Exhibit "B": Preliminary Easement Sketch

Caldwell County, MO

S14-R28W-T55N

FILED
December 28, 2016
Data Center
Missouri Public
Service Commission

EXHIBIT
54

Right-of-Way Length: Ft. +/-

Date: 4/7/2014

N

1 in = 900 ft

0 225 450 900 1,350 1,800

Feet

Measurements pending final survey and engineering, for an easement not to exceed 200 feet in width.

For discussion purposes only. All measurements and distances are approximations and pending final survey and engineering.

Prepared by:

CLS CONTRACT LAND STAFF

Contract Land Staff, LLC
2245 Texas Drive, Suite 200
Sugar Land, TX 77479

Legend

- Property Boundaries
- Section Boundaries
- Easement Consideration Area
- Adjacent Tracts

GRAIN BELT EXPRESS
CLEAN LINE

John S. Christopher

Tract No.:MO-CA-043.000

Property owned by Christopher Family Trust
100 Acres John S. & Sherry D. Christopher

Date Revised: 4/7/2014

http://www.ncbi.nlm.nih.gov/pubmed/20843128

Asian Pac J Cancer Prev. 2010;11(2):423-7.

Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study.

Sohrabi MR[1], Tarjoman T, Abadi A, Yavari P.

Author information

- [1]Department of Community Medicine, Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. m_sohrabi@sbmu.ac.ir

Abstract

This study aimed to investigate association of living near high voltage power lines with occurrence of childhood acute lymphoblastic leukemia (ALL). Through a case-control study 300 children aged 1-18 years with confirmed ALL were selected from all referral teaching centers for cancer. They interviewed for history of living near overhead high voltage power lines during at least past two years and compared with 300 controls which were individually matched for sex and approximate age. Logistic regression, chi square and paired t-tests were used for analysis when appropriate. The case group were living significantly closer to power lines (P<0.001). More than half of the cases were exposed to two or three types of power lines (P<0.02). Using logistic regression, odds ratio of 2.61 (95%CI: 1.73 to 3.94) calculated for less than 600 meters far from the nearest lines against more than 600 meters. This ratio estimated as 9.93 (95%CI: 3.47 to 28.5) for 123 KV, 10.78 (95%CI: 3.75 to 31) for 230 KV and 2.98 (95%CI: 0.93 to 9.54) for 400 KV lines. Odds of ALL decreased 0.61 for every 600 meters from the nearest power line. This study emphasizes that living close to high voltage power lines is a risk for ALL.

PMID:
20843128
[PubMed - indexed for MEDLINE]
Free full text

thebmj

Papers

Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study

BMJ 2005; 330 doi: http://dx.doi.org/10.1136/bmj.330.7503.1290 (Published 02 June 2005) Cite this as: BMJ 2005;330:1290

Gerald Draper, honorary senior research fellow (gerald.draper@ccrg.ox.ac.uk)[1], **Tim Vincent, research officer**[1], **Mary E Kroll, statistician**[1], **John Swanson, scientific adviser**[2]

[1] *Childhood Cancer Research Group, University of Oxford, Oxford OX2 6HJ*

[2] *National Grid Transco plc, London WC2N 5EH*

Correspondence to: G J Draper

- Accepted 6 April 2005

Abstract

Objective To determine whether there is an association between distance of home address at birth from high voltage power lines and the incidence of leukaemia and other cancers in children in England and Wales.

Design Case-control study.

Setting Cancer registry and National Grid records.

Subjects Records of 29 081 children with cancer, including 9700 with leukaemia. Children were aged 0-14 years and born in England and Wales, 1962-95. Controls were individually matched for sex, approximate date of birth, and birth registration district. No active participation was required.

Main outcome measures Distance from home address at birth to the nearest high voltage overhead power line in existence at the time.

Results Compared with those who lived > 600 m from a line at birth, children who lived within 200 m had a relative risk of leukaemia of 1.69 (95% confidence interval 1.13 to 2.53); those born between 200 and 600 m had a relative risk of 1.23 (1.02 to 1.49). There was a significant ($P < 0.01$) trend in risk in relation to the reciprocal of distance from the line. No excess risk in relation to proximity to lines was found for other childhood cancers.

Conclusions There is an association between childhood leukaemia and proximity of home address at birth to high voltage power lines, and the apparent risk extends to a greater distance than would have been expected from previous studies. About 4% of children in England and Wales live within 600 m of high voltage lines at birth. If the association is causal, about 1% of childhood leukaemia in England and Wales would be attributable to these lines, though this estimate

has considerable statistical uncertainty. There is no accepted biological mechanism to explain the epidemiological results; indeed, the relation may be due to chance or confounding.

Introduction

The electric power system produces extremely low frequency electric and magnetic fields. Since 1979 there has been concern that these fields may be associated with cancer.[1] Concern has concentrated on magnetic rather than electric fields and on childhood leukaemia in particular. A pooled analysis of nine studies that met specified quality criteria found that children living in homes with 24 hour average fields of ≥0.4 μT have twice the risk of leukaemia.[2] In 2001 the International Agency for Research on Cancer classified extremely low frequency magnetic fields as "possibly carcinogenic" on the basis of "limited" epidemiological evidence and "inadequate" evidence from animals.

Magnetic fields in homes arise mainly from low voltage distribution wiring, house wiring, and domestic appliances. Only a small fraction of homes are close to high voltage overhead power lines (transmission lines), but in these homes the power line is likely to be the main source of magnetic field.

We investigated whether proximity of home address at birth to transmission lines in England and Wales is associated with increased risks of childhood cancer. It is not known which period of life, if any, is relevant to induction of cancer by magnetic fields. Previous research has considered address at diagnosis or throughout some specified period. Over half (55%) of cases of childhood leukaemia and 43% of other cancers in childhood occur by the age of 5 years.

Methods

Cases and controls

Children aged 0-14 years with cancer (malignant neoplasms and tumours of the central nervous system and brain) in England, Scotland, and Wales, ascertained through several sources including the National Cancer Registration System and the UK Children's Cancer Study Group, are included in the National Registry of Childhood Tumours at the Childhood Cancer Research Group.

We identified nearly 33 000 cases of childhood cancer in children born in England and Wales, 1962-95, and diagnosed in England, Wales, or Scotland over the same period. We obtained birth information for just over 31 000 cases, 1700 having been excluded because the child was adopted or the birth record could not be traced. For each case we selected from birth registers a control matched for sex, date of birth (within six months), and birth registration district. Registration districts vary greatly in size and are frequently redefined; there are currently about 400. We attempted to find the postcode and approximate grid reference of the address at birth for all cases and controls, but this was not always possible. The final dataset comprised 29 081 matched case-control pairs (9700 for leukaemia) that we could map with respect to transmission lines.

Calculation of distance from power lines

We looked at overhead power lines forming the National Grid in England and Wales—that is, all 275 and 400 kV overhead lines (the highest voltages used) plus a small fraction of 132 kV lines, about 7000 km altogether. We obtained the grid references of all 21 800 pylons concerned from the records of National Grid Transco. Using the postcode at birth we identified subjects living within 1 km of a transmission line. For 93% of these addresses we obtained, from the Ordnance Survey product AddressPoint, a 0.1 m grid reference and hence calculated the shortest distance to any of the transmission lines that had existed in the year of birth, re-creating previous locations of lines when necessary and possible. For calculated distances less than 50 m, we took the average of the nearest and furthest points of the building from the line, using large scale maps. We aimed to obtain a complete set of accurate distances for all subjects within 600 m of a line, a distance chosen to be well beyond that at which the magnetic field from the line is thought to be important.

Statistical analysis

We used conditional logistic regression on the matched case-control pairs to calculate relative risks and χ^2 values.

Results

Table 1 shows the distribution of distances from the nearest line for cases, subdivided into leukaemia, central nervous system/brain, and "other," and for matched controls. Most (97%) of these distances were ≥600 m. The relative risk is an estimate of the incidence compared with that at distances ≥ 600 m. For leukaemia, at each distance category < 600 m the relative risks are greater than 1.0; there is some evidence that the risk varies according to distance from the line, though there is no smooth trend. For the other diagnoses, our data suggest no increased risk.

	Leukaemia			CNS/brain tumours			Other diagnoses		
Distance to line (metres)	**Cases**	**Controls**	**RR**	**Cases**	**Controls**	**RR**	**Cases**	**Controls**	**RR**
0-49	5	3	1.67	3	7	0.44	7	6	1.17
50-99	19	11	1.79	4	6	0.69	15	16	0.91
100-199	40	25	1.64	26	32	0.82	37	45	0.81
200-299	44	39	1.16	38	28	1.35	66	76	0.87
300-399	61	54	1.15	35	30	1.19	79	65	1.21
400-499	78	65	1.23	40	42	0.96	80	97	0.82
500-599	75	56	1.36	54	41	1.33	86	85	1.01
≥600 (reference group)	9378	9447	1.00	6405	6419	1.00	12 406	12 386	1.00
Total	9700	9700		6605	6605		12 776	12 776	

- CNS=central nervous system.

Table 1

Distance of address at birth from nearest National Grid line for cases and controls in each diagnostic group, and estimated relative risk (RR)

In general, emanations from a line source are expected to reduce in strength as the reciprocal of distance, but the magnetic field from a power line generally falls as the inverse square of distance, or sometimes the inverse cube.[3] For each diagnostic group, we tested whether the risk is some function of distance (*d*) from the nearest line (table 2), using three models: that the risk depends on the rank of the distance band, the reciprocal of the distance ($1/d$), or the inverse square ($1/d^2$). There were no significant results for central nervous system/brain tumours or for "other tumours." For leukaemia, the results of two of the trend analyses were significant ($P < 0.01$); these analyses suggest the risk might depend either on the rank of the distance category or on the reciprocal of distance. The latter seems more plausible. We therefore retabulated the results for leukaemia at intervals corresponding to roughly equal intervals of $1/d$ (table 3). This change in the grouping of the data does not change the pattern of relative risk estimates shown in table 1 or the significance of the test for trend with *1/d*. For simplicity we also analysed risk of leukaemia in bands 0-199 m and 200-599 m. The risks relative to ≥ 600 m were 1.69 and 1.23; the trend with *1/d* was significant (P < 0.01).

	Leukaemia	CNS/brain tumours	Other diagnoses
Ranked distances	8.76, P=0.003	0.01, P=0.924	0.64, P=0.424
Reciprocal of distance (1/d)	6.72, P=0.0095	1.09, P=0.296	0.12, P=0.733
Reciprocal of square of distance ($1/d^2$)	1.47, P=0.225	1.83, P=0.177	0.03, P=0.873

- * Distance (d) for each case is taken as midpoint of limits of band within which it lies (as specified in table 1).

Table 2

Tests of hypotheses relating trends in relative risks to alternative measures of proximity to nearest line (based on the eight distance categories* in table 1). Figures are χ^2 for trend (with 1 df) and P value

Table 3

Relative risk (RR) estimates for leukaemia using revised distance categories (see text)

Distance, d (metres)	1/d	RR (95% CI)	RR* (95% CI)
0-49	0.040	1.67 (0.40 to 6.97)	1.65 (0.39 to 6.89)
50-69	0.017	1.51 (0.48 to 4.79)	1.53 (0.48 to 4.83)
70-99	0.012	2.02 (0.76 to 5.39)	2.00 (0.75 to 5.32)
100-199	0.007	1.64 (1.00 to 2.71)	1.64 (0.99 to 2.70)
0-199	0.010	1.69 (1.13 to 2.53)	1.68 (1.12 to 2.52)
200-599	0.003	1.23 (1.02 to 1.49)	1.22 (1.01 to 1.47)
≥600 (reference group)	0.000	1.00	1.00

- * Adjusted for socioeconomic status.

We examined the possibility that the relation between distance and risk of leukaemia is a consequence of a relation between distance and socioeconomic status. We used the Carstairs deprivation index to allocate a measure of socioeconomic status to the census ward in which each child was living at birth.[4] The results in table 4 confirm the previously reported association between affluence and risk of childhood leukaemia (P for trend < 0.01).[5] Adjustment for socioeconomic status had no effect on the relative risks for distance (table 3).

Table 4

Socioeconomic status	Leukaemia	CNS/brain tumours	Other diagnoses
1 (most affluent)	1.00	1.00	1.00
2	0.96	0.97	1.04
3	0.94	0.93	0.99
4	0.90	0.97	0.95
5 (most deprived)	0.88	0.92	0.98
χ^2 for trend	6.79, P=0.009	1.38, P=0.240	1.07, P=0.302

Relative risks for categories of socioeconomic status

Power lines produce small air ions through a process known as "corona." Fews et al suggest that this could lead to health effects when winds blow the ions away from the line.6 We have made an initial test of this hypothesis using a simple model suggested by Preece et al (personal communication), assuming the prevailing wind is from the south west. The case-control ratio was no greater downwind than upwind of power lines, so, using this admittedly oversimplified approach, we have no evidence to support this hypothesis.

