Overview of the epidemiologic studies on the health effects of ELF electric and magnetic fields (ELF-EMF) published in the third quarter of 2024.

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Index

1. Reviews and meta-analyses

1.1. Extremely low-frequency electromagnetic fields from indoor transformers: a review of occupational and residential exposure assessment studies

Rathebe, P. C., Matjutla, N., Ndwandwe, V., & Mafa, T. (2024). Extremely low-frequency electromagnetic fields from indoor transformers: a review of occupational and residential exposure assessment studies. *Cogent Engineering*, *11*(1).

Background: The widespread use of electrical and electronic devices in the 21st century has led to human exposure to electromagnetic fields (EMFs), and potential public health threats. Amongst other electrical devices, indoor transformer stations have exposed both general public and workers to potentially high levels of extremely low-frequency electromagnetic fields (ELF-EMFs), resulting in acute and severe health implications. In this review, the health effects resulting from occupational and residential exposure to ELF-EMFs from indoor transformer stations were assessed by synthesizing evidence from published studies.

Methods: Population, Exposure, Comparison and Outcome (PECO) framework was used as a guide in documenting the evidence, and Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) to select studies that match the inclusion criteria.

Results: Following the PRISMA guide, a total of 13 studies formed part of this review. Highest magnetic field (MF) exposure level found from a residential exposure assessment study was 11.60 mT, 0.2 m above the transformer station, with the lowest at 0.1 mT due to household electrical appliances. Occupational exposure assessment revealed the highest exposure level of 4.67 mT in the transformer room and lowest at >0.05 mT. Cancer was mostly prevalent in residential studies with longer exposure period (>34 years), and with non-specific exposure symptoms (3 years and 18 months exposure period) within occupational exposure studies.

Conclusions: This review found insufficient evidence to suggest the average exposure levels of ELF-EMF from indoor transformers, which could pose significant health risks. However, these findings have a noteworthy implication for environmental health and occupational safety.

1.2. Health risks for medical personnel due to magnetic fields in magnetic resonance imaging.

König, A. M., Pöschke, A., & Mahnken, A. H. (2024). Health risks for medical personnel due to magnetic fields in magnetic resonance imaging. *RöFo - Fortschritte Auf Dem Gebiet Der Röntgenstrahlen Und Der Bildgebenden Verfahren*.

Background: The current state of medical and scientific knowledge on the effects of exposure to electromagnetic fields on workers in the field of clinical magnetic resonance imaging (MRI) was summarized by the authors.

Methods: A systematic literature search was conducted to analyze the health risks to medical personnel from magnetic fields in MRI. Included studies A total of 7273 sources were identified, with 7139 being excluded after screening of the title and abstract. After full-text screening, 34 sources remained and were included in this paper.

Results: There are a number of scientific publications on the occurrence of short-term sensory effects such as vertigo, metallic taste, phosphenes as well as on the occurrence of neurocognitive and neurobehavioral effects. For example, short-term exposure to clinical magnetic fields has been reported to result in a 4 % reduction in speed and precision and a 16 % reduction in visual contrast sensitivity at close range. Both eye-hand precision and coordination speed are affected. The long-term studies concern, among other things, the influence of magnetic fields on sleep quality, which could be linked to an increased risk of accidents. The data on the exposure of healthcare workers to magnetic fields during pregnancy is consistently outdated. However, it has been concluded that there are no particular deviations with regard to the duration of pregnancy, premature births, miscarriages, and birth weight.
Epidemiological studies are lacking.

Conclusions: With a focus on healthcare personnel, there is a considerable need for high-quality data, particularly on the consequences of long-term exposure to electromagnetic fields from clinical MRI and the effects on pregnancy.

2. Residential exposure
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3. Occupational exposure
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4. Exposure Assessment

4.1. Prediction of health impacts of exposure to electromagnetic field on the immunity system of power plants workers using fuzzy decision-making rules.

Korenevskiy, N. A., Al-Kasasbeh, R. T., Shaqadan, A., Myasoedova, M. A., Al-Qodah, Z., Rodionova, S. N., Eltous, Y., Filist, S., & Maksim, I. (2024). Prediction of health impacts of exposure to electromagnetic field on the immunity system of power plants workers using fuzzy decision-making rules. *International Journal of System Assurance Engineering and Management*.

Background: This study aims to enhance health assessments in environments with industrial risk factors by incorporating oxidative status indicators, such as lipid peroxidation levels and antioxidant activity, into prognostic and diagnostic models.

Methods: A novel approach was developed to quantitatively evaluate the body's protection level by synthesizing hybrid fuzzy decision rules that integrate oxidative status indicators. The methodology was validated through a case study focusing on predicting ischemic heart disease in locomotive crew drivers, who are at high risk for disability and mortality due to their occupational environment.

Results: The incorporation of oxidative status into prognostic decision rules significantly improved the accuracy and efficiency of disease prediction. In particular, fuzzy mathematical models were also developed to predict and diagnose immune system diseases in electric power industry workers exposed to electromagnetic fields and other risk factors. Statistical tests revealed that the decision rules achieved a prediction accuracy greater than 0.85, with early-stage detection accuracy reaching 0.95.

