cancer Prev. 2012;13: 2961-2966.

The aim of the present study was to assess occupationally induced chromosomal damage in EMF workers exposed to low levels of radiation. The authors used conventional metaphase chromosome aberration (CA) analysis and the micronucleus (MN) assay as biological indicators of non ionizing radiation exposure. In the present study totally 70 subjects were selected including 50 exposed and 20 controls. Informed written consent was obtained from all participants and the study was performed in accordance with the Declaration of Helsinki and the approval of the local ethical committee. A higher degree of CA and MN was observed in exposed subjects compared to controls, the frequency of CA being significantly enhanced with long years of exposure ($P<0.05$). Moreover increase in CA and MN with age was noted in both exposed subjects and controls, but was significantly greater in the former. The results of this study demonstrated that a significant induction of cytogenetic damage in peripheral lymphocytes of workers occupationally exposed to EMFs in electric transformer and distribution stations.

Conclusion: These findings suggest that EMFs possess genotoxic capability, as measured by CA and MN assays; CA analysis appeared more sensitive than other cytogenetic end-points. It can be concluded that chronic occupational exposure to EMFs may lead to an increased risk of genetic damage among electrical workers.

RISK OF NEUROLOGICAL DISEASES AMONG SURVIVORS OF ELECTRIC SHOCKS: A NATIONWIDE COHORT STUDY, DENMARK, 1968-2008.

Grell K, Meersohn A, Schüz J, Johansen C.

Bioelectromagnetics. 2012; 33: 459-465.

Several studies suggest a link between electric injuries and neurological diseases, where electric shocks may explain elevated risks for neuronal degeneration and, subsequently, neurological diseases. The authors conducted a retrospective cohort study on the risk of neurological diseases among people in Denmark who had survived an electric accident in 1968-2008. The cohort included 3,133 people and occurrences of neurological diseases were determined by linkage to the nationwide population-based Danish National Register of Patients. The numbers of cases observed at first hospital contact in the cohort were compared with the respective rates of first hospital contacts for neurological diseases in the general population. We observed significantly increased risks for peripheral nerve diseases (standardized hospitalization ratio (SHR), 1.66; 95% confidence interval (CI), 1.22-2.22), for migraine (SHR, 1.80; 95% CI, 1.23-2.54), for vertigo (SHR, 1.60; 95% CI, 1.22-2.05), and for epilepsy (SHR, 1.45; 95% CI, 1.11-1.85). Only small numbers of

cases of other neurological diseases were found, making the risk estimates unstable.

Conclusion: These findings suggest an association between a single electric shock and increased risks for peripheral nerve diseases, migraines, vertigo, and epilepsy, but confirmation of these observations is needed.

FAMILIAL, ENVIRONMENTAL, AND OCCUPATIONAL RISK FACTORS IN DEVELOPMENT OF AMYOTROPHIC LATERAL SCLEROSIS.

Das K, Nag C, Ghosh M.

N Am J Med Sci. 2012;4: 350-355.

The study was designed to evaluate the role of environmental, occupational, and familial risk factors in development of ALS. It is a case control study of 110 cases of definite ALS with 240 age and sex matched controls. Investigations were done on the following aspects- family history, occupation, living place, source of drinking water, exposure to industrial, chemical, agricultural toxins and heavy metals, physical and electrical injury, working under magnetic field for more than 10 years in both the groups. Clinical examinations, electrophysiological, and neuroimaging studies were done in every patient. Chi square test, logistic regression analysis, and calculation of odds ratio were used to analyze the data.
Rural livings (odds ratio = 1.99), smoking (odds ratio = 1.88), insecticides, and pesticides exposures (odds ratio = 1.61), electrical injury (odds ratio = 6.2) were detected as the associated factors in development amyotrophic lateral sclerosis.
Conclusion: The study expressed the need of extensive research globally in molecular and genetic levels to detect the associated factors in etiopathogenesis of ALS for better understanding the etiology and for remedial aspects.

4. Human experiment

GENE EXPRESSION PROFILES IN WHITE BLOOD CELLS OF VOLUNTEERS EXPOSED TO A 50 HZ ELECTROMAGNETIC FIELD.

Kirschenlohr H, Ellis P, Hesketh R, Metcalfe J.

Radiat Res. 2012; 1783: 138-149.

Consistent and independently replicated laboratory evidence to support a causative relationship between environmental exposure to extremely low-frequency electromagnetic fields (EMFs) at power line frequencies and the associated increase in risk of childhood leukemia has not been obtained. In particular, although gene expression responses have been reported in a wide variety of cells, none has emerged as robust, widely replicated effects. DNA microarrays facilitate comprehensive searches for changes in gene expression without a requirement to select candidate responsive genes. To determine if gene expression changes occur in white blood cells of volunteers exposed to an ELF-EMF, each of 17 pairs of male volunteers age 20-30 was subjected either to a 50 Hz EMF exposure of 62.0 ± 7.1 μT for 2 h or to a sham exposure (0.21 ± 0.05 μT) at the same time (11:00 a.m. to 13:00 p.m.). The alternative regime for each volunteer was repeated on the following day and the two-day sequence was repeated 6 days later, with the exception that a null exposure (0.085 ± 0.01 μT) replaced the sham exposure. Five blood samples (10 ml) were collected at 2 h intervals from 9:00 to 17:00 with five additional samples during the exposure and sham or null exposure periods on each study day. RNA samples were pooled for the same time on each study day for the group of 17 volunteers that were subjected to the ELF-EMF exposure/sham or null exposure sequence and were analyzed on Illumina microarrays. Time courses for 16 mammalian genes previously reported to be responsive to ELF-EMF exposure,

including immediate early genes, stress response, cell proliferation and apoptotic genes were examined in detail.