Discussion

To date this is the largest study of childhood cancer and power lines, with roughly twice the number of children living close to power lines than in the next largest study.7 We found that the relative risk of leukaemia was 1.69 (95% confidence interval 1.13 to 2.53) for children whose home address at birth was within 200 m of a high voltage power line compared with those more than 600 m from the nearest line. For 200-600 m the relative risk was 1.23 (1.02 to 1.49). The finding that the increased leukaemia risk apparently extends so far from the line is surprising in view of the very low level of magnetic field that could be produced by power lines at these distances.

Possible explanations for findings

There is no obvious source of bias in the choice of cases or controls. The study is based on records of childhood cancer in England and Wales over most of the period that the National Grid has existed. Registration for childhood cancer is nearly complete, and it seems improbable that the likelihood of registration is related to proximity of birth address to transmission lines. Controls were selected from registers compiled through the legally required process of birth registration. No participation by cases or controls was required. We calculated distances without knowing case-control status, and we were able to include 88% of the eligible cases, each with a matched control.

Populations near power lines may have different characteristics from the rest of the population. In our control data there is a slight tendency in urban areas for greater affluence (measured by the Carstairs index) closer to lines, though in rural areas there is no clear trend. There is known to be a positive association between affluence and rates of childhood leukaemia. However, adjustment for socioeconomic status of the census ward of birth address did not explain our finding. Population mixing has been associated with childhood leukaemia,8 but in our cases individual mobility, measured by changes of postcode between birth and diagnosis, was no more common for those whose home at birth was closer to the lines. Other characteristics of the population (for instance parity, which has sometimes been found to be associated with childhood leukaemia9) may vary with proximity to power lines, but we do not have the data to determine whether these explain our result.

The results are highly significant but could nevertheless be due to chance—for example, if the leukaemia controls are not sufficiently representative of the relevant population. Some support for this explanation can be derived from the different distance distributions observed for the leukaemia and non-leukaemia controls in table 1. Comparison of the leukaemia cases with the latter still suggests that there is an increased risk for leukaemia but it is much lower than that found using the matched controls. We emphasise, however, that the use of the matched controls is the most appropriate approach.

Six of the studies included in the pooled analysis referred to above[2] contain, or have been extended to include, analyses of proximity to power lines.[7 10-14] Of these, one, a previous UK study,[10] with 1582 cases of leukaemia diagnosed during 1992-6 (most of which will be contained within our 9700), found a relative risk of 1.42 (0.85 to 2.37) for acute lymphocytic leukaemia within 400 m for 275 and 400 kV lines; this supports our results. Studies in Canada[11] and Sweden[7] also found increased risks for childhood leukaemia (Canada: relative risk 1.8 (0.7 to 4.7) for residence within 100 m of transmission lines of 50 kV or more, and 1.3 within 50 m; Sweden: 2.9 (1.0 to 7.3) for residence £ 50 m versus 101-300 m from 220 and 400 kV power lines, with no increase for other childhood cancers). Studies from Denmark,[12] Norway,[13] and the United States[14] found relative risks below 1.0 but were based on smaller numbers. None of these estimates relates to distances as great as ours; some used a reference category that is within the distance where we found an increased risk.

Our study concerned home address at birth, whereas much previous magnetic field epidemiology has concerned address at other times. Half of the children with leukaemia in this study had the same address at diagnosis as at birth; we have no corresponding information for the control group.

The most obvious explanation of the association with distance from a line is that it is indeed a consequence of exposure to magnetic fields. For magnetic fields in the home the pooled analysis by Ahlbom et al found a relative risk of 2.00 (1.27 to 3.13) for exposures ≥0.4 μT versus < 0.1 μT; the risks for fields < 0.4 μT were near the no effect level.[2] Another pooled analysis, including additional studies, found a similar result with a threshold of 0.3 μT.[15] For the power lines we investigated, the magnetic field falls to 0.4 μT at an average of about 60 m from the line (based on calculations using one year of recorded loads for a sample of 42 lines). Our increased risk seems to extend to at least 200 m, and at that distance typical calculated fields from power lines are < 0.1 μT, and often < 0.01 μT—that is, less than the average fields in homes from other sources. Thus our results do not seem to be compatible with the existing data on the relation between magnetic fields and risk. The estimated relative risk was more closely related to the reciprocal of the distance from the line than to the square of the reciprocal of the distance.

Conclusions

While few children in England and Wales live close to high voltage power lines at birth, there is a slight tendency for the birth addresses of children with leukaemia to be closer to these lines than those of matched controls. An association between childhood leukaemia and power lines has been reported in several studies, but it is nevertheless surprising to find the effect extending so far from the lines. We have no satisfactory explanation for our results in terms of causation by magnetic fields or association with other factors. Neither the association reported here nor previous findings relating to level of exposure to magnetic fields are supported by convincing laboratory data or any accepted biological mechanism.

Assuming that the higher risk in the vicinity of high voltage lines is indeed a consequence of proximity to the lines we can estimate the attributable annual number of cases of childhood leukaemia in England and Wales. The annual incidence of childhood leukaemia in England and Wales is about 42 per million; the excess relative risks at distances of 0-199 m and 200-599 m are about 0.69 and 0.23, respectively, giving excess rates of 28 and 10 per million. (These two estimates allow for the fact that the incidence for England and Wales is itself partly based on cases occurring in the vicinity of power lines.) We estimate that of the 9.7 million children in the population (2003 estimate), at birth about 80 000 would have lived within 199 m of a line and 320 000 between 200 and 599 m. Thus, of the 400-420 cases of childhood leukaemia occurring annually, about five would be associated with high voltage power lines, though this estimate is imprecise. We emphasise again the uncertainty about whether this statistical association represents a causal relation.

What is already known on this topic

Power frequency magnetic fields, produced by the electric power system, are "possibly carcinogenic"

A pooled analysis of case-control studies found that children living in homes with high magnetic fields (> 0.4 μT) had twice the risk of childhood leukaemia

High voltage power lines are one source of these fields

What this study adds

A UK study of 29 000 cases of childhood cancer, including 9700 cases of leukaemia, found a raised risk of childhood leukaemia in children who lived within 200 m of high voltage lines at birth compared with those who lived beyond 600m (relative risk 1.7)

There was also a slightly increased risk for those living 200-600 m from the lines at birth (relative risk 1.2, P for trend < 0.01); as this is further than can readily be explained by magnetic fields it may be due to other aetiological factors associated with power lines

Acknowledgments

We are grateful to colleagues at the Childhood Cancer Research Group and at National Grid Transco for help with this study and to cancer registries and the United Kingdom Children's Cancer Study Group for notifications of cases of childhood cancer.

Footnotes

- Contributors GD was responsible for overall direction of the study and publication. GD and JS had the initial idea and designed the study. TV and MEK collected information on cases and controls and carried out the statistical analysis. JS assessed exposures. GD and JS are guarantors
- Funding This study was undertaken as part of a project funded by the United Kingdom Department of Health Radiation Protection Programme. The Childhood Cancer Research Group also receives funding from the Department of Health and the Scottish Ministers. The views expressed here are those of the authors and not necessarily those of the Department of Health and the Scottish Ministers. National Grid Transco provided staff time but no other funding.
- Competing interests JS is employed by National Grid Transco and worked on this project with their permission. A written contract exists between the Childhood Cancer Research Group and National Grid Transco specifying that the Childhood Cancer Research Group has complete control over the conduct, interpretation, and publication of this study; this paper has not been approved by anyone in National Grid Transco other than JS in his capacity as author and does not necessarily represent National Grid Transco's views
- Ethical approval The Childhood Cancer Research Group has local ethics committee approval and, through membership of the UK Association of Cancer Registries, has approval from the Patient Information Advisory Group with respect to cancer registration function.

References

1.Wertheimer N, Leeper E.Electrical wiring configurations and childhood cancer.*Am J Epidemiol*1979; **109**:273–84.

2.Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, et al.A pooled analysis of magnetic fields and childhood leukaemia.*Br J Cancer*2000; **83**:692–8.

3.Maddock BJ.Overhead line design in relation to electric and magnetic field limits.*Power Engineering*1992;Sep:217–24.

4.Morris R, Carstairs V.Which deprivation? A comparison of selected deprivation indexes.*J Public Health Med*1991; **13**:318–26.

5.Draper GJ, Stiller CA, O'Connor CM, Vincent TJ, Elliott P, McGale P, et al.*The geographical epidemiology of childhood leukaemia and non-Hodgkin lymphomas in Great Britain, 1966-83*.London:Office for Population Census and Surveys,1991. (OPCS Studies on Medical and Population Subjects No 53.)

6.Fews AP, Henshaw DL, Wilding RJ, Keitch PA.Corona ions from powerlines and increased exposure to pollutant aerosols.*Int J Radiat Biol*1999; **75**:1523–31.

7.Feychting M, Ahlbom A.Magnetic fields and cancer in children residing near Swedish high-voltage power lines.*Am J Epidemiol*1993; **138**:467–81.

8.Kinlen L, Doll R.Population mixing and childhood leukaemia: Fallon and other US clusters.*Br J Cancer*2004; **91**:1–3.

9.Dockerty JD, Draper GJ, Vincent TJ, Rowan SD, Bunch KJ.Case-control study of parental age, parity and socioeconomic level in relation to childhood cancers.*Int J Epidemiol*2001; **30**:1428–37.

10.UK Childhood Cancer Study Investigators.Childhood cancer and residential proximity to power lines.*Br J Cancer*2000; **83**:1573–80.

11.McBride ML, Gallagher RP, Thériault G, Armstrong BG, Tamaro S, Spinelli JJ, et al.Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada.*Am J Epidemiol*1999; **149**:831–42.

12.Olsen JH, Nielsen A, Schulgen G.Residence near high voltage facilities and risk of cancer in children.*BMJ*1993; **307**:891–5.

13.Tynes T, Haldorsen T.Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines.*Am J Epidemiol*1997; **145**:219–26.

14.Kleinerman RA, Kaune WT, Hatch EE, Wacholder S, Linet MS, Robison LL, et al.Are children living near high-voltage power lines at increased risk of acute lymphoblastic leukemia?*Am J Epidemiol*2000; **151**:512–5.

15.Greenland S, Sheppard AR, Kaune WT, Poole C, Kelsh MA.A pooled analysis of magnetic fields, wire codes, and childhood leukemia.*Epidemiology*2000; **11**:624–34.

Health Effects of EMF exposures

https://www.youtube.com/watch?v=qj_QgFIqAdE

Cellular Stress Response:

Dr. Martin Blank, PhD states, "When cells come into contact with a harmful environment, such as EMF exposures, they release stress proteins." These stress proteins cause inflammation in the body at the cellular level.

http://emwatch.com/emf-health-effects/

Health Effects of ElectroMagnetic Radiation

Published on Feb 24, 2014
Health Effects of EMF: Focus on DNA with Martin Blank, PhD on GustEnviro.com.
Department of Physiology and Cellular Biophysics, Columbia University

BJC home | AOP | Current issue | Submit article

British Journal of Cancer

Web feeds

Br J Cancer. 2010 Sep 28; 103(7): 1128–1135.
Published online 2010 Sep 28. doi: 10.1038/sj.bjc.6605838

PMCID: PMC2965855

Pooled analysis of recent studies on magnetic fields and childhood leukaemia

L Kheifets,[1,*] A Ahlbom,[2] C M Crespi,[3] G Draper,[4] J Hagihara,[5] R M Lowenthal,[6] G Mezei,[7] S Oksuzyan,[1] J Schüz,[8] J Swanson,[9] A Tittarelli,[10] M Vinceti,[11] and V Wunsch Filho[12]

[1]Department of Epidemiology, UCLA School of Public Health, 650 Charles Young Drive, Los Angeles, CA 90095, USA
[2]Division of Epidemiology, Institute of Environmental Medicine, Nobels väg 13, Karolinska Institutet, Stockholm SE-171 77, Sweden
[3]Department of Biostatistics, UCLA School of Public Health, Charles Young Drive, Los Angeles, CA 90095, USA
[4]Childhood Cancer Research Group, University of Oxford, Richards Building, Old Road Campus, Oxford OX3 7LG, UK
[5]Miyagi University, 1-1 Gakuen, Taiwa-cho Kurokawa-gun, Miyagi 981-3298, Japan
[6]School of Medicine and Menzies Research Institute, University of Tasmania, 17 Liverpool Street, Hobart, Tasmania 7000, Australia
[7]Environment Department, Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, CA 94304, USA
[8]Institute of Cancer Epidemiology, Danish Cancer Society, Strandboulevarden 49, Copenhagen DK-2100, Denmark
[9]National Grid, plc, 1-3 Strand, London WC2N 5EH, UK
[10]Cancer Registry and Environmental Epidemiology Unit, National Cancer Institute, Via Venezian, Milan 120133, Italy
[11]Department of Public Health Sciences, University of Modena and Reggio Emilia, Via Campi 287, Modena 41100, Italy
[12]School of Public Health, Av. Dr Arnaldo, 715, Universidade de São Paulo, 01246-904 São Paulo, Brazil
[*]E-mail: kheifets@ucla.edu

Received 2010 Mar 17; Revised 2010 Jun 9; Accepted 2010 Jul 12.