Conclusions: These findings provide occupational pathology specialists with a valuable tool for enhancing the precision of disease prediction and diagnosis in industrial settings. The integration of oxidative status indicators into prognostic models offers a promising approach to improving health outcomes for workers exposed to industrial risk factors.

5. Leukaemia Studies

5.1. Global incidence and mortality of childhood leukemia and its relationship with the Human Development Index.

Mohammadian-Hafshejani, A., Farber, I. M., & Kheiri, S. (2024). Global incidence and mortality of childhood leukemia and its relationship with the Human Development Index. *PLoS ONE*, *19*(7 July).

Background: Childhood leukemia (CL) is a major global concern, accounting for 33% of all new cancer cases and 31% of all cancer deaths in children aged 0–14 years. This study aimed to analyze the global incidence and mortality rates of CL in 2020 and its relationship with the Human Development Index (HDI).

Methods: In this ecologic study, the authors analyzed the 2020 cancer incidence and mortality data for children aged 0–14 years from the GLOBOCAN Project. The Age-Standardized Incidence Rate (ASIR) and Age-Standardized Mortality Rate (ASMR) of CL per 100,000 individuals were calculated. Pearson's correlation coefficient was used to examine the association between childhood leukemia ASIR, ASMR, and the HDI, with a statistical significance threshold of $P < 0.05$

Results: In 2020, there were a total of 67,008 new cases of CL worldwide, with males accounting for 57.85%. The global ASIR for CL was 3.4 per 100,000 (3.9 in males, 3 in females). Additionally, there were 25,080 CL-related deaths, with males comprising 58.86%. The overall ASMR for CL was 1.3 (1.4 in males, 1.1 in females). A significant positive correlation ($r = 0.405$, $P \leq 0.001$) was found between the global ASIR and ASMR for CL. There was a strong positive correlation ($r = 0.770$, $P = 0.001$) between the HDI and childhood leukemia ASIR, but no significant association ($r = 0.077$, $P = 0.337$) was observed with ASMR.

Conclusion: This study reveals that CL remains a significant health burden worldwide. A positive correlation between the ASIR of CL and the HDI was identified, indicating a potential role of socio-economic factors in CL incidence.

5.2. High ambient temperature in pregnancy and risk of childhood acute lymphoblastic leukaemia: an observational study.

Rogne, T., Wang, R., Wang, P., Deziel, N. C., Metayer, C., Wiemels, J. L., Chen, K., Warren, J. L., & Ma, X. (2024). High ambient temperature in pregnancy and risk of childhood acute lymphoblastic leukaemia: an observational study. *The Lancet Planetary Health*, *8*(7), e506–e514.

Background: High ambient temperature is increasingly common due to climate change and is associated with risk of adverse pregnancy outcomes. Acute lymphoblastic leukaemia is the most common malignancy in children, its incidence is increasing, and in the USA disproportionately affects Latino children. This study aimed to investigate the potential association between high ambient temperature in pregnancy and risk of childhood acute lymphoblastic leukaemia.

Methods: Data from California birth records (children born from Jan 1, 1982, to Dec 31, 2015) and California Cancer Registry (those diagnosed with childhood cancer in California from Jan 1, 1988, to

Dec 31, 2015) was used to identify acute lymphoblastic leukaemia cases diagnosed in infants and children aged 14 years and younger and controls matched by sex, race, ethnicity, and date of last menstrual period. Ambient temperatures were estimated on a 1-km grid. The association between ambient temperature and acute lymphoblastic leukaemia was evaluated per gestational week, restricted to May-September, adjusting for confounders. Bayesian meta-regression was applied to identify critical exposure windows. For sensitivity analyses a 90-day pre-pregnancy period (assuming no direct effect before pregnancy) was evaluated, adjusted for relative humidity and particulate matter less than 2,5 microns in aerodynamic diameter, and constructed an alternatively matched dataset for exposure contrast by seasonality.

Results: 6849 cases of childhood acute lymphoblastic leukaemia were identified and, of these, 6258 had sufficient data for study inclusion. 307 579 matched controls were included. Most of the study population were male (174 693 [55·7%] of the 313 837 included in the study) and of Latino ethnicity (174 906 [55·7%]). The peak association between ambient temperature and risk of acute lymphoblastic leukaemia was observed in gestational week 8, where a 5°C increase was associated with an odds ratio of 1·07 (95% CI 1·04-1·11). A slightly larger effect was seen among Latino children (OR 1·09 [95% CI 1·04-1·14]) than non-Latino White children (OR 1·05 [1·00-1·11]). The sensitivity analyses supported the results of the main analysis.

Conclusions: These findings suggest an association between high ambient temperature in early pregnancy and risk of childhood acute lymphoblastic leukaemia. Further replication and investigation of mechanistic pathways might inform mitigation strategies.