Conclusion: No genes or gene sets showed consistent response profiles to repeated ELF-EMF exposures. A stress response was detected as a transient increase in plasma cortisol at the onset of either exposure or sham exposure on the first study day. The cortisol response diminished progressively on subsequent exposures or sham exposures, and was attributable to mild stress associated with the experimental protocol.

IS NEWBORN MELATONIN PRODUCTION INFLUENCED BY MAGNETIC FIELDS PRODUCED BY INCUBATORS?

Bellieni CV, Tei M, Iacoponi F, Tataranno ML, Negro S, Proietti F, Longini M, Perrone S, Buonocore G.

Early Hum Dev. 2012; 88: 707-710.

During permanence in most incubators, newborns are very close to the electric engine, which represents a source of electromagnetic fields (EMF). Previous studies demonstrated a decrease in melatonin production in adults and animals exposed to EMF. The aim of the study was to assess melatonin production in a group of newborns exposed to EMF, and to evaluate whether removing the babies from the source of MF can affect melatonin production.
The authors have recruited 28 babies (study group), who had spent at least 48 h in incubator where we had previously assessed the presence of significant EMF. We have measured their mean 6-hydroxy-melatonin-sulfate (6OHMS) urine excretion at the end of their permanence in the incubators, and compared it with their mean 6OHMS excretion after having been put in cribs, where EMF are below the detectable limit (<0.1mG). We have also measured urine 6OHMS twice, with an interval of 48h, in a control group of 27 babies who were not exposed to EMF during both samples.
Mean 6OHMS/cr values were respectively 5.34±4.6 and 7.68±5.1ng/mg (p=0.026) when babies were exposed to EMF in incubators, and after having been put in the crib. In the control group, mean 6OHMS/cr values in the first and in the second sample were respectively 5.91±5.41 vs 6.17±3.94ng/mg (p=0.679).
Conclusion: The transitory increase in melatonin production soon after removing newborns from incubators demonstrates a possible influence of EMF on melatonin production in newborns. Further studies are needed to confirm these data.

5. Exposure assessment

OCCUPATIONAL EXPOSURE TO ELECTRIC FIELDS AND CURRENTS ASSOCIATED WITH 110 KV SUBSTATION TASKS.

Korpinen LH, Kuisti HA, Tarao H, Elovaara JA.

Bioelectromagnetics. 2012; 33: 438-442.

The main aim of this study was to investigate occupational exposure to electric fields, and current densities and contact currents associated with tasks at air-insulated 110 kV substations and analyze if the action value of EU Directive 2004/40/EC was exceeded. Four workers volunteered to simulate the following tasks: Task (A) maintenance of an operating device of a disconnector at ground or floor level, Task (B) maintenance of an operating device of a circuit breaker at ground or floor level, Task (C) breaker head maintenance from a man hoist, and Task (D) maintenance of an operating device of a circuit breaker from a service platform. The highest maximum average current density in the neck was 1.8

mA/m(2) (calculated internal electric field 9.0-18.0 mV/m) and the highest contact current was 79.4 µA.

Conclusion: All measured values at substations were lower than the limit value (10 mA/m(2)) of the EU Directive 2004/40/EC and the 2010 basic restrictions (0.1 and 0.8 V/m for central nervous system tissues of the head, and all tissues of the head and body, respectively) of the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

6. Leukemia studies

AN EXAMINATION, WITH A META-ANALYSIS, OF STUDIES OF CHILDHOOD LEUKAEMIA IN RELATION TO POPULATION MIXING.

Kinlen LJ.

Br J Cancer. 2012; 107: 1163-1168.