This article has been corrected. See Br J Cancer. 2011 January 04; 104(1): 228.

This article has been cited by other articles in PMC.

ABSTRACT

Go to:

Background: Previous pooled analyses have reported an association between magnetic fields and childhood leukaemia. We present a pooled analysis based on primary data from studies on residential magnetic fields and childhood leukaemia published after 2000.

Methods: Seven studies with a total of 10 865 cases and 12 853 controls were included. The main analysis focused on 24-h magnetic field measurements or calculated fields in residences.

Results: In the combined results, risk increased with increase in exposure, but the estimates were imprecise. The odds ratios for exposure categories of 0.1–0.2 μT, 0.2–0.3 μT and $\geqslant$0.3 μT, compared with <0.1 μT, were 1.07 (95% CI 0.81–1.41), 1.16 (0.69–1.93) and 1.44 (0.88–2.36), respectively. Without the most influential study from Brazil, the odds ratios increased somewhat. An increasing trend was also suggested by a nonparametric analysis conducted using a generalised additive model.

Conclusions: Our results are in line with previous pooled analyses showing an association between magnetic fields and childhood leukaemia. Overall, the association is weaker in the most recently conducted studies, but these studies are small and lack methodological improvements needed to resolve the apparent association. We conclude that recent studies on magnetic fields and childhood leukaemia do not alter the previous assessment that magnetic fields are possibly carcinogenic.

Keywords: magnetic fields, childhood leukaemia, pooled analysis, meta-analysis

Over the past three decades, potential health effects of residential and occupational exposure to extremely low-frequency electric and magnetic fields have been extensively investigated in epidemiological studies. Most attention has focused on a potential association between residential magnetic field exposure and childhood leukaemia. Almost all individual studies on magnetic fields and childhood leukaemia have found increased risks associated with the top percentiles of exposure levels; most of them, however, have involved a small number of exposed cases at the top percentiles. This has given rise to various interpretations. Two pooled analyses by Ahlbom *et al*, (2000) and Greenland *et al*, (2000), based on 9 and 12 studies, respectively, published up to 1999, have provided a basis for concluding that a consistent epidemiological association exists between residential exposure to magnetic fields and the risk of childhood leukaemia. Similar results were obtained by pooling data from four studies that included 24/48 h measurements, for exposure over the entire day and at night only (Schuz *et al*, 2007). Although hundreds of laboratory studies have been published, with a few reporting positive findings, most of the laboratory work has been negative. This has led to the general conclusion that robust, reliable and reproducible evidence of effects of magnetic fields at environmental levels on biological systems, either *in vivo* or *in vitro*, is lacking (IARC, 2002; WHO EHC, 2007). Thus, largely on the basis of epidemiological association of residential magnetic field exposure and childhood leukaemia, the International Agency for Research on Cancer has classified extremely low-frequency magnetic field exposure as being possibly carcinogenic to humans (Group 2B; IARC, 2002).

Since carrying out the pooled analyses, several new epidemiological studies have been published. The World Health Organization (WHO) reviewed results of the studies available through to 2006 in an Environmental Health Criteria (EHC) monograph (WHO EHC, 2007), with the conclusion that the 'possibly carcinogenic' classification does not change with the addition of new studies, but that the pooled analyses should be updated with the results from recent studies. In fact, such an analysis is identified as a high research priority in the WHO research agenda issued in 2007 (WHO, 2007).

We present a pooled analysis based on primary data of seven recent studies on magnetic fields and childhood leukaemia, to assess whether the combined results, adjusted for potential confounding, confirm the results of previous pooled analyses and whether there is an association between EMF exposure and childhood leukaemia.

MATERIALS AND METHODS

Go to:

Selection We searched the published literature through PubMed, as well as references of identified papers, and conducted an informal survey of epidemiologists involved in magnetic field research to identify relevant recent and ongoing studies on residential magnetic field exposure and childhood leukaemia published since the previous pooled analyses of childhood leukaemia published in (Ahlbom *et al*, 2000; Greenland *et al*, 2000). To be included, studies had to provide data for children, provide data separately for leukaemia, be population based and provide measured or calculated residential magnetic fields inside a home. Studies that used distance to power lines as an exposure metric were also included, but not in the main analysis.

We identified 14 studies, of which seven met our inclusion criteria (Table 1). Appendix 1 summarises the methods and findings of studies that were not included. One study (Hoffmann *et al*, 2008) did not publish data on children and had a large overlap with a large countrywide German study (Schuz et al, 2001); to maintain independence of observations, only the countrywide German study (former West Germany) was included. Three studies were excluded because they were hospital based (Perez *et al*, 2005; Feizi and Arabi, 2007; Abdul Rahman *et al*, 2008). One study was excluded because it was a case-only study (Yang *et al*, 2008). Another study was excluded because it was exclusively of children with Down's syndrome, who are at substantially higher risk for leukaemia (Mejia-Arangure *et al*, 2007). One study, the Northern California Childhood Leukemia Study (NCCLS), was not made available in time for inclusion. However, the exposure assessment methods of this study were substantially different from all other measurement studies: a 30-min measurement was taken in the room with the median spot measurement after a survey of the entire residence, as compared with a 24-h or more measurement in the child's bedroom in all other measured field studies (Does *et al*, 2009). We attempted to obtain unpublished data from all known sources, and identified three additional studies that are underway, but with completion dates several years away.

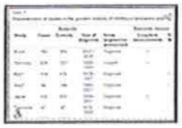


Table 1

Characteristics of studies in the pooled analysis of childhood leukaemia and EMF exposure

Materials One of the included studies (Brazil) has not yet been published (Wunsch Filho, personal communications, 2009). All included studies used a matched case–control design, although the matching variables were not the same in all studies (Bianchi *et al*, 2000; Schuz *et al*, 2001; Kabuto *et al*, 2006; Lowenthal *et al*, 2007; Kroll *et al*, 2010; Malagoli *et al*, 2010). In the original publication of one of the Italian studies, some of the controls were selected nonconcurrently (Bianchi *et al*, 2000). For this publication, the time period for that study was extended by 5 years by adding new cases and controls and was limited to the period for which concurrent control selection was possible (1978–1997). As we wanted to use as many cases and controls as possible to increase the flexibility of the analysis (and for other methodological reasons as described in Greenland *et al*, 2000), we ignored the matching and instead included adjustment for age of diagnosis, sex and study. To make the data as consistent as possible across studies, we limited the age of diagnosis to 0–15 years inclusive and converted all measured and calculated field from milligauss to microtesla. However, it should be noted that the Brazilian study included children of age 8 years or younger only, because computerised records of birth certificates used for control selection were available only from 2000 onwards. It is also the only study that includes only acute lymphoblastic leukaemia (ALL) cases.

We focused on surrogates of magnetic fields at home. All studies had long-term measurements (Brazil, Germany, Japan) or calculated magnetic fields (Italy1, Italy2, UK), except for the Tasmanian study, which included only distance to power lines. The long-term measurement studies used metres placed in the child's bedroom. Long-term measurements were taken for 24 h in two studies (Brazil, Germany), and for a 1-week period in one study (Japan). Long-term measurements can be affected by short-duration exposure to high fields, e.g., from domestic electrical appliances, which are not part of the background field at home. We followed Ahlbom *et al* (2000) and used geometric means of the long-term measurements in our analyses to reduce such effects. Three studies (UK, Italy1, Italy2) provided calculated fields, on the basis of distance between the subject's home and the closest line, taking into account historical load conditions and other line characteristics.

The studies provided exposure measurements for home at diagnosis (Brazil, Italy1, Japan), for birth home (UK) or for the home in which the child lived for the longest period of time before diagnosis (Germany). Two studies (Italy2, Tasmania) evaluated multiple residences. Some mechanisms of carcinogenesis could operate perinatally or antenatally, others later in life. In the absence of a known mechanism for magnetic fields, there is little basis for preferring one period over another, and the choice in individual studies has been highly influenced by practicalities of study design. To select an exposure proxy for subjects from these studies, we used the diagnosis home if available; if not, we used the home in which the subject lived the longest, and if that is not available, we used birth home, on the basis that, for measurement studies, more recent measurements are probably more reliable.

A number of potential confounders such as the type of dwelling, mobility, urbanisation, socioeconomic status (SES) and traffic exhaust were available in some studies (see Table 1). The number, type and coding of potential confounders differed among the studies. We examined mobility (dichotomised as one or more than one residence before diagnosis) and SES. Variables coding SES differed by study. We standardised SES to a three-level ordinal variable (low, medium and high) on the basis of SES in each country. Other potential confounders were available from too few studies to merit examination.

Statistical methods

The analysis plan largely followed that of the pooled analysis of Ahlbom *et al* (2000). An analysis using exposure as a linear predictor was conducted for a likelihood ratio test of homogeneity of effects across studies. In most analyses, increasing exposure categories of 0.1–<0.2 μT, 0.2–<0.3 μT and ⩾0.3 μT, with reference category <0.1 μT, were used. A highest cutoff point of 0.3 μT was chosen to obtain more stable results for the high-exposure category and to enable a direct comparison with results obtained by Greenland (Greenland *et al*, 2000). For comparison with results in Ahlbom, we also present some results with the highest cutoff point of 0.4 μT. Data were analysed using both ordinary logistic regression, with fixed intercepts to adjust for study, and mixed effects logistic regression, with random intercepts and exposure effect coefficients for study. Ordinary and mixed effects logistic regression yielded similar results; hence, we present results of the ordinary logistic regression analysis only. We also obtained odds ratios using a moving window of exposure. These analyses used exposure categories of 0.1–<0.2, 0.15–<0.25, 0.20–<0.30, 0.25–<0.35, ⩾0.30, ⩾0.35 and ⩾0.40, with reference category <0.1 μT, and were adjusted for age, sex and study. We estimated the trend in the log odds of being a case using a generalised additive model (GAM) (Hastie and Tibshirani, 1990) using a nonparametric curve (natural cubic smoothing spline with interior and boundary knots at the unique values of exposure) to estimate the risk associated with exposure, while controlling for study, age and sex. As a sensitivity analysis, we used a range of smoothing parameters (degrees of freedom, d.f.). These results were obtained using the gam package in R version 2.9.2 (R Development Core Team, 2009). Other analyses were conducted using Stata (StataCorp, 2007).

RESULTS

Go to:

Of the included studies, four were conducted in Europe, and one each was conducted in Japan, Brazil and Australia. Table 1 shows the numbers of cases and controls for each study, along with variables supplied by those studies. There was a total of 10 865 cases and 12 853 controls with exposure surrogates; however, total numbers in the high-exposure categories were small, even for this large data set.

Table 2 presents the absolute numbers of subjects by case–control status, study and exposure level. The UK study provided by far the largest number of cases and controls, i.e., 89 and 75% however, influence on results is more dependent on the numbers in the high-exposure category, and thus Brazil with high numbers of exposed was expected to be the most influential. Overall, in the highest-exposure category (⩾0.3 μT), there were 26 cases and 50 controls, 11 and 30 of them from the study in Brazil. Four studies (Germany, Italy1, Italy2 and Japan) provided histological type of leukaemia. Among subjects with data on type of leukaemia available, 86% were ALL cases. Numbers for other subtypes were too low to support additional analysis by subtype.

Table 2

Absolute numbers of childhood leukaemia cases and controls by study and exposure level

Table 3 summarises the main results. We present results for geometric means for long-term measurements (results for arithmetic means were similar) for each study adjusted for basic potential confounders, and separately for measured and calculated field studies, as well as combined results. A likelihood ratio test comparing models with and without random effects for exposure did not detect heterogeneity (P=0.201), supporting the pooling of studies.

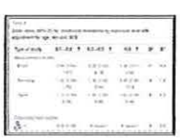


Table 3

Odds ratios (95% CI) for childhood leukaemia by exposure level with adjustment for age, sex and SES

In most individual studies and in the combined results, the risk increased with increase in exposure, although the estimates were imprecise. For calculated field studies, the number of subjects in high-exposure categories was often too small to provide reliable estimates. As Brazil was the most influential study in terms of the number of highly exposed subjects, and included only young and only ALL cases, we present results with and without Brazil. Influence analysis omitting one study at a time confirmed that Brazil was the most influential study (results not shown). Without Brazil, the summary odds ratio for ⩾0.3 μT *vs* <0.1 μT is 1.56 (95% CI 0.78–3.10), which is close to the age, sex and study-adjusted summary OR of 1.68 (95% CI 1.23–2.31) obtained in the pooled analysis of Greenland (Greenland *et al*, 2000), but less precise. In individual studies and in combined results, the number of observed cases ⩾0.3 μT was higher than the expected number obtained by modelling the probability of membership in exposure categories on the basis of the distribution of controls, including covariates.

