Bundesamt
für Strahlenschutz

Spotlight on EMF Research

Spotlight on “Residential exposure to magnetic fields from high-voltage power lines and risk of childhood leukemia” by Malagoli et al. in Environmental Research (2023)

Category [low frequency, epidemiology]

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Competence Centre Electromagnetic Fields (KEMF)

1 Putting the paper [1] into context by the BfS

In 2001, the International Agency for Research on Cancer (IARC) classified exposure to extremely low-frequency magnetic fields (ELF-MF) as possibly carcinogenic to humans (group 2B) [2]. Later on, this assessment has been confirmed by the European Commission’s Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) [3]. Both classifications are mainly based on evidence from epidemiological studies on childhood leukemia. As of today, experimental studies on animals failed to convincingly confirm an increased risk for leukemia [4]. Similarly, no plausible biophysical mechanisms have yet been identified [5, 6].

2 Results and conclusions from the authors‘ perspective

The study by Malagoli et al. [1] is the most recent primary epidemiological study on ELF-MF and childhood leukemia and is not included in the latest pooled analyses [7]. Malagoli et al. [1] targeted two central questions on the risk of childhood leukemia associated with exposure to ELF-MF. First, is childhood leukemia associated with distance to high-voltage power lines? Second, is childhood leukemia associated with estimated magnetic field exposure based on exposure modelling? The motivation for this study was to provide evidence on this potential association based on an extension of a previous study from this group [8], but now including more cases of childhood leukemia and more recent exposure data.

For this reason, they carried out a case-control study. They included 182 registry-based childhood leukemia cases, aged 0-15 years and diagnosed between 1998-2019 in the Northern Italian provinces of Modena and Reggio Emilia. Cases were matched on age, sex and province to 726 controls. All cases of childhood leukemia for that time period were ascertained through the nationwide hospital-based registry of childhood malignancies. Controls were selected from all residents enrolled in the National Health Services directory of Modena and Reggio Emilia provinces.

To estimate ELF-MF exposure in the homes of the participants, two approaches were used. First, as a proxy for the actual exposure to ELF-MF, they calculated the geocoded distance between the homes of the participants and the closest ≥132 kV power line using a Graphical Information System (GIS). To categorize the exposure, the authors used previously defined cutpoints for the distances of transmission lines to the homes (<100 meter (m), 100-200 m, 200-400 m, and ≥400 m (reference category)). Second, they performed exposure modelling to assess ELF-MF exposure based on current intensity measured every 15 minutes for all days in 2001 of 194 high-voltage power lines in the study region. The average ELF-MF exposure was modelled in corridors of 8 m in height and the exposure categories <0.1 (reference category), 0.1-0.2, 0.2-0.4 and ≥0.4 µT were defined.

To calculate the potential risk of childhood leukemia based on ELF-MF exposure, the authors used standard statistical methods. To account for potential confounding effects, the authors adjusted their main models for distance to nearest petrol station and fuel supply within a 1000 m buffer, benzene, indoor transformer stations, urban area and arable crops.

The authors observed a two times higher risk for childhood leukemia for children living <100 m from high-voltage power lines compared to children living ≥400 m away from the next high-voltage power lines, however, the risk was not statistically significant (odds ratio (OR) = 2.1 (95% confidence interval (CI) 0.9-5.2). Additional adjustment for potential confounders in the model did not modify the observed risk. In a stratified analysis on children <5 years at diagnosis and corresponding controls, the OR for the same comparison of distance was 2.4 (95% CI 0.4-14.6). In the restricted cubic spline regression models, a strong but imprecise association between distance to high-voltage power lines was identified for children living closer than 100 m away from a power line. The effect diminished with increasing distance.

For the exposure modeling-based analyses, the authors post-hoc combined the exposure categories above the reference category to one category, i.e. exposure to ≥0.1 µT, due to limited cases and controls in the single a-priori defined exposures categories. In the adjusted analyses, comparison of children exposed to <0.1 µT to children with ≥0.1 µT identified an OR of 7.6 (95% CI 0.7-83.8), based on two cases and one control.

The authors conclude that in their Italian study population, residence within 100 m of high-voltage power lines was associated with an increased risk of childhood leukemia. Furthermore, they contextualized their results with other epidemiological studies in this field, which also observed an increased risk of childhood leukemia for ELF-MF exposure levels of ≥0.1 µT. The authors hypothesize that the risk of childhood leukemia may already start to increase at these low exposure levels.