Marked influxes of people into rural areas, termed rural population mixing (PM), have been associated with excesses of childhood leukaemia (CL), consistent with mini-epidemics of a mainly immunising, subclinical infection to which CL is a rare response. For such situations of rural PM would promote contacts between infected and susceptible individuals, the latter tending to have a higher than average prevalence in rural or isolated areas. Confusion has arisen from some workers applying the term PM to non-rural situations lacking known recent change.
Available PM studies using the original definition of influxes were examined, a meta-analysis carried out of studies of CL in relation to exposure to high levels of rural PM, and also a detailed analysis by age group.
The meta-analysis of 17 studies shows a significant CL excess in association with rural PM: overall relative risk (RR) at ages 0-14: 1.57; 95% confidence interval 1.44-1.72; at 0-4 years 1.72 (1.54-1.91). This contrasts with the absence of an excess of CL in similarly exposed urban areas (RR 1.00; 0.93-1.07), pointing to a high level of immunity there. The mixed results of studies using other definitions of PM were summarised. The excess associated with rural PM below age 2 years (RR 1.51; 1.17, 1.92) was not appreciably different from that at later childhood ages.
Conclusion:Much of the inconsistency among studies ostensibly about CL and PM reflects the use of definitions other than that originally proposed. The broad similarity of the CL excess below age 2 with that at older childhood ages is inconsistent with the Greaves' delayed infection hypothesis, since any infection underlying the former is difficult to consider as delayed.

RADIATION EXPOSURE FROM CT SCANS IN CHILDHOOD AND SUBSEQUENT RISK OF LEUKAEMIA AND BRAIN TUMOURS: A RETROSPECTIVE COHORT STUDY.

Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, Kim KP, Howe NL, Ronckers CM, Rajaraman P, Sir Craft AW, Parker L, Berrington de González A.

Lancet. 2012; 380(9840): 499-505.

Although CT scans are very useful clinically, potential cancer risks exist from associated ionising radiation, in particular for children who are more radiosensitive than adults. The authors aimed to assess the excess risk of leukaemia and brain tumours after CT scans in a cohort of children and young adults.
In this retrospective cohort study, patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in England, Wales, or Scotland (Great Britain) between 1985 and 2002, when they were younger than 22 years of age were included. Data for cancer incidence, mortality, and loss to follow-up were obtained from the NHS Central Registry from Jan 1, 1985, to Dec 31, 2008. The absorbed brain and red bone marrow doses per CT

scan in mGy were estimated and excess incidence of leukaemia and brain tumours cancer with Poisson relative risk models was assessed. To avoid inclusion of CT scans related to cancer diagnosis, follow-up for leukaemia began 2 years after the first CT and for brain tumours 5 years after the first CT.
During follow-up, 74 of 178,604 patients were diagnosed with leukaemia and 135 of 176,587 patients were diagnosed with brain tumours. A positive association was noted between radiation dose from CT scans and leukaemia (excess relative risk [ERR] per mGy 0·036, 95% CI 0·005-0·120; p=0·0097) and brain tumours (0·023, 0·010-0·049; p<0·0001). Compared with patients who received a dose of less than 5 mGy, the relative risk of leukaemia for patients who received a cumulative dose of at least 30 mGy (mean dose 51·13 mGy) was 3·18 (95% CI 1·46-6·94) and the relative risk of brain cancer for patients who received a cumulative dose of 50-74 mGy (mean dose 60·42 mGy) was 2·82 (1·33-6·03).
Conclusion: Use of CT scans in children to deliver cumulative doses of about 50 mGy might almost triple the risk of leukaemia and doses of about 60 mGy might triple the risk of brain cancer. Because these cancers are relatively rare, the cumulative absolute risks are small: in the 10 years after the first scan for patients younger than 10 years, one excess case of leukaemia and one excess case of brain tumour per 10,000 head CT scans is estimated to occur. Nevertheless, although clinical benefits should outweigh the small absolute risks, radiation doses from CT scans ought to be kept as low as possible and alternative procedures, which do not involve ionising radiation, should be considered if appropriate.

MEDICALLY DIAGNOSED INFECTIONS AND RISK OF CHILDHOOD LEUKAEMIA: A POPULATION-BASED CASE-CONTROL STUDY.

Chang JS, Tsai CR, Tsai YW, Wiemels JL.

Int J Epidemiol. 2012; 41: 1050-1059.

Previous studies on the association between childhood infections and childhood leukaemia have produced inconsistent results, likely due to the recall error/bias of infection data reported by the parents. The current study used a population-based and record-based case-control design to evaluate the association between childhood leukaemia and infections using the National Health Insurance Research Database of Taiwan.
In all, 846 childhood acute lymphoblastic leukaemia (ALL) and 193 acute myeloid leukaemia (AML) patients newly diagnosed between 2000 and 2008, aged >1 and <10 years, were included. Up to four controls (3374 for ALL and 766 for AML) individually matched to each case on sex, birth date and time of diagnosis (reference date for the controls) were identified. Conditional logistic regression was performed to assess the association between childhood leukaemia and infections.
Having any infection before 1 year of age was associated with an increased risk for both childhood ALL (odds ratio = 3.2, 95% confidence interval 2.2-4.7) and AML (odds ratio = 6.0, 95% confidence interval 2.0-17.8), with a stronger risk associated with more episodes of infections. Similar results were observed for infections occurring >1 year before the cases' diagnosis of childhood leukaemia.
Conclusions: Children with leukaemia may have a dysregulated immune function present at an early age, resulting in more episodes of symptomatic infections compared with healthy controls. However, confounding by other infectious measures such as birth order and day care attendance could not be ruled out. Finally, the results are only relevant to the medically diagnosed infections.