For a more direct comparison of the current pooled results with those of Ahlbom *et al*, we conducted an analysis using the same cutoff points. Our overall risk estimates, although compatible with previously reported estimates, are substantially lower (Table 4). This is particularly true for studies on measured fields, a result heavily influenced by the Brazilian study. The combined OR for ⩾0.4 μT *vs* <0.1 μT with Brazil omitted was 2.02 (95% CI 0.87–4.69), whereas combined ORs when omitting other single studies ranged from 1.32 to 1.49. When the Brazilian study is excluded from the analysis, our point estimates are very close to the results of Ahlbom *et al.* The same is true when a cutoff point ⩾0.3 μT is used, rather than ⩾0.4 μT.

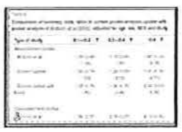


Table 4

Comparison of summary odds ratios in current pooled analysis update with pooled analysis of Ahlbom *et al* (2000); adjusted for age, sex, SES and study

Odds ratio estimates using categorical cutoff points and involving relatively small numbers of subjects are vulnerable to unstable results. To address this concern, we also calculated odds ratios using a moving window of exposure levels (Figure 1). These results also suggested a possible trend of increasing risk with increase in exposure; however, the estimates were imprecise.

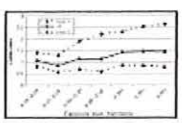


Figure 1

Odds ratios (95% CI) for moving window of exposure levels, adjusted for age, sex, SES and study. Reference level: <0.1 μT.

An ordinary logistic regression analysis using exposure as a continuous linear predictor yielded OR=1.11 (95% CI 0.98–1.26) for each increase of 0.2 μT, adjusting for age and sex. However, we prefer using a GAM, which is a more flexible modelling approach that provides a nonparametric estimate of the association between exposure and risk while controlling for potential confounders. Figure 2 presents the GAM nonparametric estimate of the trend in the log odds of being a case, with adjustment for study, age and sex. As a sensitivity analysis, we present results for a range of smoothing parameters, expressed as d.f., with models with more d.f. reflecting more fidelity to the data and models with fewer d.f. yielding more smoothing. Confidence limits widen as exposure increases, reflecting smaller number of subjects at high exposure levels. Although the curve suggests a positive exposure–response relationship, the width of the confidence bands indicates that a variety of exposure–response relationships, including no increase in risk, are compatible with the data.

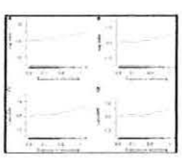


Figure 2

Nonparametric estimates of trend in log odds of being a case with a range of levels of smoothing (**A.** 2 d.f.; **B.** 3 d.f.; **C.** 4 d.f.; **D.** 5 d.f.) from a generalised additive model, with adjustment for study, age of diagnosis ...

Table 5 presents sensitivity and subgroup analyses in which we examine whether results change with adjustments for potential confounders and to what extent results are limited to a particular subgroup. Not all potential confounders were available in all studies. Analyses adjusting for confounding were carried out on the subset of studies and subjects for which data on the confounder were available. Most adjustments did not make appreciable changes in odds ratio estimates. Risks were a little higher for ALL and for a younger age group, and a little lower for residences at birth, despite a suggestion from one study (Lowenthal *et al*, 2007) that exposure at birth might carry particular risks. Neither an adjustment for mobility nor restriction to subjects who lived in a single residence before diagnosis changed the risk estimates appreciably. All confidence intervals included the null value.

Table 5

Summary odds ratios (95% CI) for leukaemia by exposure level with adjustments for study and other potential confounders and within subgroups

In very early studies on magnetic field exposure, distance from power lines was used as a proxy for magnetic fields, but distance alone is a poor predictor of magnetic fields when a study involves lines of varying characteristics, as highlighted in a recent methodological paper (Maslanyj *et al*, 2009). Draper *et al*, (2005) found elevated risks at distances well beyond the point at which the magnetic fields from power lines would be elevated, but were unable to offer an explanation for this finding. Using the pooled data, we, similar to Draper *et al* (2005), evaluated the risk of childhood leukaemia as it relates to distance as an 'exposure' in its own right and not as a substitute for magnetic fields.

The results for risk of childhood leukaemia as related to distance based on six studies (all except Germany) are shown in Table 6. Risk estimates increase with a decrease in distance, and the risk estimate for the closest band (⩽50 m) is the highest and relatively precise, but full exploration of how this effect occurs will require consideration of the different voltage lines involved and the effect of alternative reference levels.

Table 6

Odds ratios (95% CIs) for childhood leukaemia and distance from nearest power line, adjusted for study, age, sex and SES

DISCUSSION

Go to:

We conducted a pooled analysis of seven recent epidemiological studies on the association between residential magnetic field exposure and childhood leukaemia. Pooled analysis, considered the gold standard for synthesising results from multiple studies, allows for comparison across different studies and metrics, free of artefacts introduced by analytical differences, and for derivation of statistically more stable results (Kheifets *et al*, 2006). Pooled analysis uses raw data from previous studies, and thus can apply identical analyses to all included studies. The choices of cutoff points, reference groups, metrics, etc., in a pooled analysis may differ from the choices made in the original studies and may result in changes in the study-specific effect estimates. Despite strengths, results from pooled analyses are prone to the same biases operating in the original studies. Studies using measurements generally have low participation rates, which might have led to selection bias (Mezei and Kheifets, 2006; Schuz and Ahlbom, 2008). Studies estimating calculated fields do not require participation and are thus less vulnerable to selection bias, but they neglect sources of magnetic fields other than high-voltage power lines and are thus likely to introduce exposure misclassification and loss of statistical power.

Our results, adjusting for potential confounding, broadly confirm the results of the previous pooled analyses by Greenland and Ahlbom, although the association is weaker when all studies are included. Our results are highly dependent on one study from Brazil that has greater influence because of comparatively high numbers of cases and controls at the upper exposure level. Possible explanations for the weaker association seen in the study from Brazil include: this study is affected by a bias that masks a true association more than other studies; this study is less affected by a bias evident in other studies that creates a spurious or stronger association; or that this is only a random variation.

Several unique features of the Brazilian study raise questions about the potential for bias. On one hand, it focuses on ALL, a more specific definition of disease, and on children <8 years of age, making it more likely that residential exposures are representative of total exposure. However, our subgroup analyses of ALL and of younger ages showed no strong indication that specificity of diagnosis or age is important. On the other hand, there are several limitations that might have led to bias. It is common in Brazil to move close to the treating hospital, and subjects who moved after diagnosis were not included, as it was logistically infeasible to conduct measurements in the homes in which they lived before diagnosis. In addition, participation between cases and controls was highly differential, in part because of the use of birth certificates as a source for controls and the difficulty in tracing individuals. As a result, 94.2% of controls in the Brazilian study have lived in a single residence, compared with 54.0% of cases. Thus, we speculate that the Brazilian study unduly pushes our risk estimates down. This is confirmed by an analysis of Brazilian data limited to residentially stable subjects: OR for $\geqslant$0.3 μT *vs* <0.1 μT increases to 1.46 (95% CI 0.61–3.50, adjusted for age, sex and SES).

Although our results are compatible with no effect, when considering all studies combined, our findings suggest a small increase in risk with increasing exposure, regardless of the model chosen. Without the Brazilian study, our estimates are very close to those by Ahlbom *et al*, but less precise. Importantly, this pooled analysis, as compared with previous pooled analyses, includes a wider range of countries, including those in Asia and South America.

Most of the studies not included reported much higher estimates of risk, but had serious methodological problems. The addition of the one study that met our inclusion criteria but was not made available in time for this analysis, the Northern California Childhood Leukaemia Study, changes the risk estimates only slightly, resulting in OR=1.29 (0.81–2.06) for exposure $\geqslant$0.3 μT (results obtained using counts of cases and controls in exposure categories for NCCL, which were available from the conference presentation; results adjusted for study only, as confounders were not available). Recall, however, that the measurements in this study are substantially different in length and most importantly in the location chosen for measurements.

In conclusion, our results are in line with previous pooled analyses showing an association between residential magnetic field exposure and childhood leukaemia, but the association is weaker in recent studies and imprecise because of small numbers of highly exposed individuals. At the same time, recent studies are small and lack methodological improvements needed to resolve scientific uncertainties regarding the apparent association. In the IARC classification scheme, a key issue is whether 'chance, bias and confounding could be ruled out with reasonable confidence'. Our results, added to the previous pooled analyses, make chance less likely, but do not rule out bias or confounding, as whatever bias or confounding was present in previous studies could be present in these studies as well. Therefore, our results support conclusions of the WHO EHC (WHO EHC, 2007) and the European Union Scientific Committee on Emerging and Newly Identified Health Risks (Scientific Committee on Emerging and Newly Identified Health Risks, 2007) that recent studies on magnetic fields and childhood leukaemia do not alter the previous assessment that magnetic fields are possibly carcinogenic to humans.


Table 7

Go to:

ACKNOWLEDGMENTS

This work was supported by funding from CHILDREN with LEUKAEMIA, a UK charity. CMC was also supported by NIH NCI CA016042. The Brazilian study was conducted under the EMF Project-SP, P&D project, with resources allocated by the Brazilian Electricity Regulatory Agency (0390-041/2004 ANNEL), coordinated by the Brazilian Association for Electromagnetic Compatibility (ABRICEM), and performed at the University of Sao Paulo School of Public Health. Main collaborators were Daniele M Pelissari, Dr Claúdia T de Oliveira, Dr Juliana F da Mata, Luiz G Tone, Dr Maria Lydia M de André, Dr Maria L Lee, Dr Paula Bruniera, Dr Sidnei Epelman and Dr Vicente Odone Filho. The Italy1 study was conducted by the National Cancer Institute of Milan, in collaboration with Health Local Unit (ASL) of Varese Province and of Regional Environmental Protection Agency (ARPA – Varese Province). The main collaborators were Crosignani P, Borgini A, Bertoldi M, Codazzi T, Bianchi N, Rovelli A and Porro E. The Italy2 study was supported by ASEOP (Associazione Sostegno Ematologia Oncologia Pediatrica) of Modena and by the Reggio Emilia Municipality – Department of the Environment. The main collaborators were Carlotta Malagoli MD, Mariagiulia Calzari PhD, Sara Fabbi PhD, Sergio Teggi PhD, Giovanni Palazzi MD, Paolo Paolucci MD, Maurizio Poli PhD, Elena Ballotti, Barbara Notari PhD and Maurizio Bruni. The German study was funded by the Federal Ministry for the Environment, Nuclear Safety and Nature Preservation, and we thank Drs Jörg Michaelis and Peter Kaatsch for providing the German data. RML sincerely thanks his co-workers on the Tasmanian study, Ms Deirdre Tuck (research associate) and Dr Issy Bray (statistician). We are grateful to Tim Vincent of the CCRG for his work on data from the UK study. JS worked on this paper with permission from the National Grid, but no results were shared nor was approval sought from anyone in the National Grid and the views expressed are his alone.

APPENDIX 1

Go to:

Summary of recent studies not included in the pooled analysis

REFERENCES

Go to:

Abdul Rahman HI, Shah SA, Alias H, Ibrahim HM. A case-control study on the association between environmental factors and the occurrence of acute leukemia among children in Klang Valley, Malaysia. Asian Pac J Cancer Prev. 2008;9 (4:649–652. [PubMed]

Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, Linet M, McBride M, Michaelis J, Tynes T, Verkasalo PK. A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer. 2000;83 (5:692–698. [PMC free article] [PubMed]

Bianchi N, Crosignani P, Rovelli A, Tittarelli A, Carnelli CA, Rossitto F, Vanelli U, Porro E, Berrino F. Overhead electricity power lines and childhood leukemia: a registry-based, case-control study. Tumori. 2000;86 (3:195–198. [PubMed]

Does M, Scelo G, Metayer C, Selvin S, Kavet R, Buffler P. 2009Exposure to contact currents and magnetic fields and the risk of childhood leukemiaPaper presented at: The BIOEM 2009 Congress, Joint Meeting of The Bioelectromagnetics Society and the European BioElectromagnetics Association; 14-19 June, 2009; Davos, Switzerland

Draper G, Vincent T, Kroll ME, Swanson J. Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study. BMJ. 2005;330 (7503:1290. [PMC free article] [PubMed]

Feizi AA, Arabi MA. Acute childhood leukemias and exposure to magnetic fields generated by high voltage overhead power lines – a risk factor in Iran. Asian Pac J Cancer Prev. 2007;8 (1:69–72. [PubMed]

Greenland S, Sheppard AR, Kaune WT, Poole C, Kelsh MA. A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology. 2000;11 (6:624–634. [PubMed]

Hastie TJ, Tibshirani RJ. Generalized Additive Models. Chapman and Hall/CRC: Boca Raton; 1990.