3 Comments by the BfS

The topic of the recent paper by Malagoli et al. [1] has a high public health relevance. Cancer in children is a rare disease, accounting for approximately 1% of all incident malignancies [9]. However, cancer is the most common cause of disease-related death in children in high-income countries [10]. Of all cancer cases in children, leukemia is the most common childhood cancer in industrialized countries with about 34% [9]. While treatment and survival of childhood leukemia made some remarkable improvements over the past decades, survivors are yet at risk of a wide range of potential late effects including psychosocial and socioeconomic consequences later in life and somatic effects, e.g. treatment-induced second malignancies. For this reason, establishing primary preventive measures remains a central goal. Identifying modifiable risk factors is crucial for this task and only a few potential factors have been identified [11]. Among them, exposure to ELF-MF is discussed [12]. The paper is contributing to the ongoing discussion on EMF and cancer and is therefore an important addition to the body of evidence.

The authors conclude that residence within 100 m of high-voltage power lines is associated with an increased risk of childhood leukemia in their study population. Although the study has its strengths, namely a complete coverage of cases in the study region, blind exposure assessment und avoiding selection bias due to no active participation of the study population, three main limitations of the study have to be pointed out in order to evaluate its validity and implications.

First, both the number of cases and the percentage of highly exposed participants in this study is small, which leads to uncertainties in the risk estimates. For example, the group of children living <100 m to a high-voltage power line includes only 8 cases and 15 controls. At exposure ≥0.4 µT, there is only one case, making an analysis of this category impossible. However, even when grouping together children with exposure above ≥0.1 µT, only two cases and one control are available. This results in an extremely wide CI and it cannot be ruled out that the observed increased risks are a chance finding.

Second, the authors listed a range of potential confounders included in their study. However, they missed to adjust for the single established risk factor for childhood leukemia, which is ionizing radiation [12], because they did not have information on this variable. Not adjusting for background radiation or diagnostic radiation could lead to biased results. Additionally, only for approximately half of the cases and controls complete information on confounders is available, resulting in a significant number of missings. Comparing the results of the analyses based on cases and controls with all adjustment variables, which are presented in the Appendix, differences in OR can be observed. Analyses based on available 93 cases and 368 controls with all confounding variables available showed an adjusted OR of 1.3 (95% CI 0.3-5.0) for children living <100 m vs >400 m from high-voltage power-lines. In comparison, the OR presented as the main result, based on 182 cases and 726 controls with a reduced set of available covariates, was 2.0 (95% CI 0.8-5.0). However, even in the non-adjusted analyses of the 93 cases and 368 controls with all available confounder variables, the OR was 1.3 (95% CI 0.3-4.9). This raises the question if this group is considerably different on its own compared to the complete group as the OR differ. Potential reasons for missing information in the covariates were not given by the authors, which makes the interpretation of the results less reliable.

Third, the exposure assessment is susceptible to exposure misclassification for two reasons. One, the exposure was retrospectively estimated for the residency at time of diagnosis. The residence and therefore the exposure at time of diagnosis is not necessarily always identical with the place of residence at the time of the study, e.g. in case of moving. A complete history of residencies with corresponding time windows until diagnosis would have been more informative and would effectively reduce the risk for exposure misclassification. Assuming this effect to be non-differential for cases and controls, it could bias the results towards or away from the null [13]. In addition, modelling of exposure to ELF-MF is based on data on current intensity from 2001. It is possible that current intensity changed through the years, e.g. because of higher demands. The authors explain that in the study area limited variability over time of current flows of power lines was present. However, the authors state that during 1986-2007 the power line flow increased by about 3% per year and after that remained stable in most recent years. They referenced this statement with one article [14]. However, this reference does not include any more information on this aspect, making it impossible to validate that statement.

The findings by Malagoli et al. [1] have to be interpreted in the light of the small number of cases, especially in the exposed group, of susceptibility to confounding, and the potential risk for exposure misclassification. However, these are typical limitations of epidemiological studies in this field. Given these uncertainties, we do not agree with the authors' conclusion, especially regarding a potential increase of the risk of childhood leukemia starting already at ELF-MF exposure of 0.1 µT. In our opinion large pooled analyses with individual-level data can provide more convincing evidence, such as the recent pooled study with data of 24,994 cases and 30,769 controls that showed an OR of 1.01 (95% CI 0.61-1.66, comparing <0.1 µT vs. ≥0.4 µT) [7] for the risk of childhood leukemia in children exposed to ELF-MF. However, the results of Malagoli et al. [1] underscore the importance of continued research in this area.

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