5.3. Breastfeeding Duration Reduces the Risk of Childhood Leukemia and Modifies the Risk of Developing Functional Gastrointestinal Disorders.

Bener, A., Tokaç, M., Tewfik, I., Zughaier, S. M., Ağan, A. F., & Day, A. S. (2024). Breastfeeding Duration Reduces the Risk of Childhood Leukemia and Modifies the Risk of Developing Functional Gastrointestinal Disorders. *Breastfeeding Medicine*, *19*(7), 539–546.

Background: The aim of this study was to test the hypothesis that the duration of breastfeeding in infancy reduces the risk of childhood leukemia or lymphoma, and modifies the risk of developing functional gastrointestinal disorders (FGIDs).

Methods: This case–control study involved the recruitment of children with lymphoid malignancy and functional gastrointestinal symptoms with healthy children as controls. Focused questionnaires were used to collect data on breastfeeding history and other key risk factors. Univariate and multivariate analyses were undertaken.

Results: Of the 334 children with lymphoid malignancy, 65% were male. The control group included 334 age and sex-matched participants. Most (n=189; 56.6%) of the children with leukemia were <10 years of age. Differences between cases and controls included the duration of breastfeeding (p<0.0001), mean birthweight (p<0.001), maternal age (p<0.001), paternal age (p<0.001), birth order (p<0.001), mean number of children (p<0.001), BMI percentile (p=0.042), and maternal smoking (p=0.012). Breastfeeding duration of up to 6 months' duration, when compared with feeding of longer than 6 months, was associated with increased odds ratios (OR) for acute lymphoblastic leukemia

(OR=3.43, 95% confidence interval [CI] 2.37–4.98; p<0.001), Hodgkin's lymphoma (OR=1.58, 95% CI: 0.88–2.84, p=0.120), Non-Hodgkin's lymphoma (OR=2.14, 95% CI: 1.25–3.65, p=0.005), and overall (OR=1.95, 95% CI: 1.40–2.71, p<0.001). Cases also differed from controls with regard to FGIDs, such as stomach ache (p<0.001), dyspepsia (p<0.001), early satiety (p=0.017), bowel satisfaction (p<0.001), bloating (p<0.001), nausea (p=0.005), vomiting (p=0.039), constipation (p=0.003), diarrhea (p=0.010), gastrointestinal canal congestion (p=0.039), muscle aches pains (p=0.008), fecal incontinence (p=0.021), and indigestion (p=0.003).

A multivariate stepwise regression analysis revealed that maternal smoking (p<0.001), formula feeding (p<0.001), duration of breastfeeding (p<0.001), birth order (p=0.002), mother's age (p=0.004) and the child's birthweight (p=0.009) were predictors for leukemia.

Further analysis showed that dyspepsia (p<0.001), gastrointestinal tract canal congestion (p<0.001), constipation (p=0.009), diarrhea (p=0.013), bowel satisfaction (p=0.021), bloating (p=0.022), duration of breastfeeding (p<0.001), and stomach ache (p=0.025) were significant predictors for developing FGID symptoms after adjusting for age, gender, and other confounding variables.

Conclusions: This study confirmed that breastfeeding has some effect on reducing possible risk of childhood lymphoma and leukemia and FGID symptoms compared with healthy control children.

5.4. Danish population based study of familial epilepsy and childhood cancer.

Platamone, C. C., Deng, C., Mazumder, R., Ritz, B., Olsen, J., Hansen, J., Saechao, C., & Heck, J. E. (2024). Danish population based study of familial epilepsy and childhood cancer. *European Journal of Epidemiology*.

Background: Results from studies investigating the association between maternal or child epilepsy, use of anticonvulsants in pregnancy, and childhood cancer are inconsistent and at times contradictory. This study aimed to evaluate to link between diagnosis of epilepsy, the use of anticonvulsant drugs, and childhood cancer.

Methods: Linking Danish national databases, the authors obtained epilepsy and childhood cancer diagnoses, and anticonvulsant use data. Adjusted odds ratios of all or specific childhood cancers in relation to maternal or child epilepsy and anticonvulsant therapies were estimated using conditional logistic regression.

Results: Maternal epilepsy was positively associated with all childhood cancers in offspring, specifically, with acute lymphoblastic leukemia (Odds Ratio (OR)=1.68, 95% Confidence Interval (CI)=1.16, 2.43) and Wilms tumor (OR=2.13, 95% CI=0.97, 4.68). When considering maternal ever (lifetime) ingestion of anticonvulsants, a positive association was found with all cancers (OR=1.14, 95% CI=1.00, 1.30), and central nervous system tumors (CNS) (OR=1.36, 95% CI=1.04, 1.76) as well as neuroblastoma (OR=1.76, 95% CI=1.06, 2.90) among offspring. Maternal anticonvulsant use before or during the index pregnancy was related to CNS tumors in offspring (OR=1.99, 95% CI=0.99, 4.00).

Conclusions: This study provides an indication that certain anticonvulsant medications may be carcinogenic to children exposed in utero.

6. References

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