Hoffmann W, Terschueren C, Heimpel H, Feller A, Butte W, Hostrup O, Richardson D, Greiser E. Population-based research on occupational and environmental factors for leukemia and non-Hodgkin's lymphoma: the Northern Germany Leukemia and Lymphoma Study (NLL) Am J Ind Med. 2008;51 (4:246–257. [PubMed]

IARC working group Part 1: static and extremely low-frequency (ELF) electric and magnetic fields. IARC Monograph on the Evaluation of Carcinogenic Risks to Humans. 2002;80:1–395. [PMC free article] [PubMed]

Kabuto M, Nitta H, Yamamoto S, Yamaguchi N, Akib S, Honda Y, Hagihara J, Isaka K, Saito T, Ojima T, Nakamura Y, Mizoue T, Ito S, Eboshida A, Yamazaki S, Sokejima S, Kurokawa Y, Kubo O. Childhood leukemia and magnetic fields in Japan: a case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan. Int J Cancer. 2006;119 (3:643–650. [PubMed]

Kheifets L, Mezei G, Greenland S. 2006Comment concerning 'Childhood leukemia and residential magnetic fields: are pooled analyses more valid than the original studies?' (Bioelectromagnetics 27:1-7 (2006)) Bioelectromagnetics 27(8674–675.675discussion 675–676 [PubMed]

Kroll ME, Swanson J, Vincent TJ, Draper GJ. 2010Childhood cancer and magnetic fields from high voltage power lines in England and Wales: a case-control study Br J Cancerthis issue) [PMC free article] [PubMed]

Lowenthal RM, Tuck DM, Bray IC. Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study. Intern Med J. 2007;37 (9:614 –619. [PubMed]

Malagoli C, Fabbi S, Teggi S, Calzari M, Poli M, Ballotti E, Notari B, Bruni M, Palazzi G, Paolucci P, Vinceti M. Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy. Environ Health. 2010;9:16. [PMC free article] [PubMed]

Maslanyj M, Simpson J, Roman E, Schuz J. Power frequency magnetic fields and risk of childhood leukaemia: misclassification of exposure from the use of the 'distance from power line' exposure surrogate. Bioelectromagnetics. 2009;30 (3:183–188. [PubMed]

Mejia-Arangure JM, Fajardo-Gutierrez A, Perez-Saldivar ML, Gorodezky C, Martinez-Avalos A, Romero-Guzman L, Campo-Martinez MA, Flores-Lujano J, Salamanca-Gomez F, Velasquez-Perez L. Magnetic fields and acute leukemia in children with Down syndrome. Epidemiology. 2007;18 (1:158–161. [PubMed]

Mezei G, Kheifets L. Selection bias and its implications for case-control studies: a case study of magnetic field exposure and childhood leukaemia. Int J Epidemiol. 2006;35 (2:397–406. [PubMed]

Perez CB, Pineiro RG, Diaz NT. Campos electromagneticos de baja frecuencia y leucemia infantil en Cuidad de La Habana. Rev Cubana Hig Epidemiol. 2005;43 (3:1–10.

R Development Core Team 2009R: A Language and Environment for Statistical Computing [Computer Program]Version 2.9.2.R Foundation for Statistical Computing: Vienna, Austria; URL http://www.R-project.org

Schuz J, Ahlbom A. Exposure to electromagnetic fields and the risk of childhood leukaemia: a review. Radiat Prot Dosimetry. 2008;132 (2:202–211. [PubMed]

Schuz J, Grigat JP, Brinkmann K, Michaelis J. Residential magnetic fields as a risk factor for childhood acute leukaemia: results from a German population-based case-control study. Int J Cancer. 2001;91 (5:728–735. [PubMed]

Schuz J, Svendsen AL, Linet MS, Linet MS, McBride ML, Roman E, Feychting M, Kheifets L, Lightfoot T, Mezei G, Simpson J, Ahlbom A. Nighttime exposure to electromagnetic fields and childhood leukemia: an extended pooled analysis. Am J Epidemiol. 2007;166 (3:263–269. [PubMed]

Scientific Committee on Emerging and Newly Identified Health Risks Possible effects of electromagnetic fields on human health 2007. [PubMed]

StataCorp . Stata Statistical Software: Release 10 (computer program). Version Release 10. StataCorp LP: College Station, TX; 2007.

World Health Organization 2007WHO Research Agenda for Extremely Low Frequency Fields . http://www.who.int/peh-emf/research/ elf_research_agenda_2007.pdf . . Accessed Nov.1, 2009

World Health Organization Environmental Health Criteria (WHO EHC) 2007Extremely Low Frequency FieldsVol 238.WHO: Spain
Yang Y, Jin X, Yan C, Tian Y, Tang J, Shen X. Case-only study of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1 and XPD) and low-frequency electromagnetic fields in childhood acute leukemia. Leuk Lymphoma. 2008;49 (12:2344–2350. [PubMed]

---

http://www.niehs.nih.gov/health/topics/agents/emf/

Typical EMF Levels for Power Transmission Lines*

115 kV

		Approx. Edge of Right-of-Way 15 m (50 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	1.0	0.5	0.07	0.01	0.003
Mean Magnetic Field (mG)	29.7	6.5	1.7	0.4	0.2

230 kV

		Approx. Edge of Right-of-Way 15 m (50 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	2.0	1.5	0.3	0.05	0.01
Mean Magnetic Field (mG)	57.5	19.5	7.1	1.8	0.8

500 kV

		Approx. Edge of Right-of-Way 20 m (65 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	7.0	3.0	1.0	0.3	0.1
Mean Magnetic Field (mG)	86.7	29.4	12.6	3.2	1.4

Magnetic Field from a 500-kV Transmission Line Measured on the Right-of-Way Every 5 Minutes for 1 Week

Electric fields from power lines are relatively stable because line voltage doesn't change very much. Magnetic fields on most lines fluctuate greatly as current changes in response to changing loads. Magnetic fields must be described statistically in terms of averages, maximums, etc. The magnetic fields above are means calculated for 321 power lines for 1990 annual mean loads. During peak loads (about 1% of the time), magnetic fields are about twice as strong as the mean levels above. The graph on the left is an example of how the magnetic field varied during one week for one 500-kV transmission line.

*These are typical EMFs at 1 m (3.3 ft) above ground for various distances from power lines in the Pacific Northwest. They are for general information. For information about a specific line, contact the utility that operates the line.
Source: Bonneville Power Administration, 1994.

Epidemiological study (observational study)

Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls. epidem.

By: *Zhao L, Liu X, Wang C, Yan K, Lin X, Li S, Bao H, Liu X*
Published in: Leuk Res 2014; 38 (3): 269-274
Journal , PubMed , DOI: 10.1016/j.leukres.2013.12.008

Aim of study (acc. to author)

The association between magnetic field exposure of power lines and the childhood leukemia risk was investigated in a meta-analysis. Following nine studies were included: Michaelis et al, 1997 (Germany), Linet et al, 1997 (USA), Dockerty et al, 1998 (New Zealand), McBride et al, 1999 (Canada), Green et al, 1999 (Canada), Schüz et al, 2001 (Germany), Kabuto et al, 2006 (Japan), Kroll et al, 2010 (UK), and Malagoli et al, 2010 (Italy).

Endpoint/type of risk estimation

- childhood leukemia: all childhood leukemia, acute lymphocytic leukemia

Type of risk estimation: incidence (odds ratio (OR))

Exposure

- 50/60 Hz, magnetic field
- power transmission line
- residential

Assessment

- measurement

Exposure groups

Reference group 1	magnetic field strength: < 0.1 µT
Group 2	magnetic field strength: 0.1-0.2 µT
Group 3	magnetic field strength: 0.2-0.4 µT
Group 4	magnetic field strength: ≥ 0.4 µT
Reference group 5	magnetic field strength: < 0.2 µT
Group 6	magnetic field strength: ≥ 0.2 µT
Reference group 7	magnetic field strength: < 0.1 µT
Group 8	magnetic field strength: 0.1-0.2 µT
Group 9	magnetic field strength: 0.2-0.3 µT
Group 10	magnetic field strength: ≥ 0.3 µT

Population

Group: children
Age: 0-15 years
Observation period: 1962 - 2007
Study location: USA, Canada, UK, Germany, Italy, Japan, New Zealand

Study size

Total	24,893

Other: 11,699 cases and 13,194 controls
Statistical analysis method: heterogeneity analysis, Funnel plot, Egger's test

Conclusion (acc. to author)

A statistically significant association between magnetic field intensity of ≥ 0.4 µT (reference level of < 0.1 µT) and childhood leukemia risk was observed (for total leukemia: OR 1.57, CI 1.03-2.40; for acute lymphocytic leukemia: OR 2.43, CI 1.30-4.55). On condition of the reference level of < 0.2 µT, the positive association between magnetic field intensity ≥ 0.2 µT and childhood leukemia was found (OR

1.31, CI = 1.06-1.61).

The authors concluded that magnetic field exposure level may be associated with childhood leukemia.

Study funded by

- National Natural Science Foundation (NSFC), China
- Research Fund for the Doctoral Program of Higher Education, China
- Major State Basic Research Development Program, China
- Program of New Century Excellent Talents in University of China
- Department of Health of Jilin Province, China
- Fundamental Research Funds for the Jilin University, China
- Postdoctoral Scientific Research Project of Jilin Province, China

Comments on this article

- Valera ET et al. (2014): Electromagnetic fields at extremely low frequencies and the risk for childhood leukemia: do we have enough information to warrant this association?

Related articles

- Crespi CM et al. (2016): Childhood leukaemia and distance from power lines in California: a population-based case-control study.
- Bunch KJ et al. (2016): Epidemiological study of power lines and childhood cancer in the UK: further analyses.
- Salvan A et al. (2015): Childhood Leukemia and 50 Hz Magnetic Fields: Findings from the Italian SETIL Case-Control Study.
- Pedersen C et al. (2015): Residential exposure to extremely low-frequency magnetic fields and risk of childhood leukaemia, CNS tumour and lymphoma in Denmark.
- Tabrizi MM et al. (2015): Increased risk of childhood acute lymphoblastic leukemia (ALL) by prenatal and postnatal exposure to high voltage power lines: a case control study in Isfahan, Iran.
- Tabrizi MM et al. (2015): Role of electromagnetic field exposure in childhood acute lymphoblastic leukemia and no impact of urinary alpha-amylase - a case control study in Tehran, Iran.
- Leitgeb N (2015): Synoptic Analysis Clarifies Childhood Leukemia Risk from ELF Magnetic Field Exposure.
- Pedersen C et al. (2014): Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark.
- Bunch KJ et al. (2014): Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
- Swanson J et al. (2014): Childhood cancer and exposure to corona ions from power lines: an epidemiological test.
- Ba Hakim AS et al. (2014): ELF-EMF correlation study on distance from overhead transmission lines and acute leukemia among children in Klang Valley, Malaysia.
- Sermage-Faure C et al. (2013): Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007.
- Keegan TJ et al. (2012): Case-control study of paternal occupation and childhood leukaemia in Great Britain, 1962-2006.
- Swanson J et al. (2012): Could the geomagnetic field be an effect modifier for studies of power-frequency magnetic fields and childhood leukaemia?
- Jirik V et al. (2012): Association between Childhood Leukaemia and Exposure to Power-frequency Magnetic Fields in Middle Europe.
- Schüz J et al. (2012): Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: an international follow-up study.
- Does M et al. (2011): Exposure to electrical contact currents and the risk of childhood leukemia.
- Wünsch Filho V et al. (2011): Exposure to magnetic fields and childhood acute lymphocytic leukemia in Sao Paulo, Brazil.
- Reid A et al. (2011): Risk of childhood acute lymphoblastic leukaemia following parental occupational exposure to extremely low frequency electromagnetic fields.
- Malagoli C et al. (2010): Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy.
- Hug K et al. (2010): Parental occupational exposure to extremely low frequency magnetic fields and childhood cancer: a German case-control study.
- Kheifets L et al. (2010): Pooled analysis of recent studies on magnetic fields and childhood leukaemia.
- Sohrabi MR et al. (2010): Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study.
- Kroll ME et al. (2010): Childhood cancer and magnetic fields from high-voltage power lines in England and Wales: a case-control study.
- Negishi T et al. (2008): Lack of promotion effects of 50 Hz magnetic fields on 7,12-dimethylbenz(a)anthracene-induced malignant lymphoma/lymphatic leukemia in mice.
- Yang Y et al. (2008): Case-only study of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1 and XPD) and low-frequency electromagnetic fields in childhood acute leukemia.
- Rahman HIA et al. (2008): A case-control study on the association between environmental factors and the occurrence of acute leukemia among children in Klang Valley, Malaysia.
- Lowenthal RM et al. (2007): Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study.
- Schüz J et al. (2007): Nighttime exposure to electromagnetic fields and childhood leukemia: an extended pooled analysis.
- Svendsen AL et al. (2007): Exposure to magnetic fields and survival after diagnosis of childhood leukemia: a German cohort study.
- Feizi AA et al. (2007): Acute childhood leukemias and exposure to magnetic fields generated by high voltage overhead power lines - a risk factor in Iran.
- Foliart DE et al. (2007): Magnetic field exposure and prognostic factors in childhood leukemia.
- Mejia-Arangure JM et al. (2007): Magnetic fields and acute leukemia in children with Down syndrome.
- Kabuto M et al. (2006): Childhood leukemia and magnetic fields in Japan: a case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan.
- Foliart DE et al. (2006): Magnetic field exposure and long-term survival among children with leukaemia.
- Draper G et al. (2005): Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study.
- Schüz J et al. (2001): Residential magnetic fields as a risk factor for childhood acute leukaemia: results from a German population-based case-control study.
- Greenland S et al. (2000): A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group.

- Kleinerman RA et al. (2000): Are children living near high-voltage power lines at increased risk of acute lymphoblastic leukemia?
- Bianchi N et al. (2000): Overhead electricity power lines and childhood leukemia: a registry-based, case-control study.
- Ahlbom A et al. (2000): A pooled analysis of magnetic fields and childhood leukaemia.
- UK Childhood Cancer Study Investigators (2000): Childhood cancer and residential proximity to power lines.
- Green LM et al. (1999): Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada.
- Green LM et al. (1999): A case-control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences.
- Dockerty JD et al. (1999): Electromagnetic field exposures and childhood leukaemia in New Zealand.
- UK Childhood Cancer Study Investigators (1999): Exposure to power-frequency magnetic fields and the risk of childhood cancer.
- Angelillo IF et al. (1999): Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis.
- McBride ML et al. (1999): Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada.
- Dockerty JD et al. (1998): Electromagnetic field exposures and childhood cancers in New Zealand.
- Michaelis J et al. (1998): Combined risk estimates for two German population-based case-control studies on residential magnetic fields and childhood acute leukemia.
- Michaelis J et al. (1997): Childhood leukemia and electromagnetic fields: results of a population-based case-control study in Germany.
- Linet MS et al. (1997): Residential exposure to magnetic fields and acute lymphoblastic leukemia in children.
- Petridou E et al. (1997): Electrical power lines and childhood leukemia: a study from Greece.
- Tynes T et al. (1997): Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines.
- Olsen J et al. (1993): Residence near high voltage facilities and risk of cancer in children.
- Petridou E et al. (1993): Age of exposure to infections and risk of childhood leukaemia.
- Verkasalo PK et al. (1993): Risk of cancer in Finnish children living close to power lines.
- Feychting M et al. (1993): Magnetic fields and cancer in children residing near Swedish high-voltage power lines.
- Myers A et al. (1990): Childhood cancer and overhead powerlines: a case-control study.
- Coleman MP et al. (1989): Leukaemia and residence near electricity transmission equipment: a case-control study.

http://www.bcmj.org/bc-centre-disease-control/living-near-power-lines-bad-our-health

Is living near power lines bad for our health?

Issue: BCMJ, Vol. 50, No. 9, November 2008, page(s) 494 BC Centre for Disease Control
Ray Copes, MD, FRCPC, Prabjit Barn, MSc

The debate of whether there are adverse effects associated with electromagnetic fields from living close to high-voltage power lines has raged for years. While research indicates that large risks are not present, the possibility of a relatively small risk cannot be conclusively excluded.

Electromagnetic fields (EMFs) are produced by electrical appliances, electrical wiring, and power lines, and everyone is exposed to them at some level. Numerous studies have investigated EMF exposure and health. Although earlier studies did suggest associations between exposure and a variety of health effects including brain cancer, breast cancer, cardiovascular disease, and reproductive and developmental disorders, most of these associations have not been substantiated by more recent research. One notable exception to this is the association with childhood leukemia, which the International Agency for Research on Cancer regards as sufficiently well established to rate extremely low frequency magnetic fields as a "possible" human carcinogen.[1]

The first study to link childhood leukemia with residential EMF exposure was published in 1979[2] and since then, a number of studies have found weak associations to support this original finding. Studies investigating childhood leukemia as a health outcome of EMF exposure have used measured and calculated magnetic fields, as well as distance of homes to power lines, as an exposure measure. Studies using magnetic field strength as an exposure measure have found that exposures greater than the range of 0.3 to 0.4 μT lead to a doubling risk of leukemia, with very little risk below this level. This exposure range is approximately equal to a distance of 60 m within a high-voltage power line of 500 kV.

However, a more recent study showed an elevated risk of leukemia among children living in homes with distances much greater than 60 m from high voltage power lines.[3] This study involved close to 30000 matched case-control pairs of children living in the United Kingdom. It was found that children living in homes as far as 600 m from power lines had an elevated risk of leukemia. An increased risk of 69% for leukemia was found for children living within 200 m of power lines while an increased risk of 23% was found for children living within 200 to 600 m of the lines.[3] This study was notable in that it found some elevation of risk at much greater distances than previous studies.

Although distance of homes from power lines can be considered a crude measure of exposure, the results of this study do merit attention. A limited understanding exists of how exposure to EMF can affect health. The underlying biological mechanism is unknown, making it difficult to determine which measure of EMF is most appropriate when evaluating health outcomes. Use of residential proximity may be a reasonable surrogate for direct measurements of EMF, but may also reflect other factors that are related to proximity to high voltage lines.

If the association found in the UK study does reflect a causal relationship, what are the potential impacts in BC? Using current BC leukemia rates[4] and assuming similar proportions of the population live near high voltage lines, on a statistical basis, there may be one additional leukemia in BC every 2 years. To eliminate this risk, one would need to achieve a separation distance of 600 m (1968 ft.) between every high voltage power line and the nearest residence. While this could be done, it would require substantial changes to existing land use patterns and would require significant resources. While it can be argued that this action is consistent with some forms of the precautionary principle, based on best available evidence, one can achieve much greater risk reduction or health benefits if resources are directed to other larger, better established risks.

References

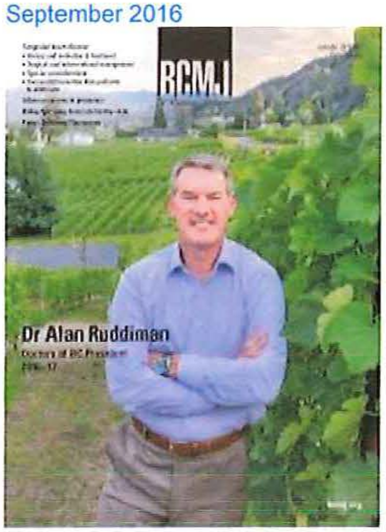
1. World Health Organization. Extremely low frequency fields environmental health criteria monograph no. 238. 2007. www.who.int/peh-emf/publications/elf_ehc/en/index.html (accessed 12 September 2008).

2. Wertheimer N, Leeper E. Electrical wiring configurations and childhood cancer. Am J Epidemiol 1979;109:273-284.

3. Draper G, Vincent T, Kroll ME, et al. Childhood cancer in relation to distance from high voltage power lines in England and Wales: A case-control study. BMJ 2005;330:1290.

4. BC Cancer Agency. Leukemia. 2008. www.bccancer.bc.ca/NR/rdonlyres/AC6262BC-634F-4227-BF14-163182197EDF/25977/leukemia1.pdf (accessed 24 September 2008).

Dr Copes is the director of BCCDC's Environmental Health Services Division. Ms Barn is an environmental health scientist at BCCDC.



http://www.nbcnews.com/id/34370106/ns/health-health_care/t/power-line-pollutants-pose-health-risks/#.V9eGAY-cHmQ

Power line pollutants pose health risks

Living near electrical lines may make some people sick, researchers find 1

DiscoveryNews.
updated 12/10/2009 6:22:43 PM ET

High voltage power lines in Sweden trap cancer-causing pollutants in their electric fields, according to a new study, potentially raising health risks for people who live beneath them.

It's a decades-old question: does living near power lines make people sick? For the most part, studies have shown little beyond a weak up-tick in leukemia among children who live near electrical lines. Laboratory animals exposed to electrical and magnetic fields have shown no effect whatsoever.

Case closed, it would seem. But what if electrical fields corral air pollution, concentrating it in a small area? Scientists have wondered whether toxins like polychlorinated biphenyls (PCBs) and other compounds might gather under power lines in this way.

Researchers at the University of Kalmar in Sweden have now shown for the first time that this phenomenon is real. They took samples from pine needles at several sites directly beneath a 400 kilovolt power line in southern Sweden, and at distances up to several miles away.

Trees growing directly beneath the lines had about double the amount of PCBs on their needles as those plants that were some distance away, the researchers found. The elevated levels were still below anything that would be considered hazardous, but it raises the possibility that other air pollutants may get trapped in the electric field as well.

"We didn't measure anything except PCBs," study leader Tomas Oberg said. "But we could have looked at dioxins or polycyclic aromatic hydrocarbons (PAHs); there's no reason they wouldn't behave the same way."

The increased pollutant concentrations are likely the result of the electric field causing microscopic dust particles laced with pollutants to become charged. That charge makes them more likely to stick to nearby surfaces.

The study was published in the journal Atmospheric Environment.

It's an intriguing finding, but Oberg cautioned that it is far too soon to draw conclusions about any potential health risks.

"You cannot extrapolate this to human health risks," he said. "But there is definitely a significant increase in deposition of semi-volatile organic compounds here."

John Moulder of the Medical College of Wisconsin in Milwaukee isn't impressed.

"While I can't dismiss it, I can't get very excited about it either," Moulder said of possible health risks. "First, I'd want to go and check to see if there is any evidence that children with leukemia have higher body burdens of PCBs. If it turns out that they do, I might get a lot more excited about it."

404 - File or directory not found.

The resource you are looking for might have been removed, had its name changed, or is temporarily unavailable.

Epidemiological study (observational study)

Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy. epidem.

By: *Malagoli C, Fabbi S, Teggi S, Calzari M, Poli M, Ballotti E, Notari B, Bruni M, Palazzi G, Paolucci P, Vinceti M*
Published in: Environ Health 2010; 9 (1): 16-1-16-8
Full-text, Journal, PubMed

Aim of study (acc. to author)

A case-control study was conducted in Italy to investigate the association between magnetic fields exposure generated by power lines and the risk of leukemia and other hematological cancers in children.

Further details

Children were classified as exposed if they have been living with a magnetic field exposure of more than 0.1 µT for more than 6 months.

Endpoint/type of risk estimation

- childhood leukemia: acute lymphoblastic leukemia, all types of leukemia
- childhood lymphoma: all malignant neoplasms of the lymphatic and hematopoietic tissue

Type of risk estimation: incidence (relative risk (RR))

Exposure

- 50/60 Hz, magnetic field
- power transmission line
- residential

Assessment

- calculation: magnetic field intensity based on distance of residence to power line; geocoding of residence

Exposure groups

Reference group 1	magnetic field exposure: 0.1 - < 0.2 µT
Group 2	magnetic field exposure: 0.2 - < 0.4 µT
Group 3	magnetic field exposure: ≥ 0.4 µT
Reference group 4	magnetic field exposure: < 0.1 µT
Group 5	magnetic field exposure: ≥ 0.1 µT
Group 6	magnetic field exposure: ≥ 0.4 µT

Population

Group: children
Age: 0–13 years
Observation period: 1986 - 2007
Study location: Italy (municipalities of Modena and Reggio Emilia)

Case group

Characteristics: hematological malignancies
Data source: nation-wide hospital-based registry of childhood malignancies (AIEOP registry)

Control group

Selection: population-based
Matching: sex, age, area, case:control = 1:4

Study size

	Cases	Controls
Eligible	64	256

Statistical analysis method: unconditional logistic regression, conditional logistic regression (adjustment: paternal education level, maternal education level and paternal income)

Conclusion (acc. to author)

2 cases and 5 controls have been exposed to magnetic fields from power lines (1 case and 3 controls with magnetic field intensity of 0.1 µT up to 0.2 µT; 1 case and 2 controls with 0.4 µT or more).

A statistically nonsignificant increased risk for childhood leukemia was observed for antecedent residence with a magnetic field exposure above 0.1 µT (RR 6.7, CI 0.6-78.3) and above 0.4 µT (RR 2.1, CI 0.2-26.2). A statistically nonsignificant increased risk for acute lymphoblastic leukemia was found for children with an exposure above 0.1 µT (RR 5.3, CI 0.7-43.5). The authors concluded that the results appeared to support the hypothesis that magnetic field exposure increases the risk of childhood leukemia.

Limitations (acc. to author)

The findings are based on low numbers of exposed cases and controls.

Study funded by

- Associazione Sostegno Ematologia Oncologia Pediatrica (ASEOP) ONLUS, Italy
- Department of the Environment of Reggio Emilia Municipality, Italy

Related articles

- Crespi CM et al. (2016): Childhood leukaemia and distance from power lines in California: a population-based case-control study.
- Bunch KJ et al. (2016): Epidemiological study of power lines and childhood cancer in the UK: further analyses.
- Salvan A et al. (2015): Childhood Leukemia and 50 Hz Magnetic Fields: Findings from the Italian SETIL Case-Control Study.
- Pedersen C et al. (2015): Residential exposure to extremely low-frequency magnetic fields and risk of childhood leukaemia, CNS tumour and lymphoma in Denmark.
- Tabrizi MM et al. (2015): Increased risk of childhood acute lymphoblastic leukemia (ALL) by prenatal and postnatal exposure to high voltage power lines: a case control study in Isfahan, Iran.
- Tabrizi MM et al. (2015): Role of electromagnetic field exposure in childhood acute lymphoblastic leukemia and no impact of urinary alpha-amylase - a case control study in Tehran, Iran.
- Zhao L et al. (2014): Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls.
- Pedersen C et al. (2014): Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark.
- Bunch KJ et al. (2014): Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
- Swanson J et al. (2014): Childhood cancer and exposure to corona ions from power lines: an epidemiological test.
- Ba Hakim AS et al. (2014): ELF-EMF correlation study on distance from overhead transmission lines and acute leukemia among children in Klang Valley, Malaysia.
- Sermage-Faure C et al. (2013): Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007.
- Mahram M et al. (2013): The effect of extremely low frequency electromagnetic fields on pregnancy and fetal growth, and development.
- Malagoli C et al. (2012): Maternal exposure to magnetic fields from high-voltage power lines and the risk of birth defects.
- Jirik V et al. (2012): Association between Childhood Leukaemia and Exposure to Power-frequency Magnetic Fields in Middle Europe.
- Swanson J et al. (2012): Could the geomagnetic field be an effect modifier for studies of power-frequency magnetic fields and childhood leukaemia?
- Schüz J et al. (2012): Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: an international follow-up study.
- Wünsch Filho V et al. (2011): Exposure to magnetic fields and childhood acute lymphocytic leukemia in Sao Paulo, Brazil.
- Kheifets L et al. (2010): A Pooled Analysis of Extremely Low-Frequency Magnetic Fields and Childhood Brain Tumors.
- Saito T et al. (2010): Power-frequency magnetic fields and childhood brain tumors: a case-control study in Japan.
- Kheifets L et al. (2010): Pooled analysis of recent studies on magnetic fields and childhood leukaemia.
- Kroll ME et al. (2010): Childhood cancer and magnetic fields from high-voltage power lines in England and Wales: a case-control study.
- Sohrabi MR et al. (2010): Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study.
- Li P et al. (2009): Maternal occupational exposure to extremely low frequency magnetic fields and the risk of brain cancer in the offspring.
- Fazzo L et al. (2009): Morbidity experience in populations residentially exposed to 50 Hz magnetic fields: methodology and preliminary findings of a cohort study.
- Yang Y et al. (2008): Case-only study of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1 and XPD) and low-frequency electromagnetic fields in childhood acute leukemia.
- Rahman HIA et al. (2008): A case-control study on the association between environmental factors and the occurrence of acute leukemia among children in Klang Valley, Malaysia.
- Mezei G et al. (2008): Residential Magnetic Field Exposure and Childhood Brain Cancer: A Meta-Analysis.
- Lowenthal RM et al. (2007): Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study.
- Swanson J et al. (2006): Power-frequency electric and magnetic fields in the light of Draper et al. 2005.
- Kabuto M et al. (2006): Childhood leukemia and magnetic fields in Japan: a case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan.
- Draper G et al. (2005): Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study.
- Schüz J et al. (2001): Risk factors for pediatric tumors of the central nervous system: results from a German population-based case-control study.
- Bianchi N et al. (2000): Overhead electricity power lines and childhood leukemia: a registry-based, case-control study.
- Ahlbom A et al. (2000): A pooled analysis of magnetic fields and childhood leukaemia.
- Kleinerman RA et al. (2000): Are children living near high-voltage power lines at increased risk of acute lymphoblastic leukemia?
- UK Childhood Cancer Study Investigators (2000): Childhood cancer and residential proximity to power lines.
- Greenland S et al. (2000): A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group.
- McBride ML et al. (1999): Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada.
- Angelillo IF et al. (1999): Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis.
- UK Childhood Cancer Study Investigators (1999): Exposure to power-frequency magnetic fields and the risk of childhood cancer.

- Green LM et al. (1999): A case-control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences.
- Green LM et al. (1999): Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada.
- Michaelis J et al. (1998): Combined risk estimates for two German population-based case-control studies on residential magnetic fields and childhood acute leukemia.
- Tynes T et al. (1997): Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines.
- Michaelis J et al. (1997): Childhood leukemia and electromagnetic fields: results of a population-based case-control study in Germany.
- Petridou E et al. (1997): Electrical power lines and childhood leukemia: a study from Greece.
- Linet MS et al. (1997): Residential exposure to magnetic fields and acute lymphoblastic leukemia in children.
- Gurney JG et al. (1996): Childhood brain tumor occurrence in relation to residential power line configurations, electric heating sources, and electric appliance use.
- Preston-Martin S et al. (1996): Los Angeles study of residential magnetic fields and childhood brain tumors.
- Olsen J et al. (1993): Residence near high voltage facilities and risk of cancer in children.
- Verkasalo PK et al. (1993): Risk of cancer in Finnish children living close to power lines.
- Feychting M et al. (1993): Magnetic fields and cancer in children residing near Swedish high-voltage power lines.
- Petridou E et al. (1993): Age of exposure to infections and risk of childhood leukaemia.
- Myers A et al. (1990): Childhood cancer and overhead powerlines: a case-control study.
- Coleman MP et al. (1989): Leukaemia and residence near electricity transmission equipment: a case-control study.
- Savitz DA et al. (1988): Case-control study of childhood cancer and exposure to 60-Hz magnetic fields.
- Tomenius L (1986): 50-Hz electromagnetic environment and the incidence of childhood tumors in Stockholm County.
- Wertheimer N et al. (1979): Electrical wiring configurations and childhood cancer.

Epidemiological study (observational study)

Childhood cancer and exposure to corona ions from power lines: an epidemiological test. epidem.

By: *Swanson J, Bunch KJ, Vincent TJ, Murphy MF*
Published in: J Radiol Prot 2014; 34 (4): 873-889
Journal, PubMed, DOI: 10.1088/0952-4746/34/4/873

Aim of study (acc. to author)

The authors previously reported an association between childhood leukemia in Great Britain and proximity of the child's address at birth to high-voltage power lines that declines from the 1960s to the 2000s (Bunch et al., 2014). In the present study they tested whether the corona-ion hypothesis could explain these results.

Further details

Corona ions are atmospheric ions produced by electric fields of the power lines and blown away from them by the wind. The corona-ion hypothesis proposes that corona ions attach themselves to airborne pollutants and increase the charge on those pollutant particles. Thereby more of these airborne pollutants could be retained in the airways when breathed in and hence cause disease. Therefore in this context, children living downwind of high-voltage power lines would be at increased risk of childhood leukemia produced by the electrically charged airborne pollutants.
An improved model for calculating exposure to corona ions, using data on winds (wind direction and wind speed) from 8 meteorological stations in Wales and England was developed under consideration of the whole length of power line within 600 m of each subject's address.

Endpoint/type of risk estimation

- childhood leukemia
- childhood brain/cns tumor
- other childhood cancer

Type of risk estimation: incidence (relative risk (RR))

Exposure

- 50/60 Hz, electric field, non-EMF
- power transmission line
- residential, co-exposure

Assessment

- calculation: model to calculate exposure to corona ions for each subject including parameters: source-strength consisting of line design, voltage, number and size of conductors, propensity of different power lines to produce ions, concentration of corona ions in relation to distance to power line, wind direction and wind-speed; calculations for points at 10 m intervals for each address and for lengths of line within 600 m

Exposure groups

Reference group 1	no exposure and distance between residence and the nearest power line > 600 m
Group 2	calculated exposure: 1st quartile
Group 3	calculated exposure: 2ndt quartile
Group 4	calculated exposure: 3rd quartile
Group 5	calculated exposure: 4th quartile

Population

Group: children
Age: 0–14 years
Observation period: 1962 - 2008
Study location: UK (England and Wales)

Case group

Characteristics: children with cancer
Data source: UK National Registry of Childhood Tumours

Control group

Selection: population-based

Matching: sex, age, birth registration sub-district, case:control = 1:1

Study size

	Cases
Eligible	53,515

Statistical analysis method: conditional logistic regression

Conclusion (acc. to author)

Overall, 7347 children have been living within 600 m to power lines.

Corona-ion exposure is highly correlated with proximity to power lines, and therefore the results parallel the elevations in childhood leukemia risk seen with distance in the previous publication by Bunch et al (2014). But the model explains the observed pattern of leukemia rates around power lines less well than straightforward distance measurements. This does not disprove the corona-ion hypothesis as the explanation for the previous results, but nor does it provide support for it, or, by extension, any other hypothesis dependent on wind direction.

Study funded by

- United Kingdom Department of Health Radiation Protection Programme
- CHILDREN with CANCER UK

Comments on this article

- Jeffers D (2015): Comment on: Childhood cancer and exposure to corona ions from power lines: an epidemiological study.
- Swanson J et al. (2015): Reply to 'Comment on: Childhood cancer and exposure to corona ions from power lines: an epidemiological study'.

Related articles

- Bunch KJ et al. (2016): Epidemiological study of power lines and childhood cancer in the UK: further analyses.
- Crespi CM et al. (2016): Childhood leukaemia and distance from power lines in California: a population-based case-control study.
- Tabrizi MM et al. (2015): Increased risk of childhood acute lymphoblastic leukemia (ALL) by prenatal and postnatal exposure to high voltage power lines: a case control study in Isfahan, Iran.
- Salvan A et al. (2015): Childhood Leukemia and 50 Hz Magnetic Fields: Findings from the Italian SETIL Case-Control Study.
- Bunch KJ et al. (2015): Magnetic fields and childhood cancer: an epidemiological investigation of the effects of high-voltage underground cables.
- Pedersen C et al. (2015): Residential exposure to extremely low-frequency magnetic fields and risk of childhood leukaemia, CNS tumour and lymphoma in Denmark.
- Tabrizi MM et al. (2015): Role of electromagnetic field exposure in childhood acute lymphoblastic leukemia and no impact of urinary alpha-amylase - a case control study in Tehran, Iran.
- Zhao L et al. (2014): Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls.
- Bunch KJ et al. (2014): Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
- Pedersen C et al. (2014): Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark.
- Ba Hakim AS et al. (2014): ELF-EMF correlation study on distance from overhead transmission lines and acute leukemia among children in Klang Valley, Malaysia.
- Sermage-Faure C et al. (2013): Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007.
- Jirik V et al. (2012): Association between Childhood Leukaemia and Exposure to Power-frequency Magnetic Fields in Middle Europe.
- Schüz J et al. (2012): Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: an international follow-up study.
- Swanson J et al. (2012): Could the geomagnetic field be an effect modifier for studies of power-frequency magnetic fields and childhood leukaemia?
- Wünsch Filho V et al. (2011): Exposure to magnetic fields and childhood acute lymphocytic leukemia in Sao Paulo, Brazil.
- Malagoli C et al. (2010): Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy.
- Kheifets L et al. (2010): A Pooled Analysis of Extremely Low-Frequency Magnetic Fields and Childhood Brain Tumors.
- Kheifets L et al. (2010): Pooled analysis of recent studies on magnetic fields and childhood leukaemia.
- Kroll ME et al. (2010): Childhood cancer and magnetic fields from high-voltage power lines in England and Wales: a case-control study.
- Sohrabi MR et al. (2010): Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study.
- Yang Y et al. (2008): Case-only study of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1 and XPD) and low-frequency electromagnetic fields in childhood acute leukemia.
- Rahman HIA et al. (2008): A case-control study on the association between environmental factors and the occurrence of acute leukemia among children in Klang Valley, Malaysia.
- Mezei G et al. (2008): Residential Magnetic Field Exposure and Childhood Brain Cancer: A Meta-Analysis.
- Lowenthal RM et al. (2007): Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study.
- Swanson J et al. (2006): Power-frequency electric and magnetic fields in the light of Draper et al. 2005.
- Kabuto M et al. (2006): Childhood leukemia and magnetic fields in Japan: a case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan.
- Draper G et al. (2005): Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study.
- Greenland S et al. (2000): A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group.

- Ahlbom A et al. (2000): A pooled analysis of magnetic fields and childhood leukaemia.
- Kleinerman RA et al. (2000): Are children living near high-voltage power lines at increased risk of acute lymphoblastic leukemia?
- UK Childhood Cancer Study Investigators (2000): Childhood cancer and residential proximity to power lines.
- Bianchi N et al. (2000): Overhead electricity power lines and childhood leukemia: a registry-based, case-control study.
- Green LM et al. (1999): A case-control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences.
- Green LM et al. (1999): Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada.
- UK Childhood Cancer Study Investigators (1999): Exposure to power-frequency magnetic fields and the risk of childhood cancer.
- McBride ML et al. (1999): Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada.
- Angelillo IF et al. (1999): Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis.
- Michaelis J et al. (1998): Combined risk estimates for two German population-based case-control studies on residential magnetic fields and childhood acute leukemia.
- Linet MS et al. (1997): Residential exposure to magnetic fields and acute lymphoblastic leukemia in children.
- Michaelis J et al. (1997): Childhood leukemia and electromagnetic fields: results of a population-based case-control study in Germany.
- Tynes T et al. (1997): Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines.
- Petridou E et al. (1997): Electrical power lines and childhood leukemia: a study from Greece.
- Petridou E et al. (1993): Age of exposure to infections and risk of childhood leukaemia.
- Feychting M et al. (1993): Magnetic fields and cancer in children residing near Swedish high-voltage power lines.
- Verkasalo PK et al. (1993): Risk of cancer in Finnish children living close to power lines.
- Olsen J et al. (1993): Residence near high voltage facilities and risk of cancer in children.
- Myers A et al. (1990): Childhood cancer and overhead powerlines: a case-control study.
- Coleman MP et al. (1989): Leukaemia and residence near electricity transmission equipment: a case-control study.

EM Watch

Electromagnetic Radiation Health and Safety

Living Close to Power Lines

Power lines carry high-voltage electric current from one place to another. When current flows through a wire, two fields are created around it: an electric field and a magnetic field. These are the two components of the electromagnetic field.

The magnetic portion is the more dangerous because of its ability to penetrate the human body. The strength and extent of this magnetic field depends on three things: how much current is flowing, the voltage, and the configuration of the wires (i.e. how far apart the wires are from each other, and similar factors).

Since power lines may carry huge amounts of current, often at high voltages, substantial electromagnetic fields (EMF) are created. In the case of high-voltage transmission lines, the EMF can extend to about 300 meters.

Power Line EMF is strongest directly underneath the power lines, and gradually fades away with increasing distance.

Health Effects of Living Near Power Lines – Is EMF Really Harmful?

There has been concern over power line radiation and its effect on human health for at least 40 years. Living close to power lines has been shown to increase the risk of leukemia and other cancers since 1979, when convincing evidence was first published by Wertheimer and Leeper in the American Journal of Epidemiology.

Since then, dozens of published papers have found links between living near power lines (and other electrical wiring configurations) and a range of health woes, including

- brain cancer

- childhood and adult leukemia
- Lou Gehrig's disease (ALS)
- Alzheimer's disease
- breast cancer in women and men,
- miscarriage, birth defects and reproductive problems,
- decreased libido
- fatigue
- depression and suicide
- blood diseases
- hormonal imbalances
- heart disease
- neuro-degenerative diseases
- sleeping disorders

and many others.

How Strong is the Evidence For Power Line Health Effects?

To appreciate the sheer weight of this evidence, see the excellent list of published research papers compiled by Powerwatch UK which identifies over 300 papers relating to EMF from power lines and electricity sub-stations.

Of these, more than 200 were able to find a link between this type of radiation and (mostly) harmful biological effects. It is extremely unlikely that all these studies were mistaken in their conclusions.

But in some cases, subsequent studies which tried to replicate the original results have failed to confirm the effect. So the evidence cannot be considered to be 100% conclusive for any of the diseases mentioned.

Should you take it seriously?

What Does the Government Say about Power Line Radiation?

Environmental agencies, health organisations and power-industry spokesmen generally stress the weaknesses of the evidence, inconsistencies in the data, and lack of conclusive proof.

Government organisations (which fund many of the studies) may not wish to promote the view that power line EMF can cause disease. People would ask "why have you allowed this health hazard?" The same applies to the power distribution industry.

Research studies can be structured so as to demonstrate whatever conclusions their sponsors would like to promote.

Big money, from government and industry, could be backing the (minority of) research which fails to find health effects from power line radiation. These large and powerful organisations greatly influence public (and even scientific) opinion.

Therefore the evidence for EMF health effects will likely remain inconclusive, and may never be sufficient to prove unequivocally that long-term exposure to low-level, low-frequency EMF actually causes disease.

What do Scientists Believe about EMF Health Risks?

Power line EMF is classified as Extremely Low Frequency (ELF) radiation. The lower the frequency, the longer the wavelength.

Back in the 1970's many scientists believed that ELF electromagnetic radiation could not possibly have any biological effects, damaging or otherwise, because it was thought that the long wavelength would prevent its interaction with a relatively small body such as a human being. (The wavelength of a 60 Hz power wave is 5000 km.)

But as the economist Keynes said "When the facts change, I change my mind".

Well, the facts (or at least our understanding of them) *have* changed.

And yet we may not fully understand exactly how and why low-frequency EM radiation affects human bodies and health. All we know is that it does.

Fortunately, scientists are just as good as economists at changing their mind! Concerning power line EMF and health issues, most of them already have, judging by the Bio-Initiative Report of 2012.

This report, compiled by a group of internationally respected scientists specialising in this field, urges

"Health agencies and regulatory agencies that set public safety standards for ELF-EMF and RFR should act now to adopt new, biologically-relevant safety limits that key to the lowest scientific benchmarks for harm coming from the recent studies, plus a lower safety margin.

Existing public safety limits are too high by several orders of magnitude…" (Emphasis mine)

And long ago in 2002, the World Health Organisation's International Agency for Research on Cancer (IARC) upped its classification of power line radiation to "possibly carcinogenic (cancer-causing) to humans."

Should You Worry About Radiation from Power Lines?

The strongest evidence we have so far relates to childhood leukemia, where it appears that exposure to magnetic fields higher than 3 milligauss increases the risk of acquiring it. Several studies confirm this.

The risk of childhood leukemia in children **not** exposed to unusual amounts of low-frequency EMF is fortunately very low – between 3 and 5 cases per 100,000 children – but it increases by approximately 100% in homes where the average low-frequency EMF level is higher than 4 milligauss.

Power lines are only one source of low-frequency EMF found in the home and workplace. There are many others. So it is quite possible for low frequency EMF to exceed 4 milligauss in a person's bedroom at night (even though most of the electrical circuits in the house are not in use) especially if the constant background EMF from a nearby power line is contributing, say, 2 milligauss.

In that situation a person could easily be exposed to low-frequency EMF – at a level sufficient to cause leukemia in some children.

But it would be a mistake to focus only on childhood leukemia, or any other health outcome.

The real issue is the long-term cellular damage that apparently affects every person who is exposed to low-frequency EMF, for as long as they remain exposed.

Fortunately, most people do not succumb to any major illness as a result of their exposure to this kind of EMF. Their biological repair mechanisms are able to deal with the damage.

But a repair process does have to take place, and it does use up energy and resources – which are therefore no longer available to the body when dealing with other stresses. And that is enough to cause serious disease in some of the more vulnerable members of the community, including the unborn, pregnant mothers, children, sick people, and the aged.

So long-term exposure to high levels of power line and sub-station EMF is actually not good for anyone – and is potentially harmful to everyone.

Duration of EMF Exposure – How Long is Too Long?

Most studies show that the association between health effects, such as cancer, and high EMF occurs over many years. But you would not want to be too relaxed about this.

Leukemia, cancer and heart disease are not conditions which suddenly arise out of nowhere. There is a long process of gradually deteriorating conditions within the body, which finally culminates in disease.

Electromagnetic radiation starts doing damage from the first exposure. For a long while there may be no noticeable symptoms, but that does not mean that nothing is happening. As the exposure continues, damage could be accumulating.

If the exposure is stopped early enough, the body can recover completely and repair, or adapt to the damage that has occurred.

No one can tell exactly how long it will take for power line radiation to cause a serious disease in any individual. For most people it may take decades and for others it will not occur in a lifetime.

But a small percentage of people who live close to power lines will become sick within 3 to 5 years. Children are most vulnerable, particularly to leukemia. See our page **Who is at risk?** for more information on this.

Power Line Radiation – How Close is Too Close?

Both high-voltage transmission lines and also neighbourhood power lines constitute a radiation hazard. The size of the power line is not the issue. The strength of the electromagnetic field (especially the magnetic component) **where you live** is what is important.

The configuration of power transmission lines greatly affects the EMF. As with house wiring, how it's designed makes all the difference.

It is common for high-voltage, high-current-carrying power transmission lines to generate a magnetic field whose strength is well above normal household ambient levels, at distances up to 200 metres, although most suburban power lines would generate a much smaller EMF.

But it is also common for a neighbourhood power line (suspended on street poles) to create an unhealthy EMF at a distance of 15 metres, affecting a row of houses all along the street.

In each case, much depends on the configuration of the wires and how much current they carry.

We All Live Next to Power Lines

Even if you can see no power lines in your area, there may be underground cables much closer than you imagine. The power must get to your house somehow!

Normally underground cables produce little electromagnetic radiation, not because they are buried (the magnetic energy penetrates the soil) but because the electromagnetic forces are opposed by current flowing in the opposite direction in adjacent wires.

EMF is highest at times when current flow is highest (usually during the day in industrial and commercial areas, and during the early-morning and early evening for residential areas).

For an indication of power line EMF strength and distance, see our **Sample Power Line Measurements**, but remember that these are typical measurements. The extent of the EMF varies with different power lines.

Protection from Power Line Radiation

Your best protection from power line health risks is knowledge, and that may mean taking measurements.

If you have no way of measuring power line radiation levels, it may help to know that the strongest high voltage transmission lines (400kV) typically produce less than 0.5 milligauss EMF at 200 metres. The strongest street pole power lines (33 kV) generally produce less than 0.5 milligauss at 25 metres. Many street pole power lines are of a lower voltage than this, and their EMF would extend far less.

Power lines vary, so if your house is less than 200 metres from major power lines, or within 25 metres of street-pole power lines, you may want to use a Low Frequency Gaussmeter suitable for power line radiation detection:

- Measure the strength of the magnetic field in the areas where your family spend most of their time, especially bedrooms (place the meter on the pillow), kitchens and living areas.
- Do this with your power switched off at the mains, then again with it turned on. That way you can determine how much of the EMF is coming from power line (or sub-station) radiation and how much from your own house-wiring and appliances.
- Don't forget to measure the field strength outdoors, where you sit, and where children play.
- Take measurements at the same locations at various times of the day.

If you have access to a low-frequency EMF meter, and your meter shows less than 0.5 milligauss there is no cause for concern. See our EMF-Guidelines for risk assessment at various EMF levels.

If your EMF values (from power line radiation alone) are above 1.0 milligauss you may be at risk from health effects in the long term.

Screening Power Line Radiation

There is no way to screen low-frequency **magnetic** fields (although the **electric** field is easily screened by window glass or almost any material). Unfortunately it is the magnetic component which penetrates the body and causes health damage.

Remember that power lines are not the only source of EMF in your home, and may not even be the main source. A sound strategy is to minimise your EMF exposure from all other sources.

Most people who are concerned about nearby power lines or sub-stations are being exposed to high levels of EMF from equipment **within** their home. This often far exceeds the power line radiation.

An EMF survey of your home can help you evaluate your risk from all forms of low-frequency and radio-frequency (microwave) radiation.

You can also help your body to repair the damage caused by living near power lines by improving your diet and lifestyle. Eat fewer processed foods, less refined sugar, and more fresh fruit and vegetables. Get a good night's sleep – that's when repair takes place, and exercise regularly.

But you knew all that stuff already, didn't you?

You may also find these articles helpful:

- EMF Health Effects
- What EMF Does to Your Body
- EMF Protection Tips
- EMF Pollution
- Measuring Power Line Radiation
- Housewiring Radiation
- Substation Radiation

photos by: johnnytakespictures & Bardsworld, timo_w2s, ngotoh, borkur.net, Maurizio Zanetti

Product Categories

- Cell Phone Radiation Protection
- EMF Books
- Ionizing Radiation Meters
- Low Frequency EMF Meters
- Other Radiation Shielding
- Radiation Shielding Fabric
- Radiation Shielding Paint
- Radio Frequency EMF Meters
- Uncategorized

Popular Articles

- Can Smart Meter Radiation Endanger Your Health?
- EMF Pollution
- What is EMF
- What EMF does to Your Body
- Living Close to Power Lines
- What kinds of EMF are Harmful?
- EMF Health Effects

- EMF Health Dangers - Who is at Risk?
- Six EMF Protection Tips
- Cell Tower Health Risks
- Cell Phone Radiation Health Danger
- How to Keeep Safe from Cell Phone Radiation
- Is Computer Radiation Damaging Your Health?
- EMF from Cars and Bikes
- TV Radiation
- Radiation from Domestic Appliances
- Microwave Oven Radiation
- Poor House Wiring Causes Strong Magnetic Fields
- EMF Values for Sample Appliances
- EMF Survey Services
- EMF Research Quality and Quantity
- Substation Health Risks

Share this page with your friends...

- Home
- EMF & Health Risks

Resources

Health Risks - Power Line Studies

Facts About Power Lines

High voltage transmission lines (those towering metal power lines you often see usually along highways and across rural landscapes.

- Use high voltage direct current (HVDC) to transmit large amounts of power from the generating station over long distances
- Voltage varies from 138kV to 765kV
- Radiate powerful electromagnetic fields (EMFs)
- Linked to diseases in animals and humans
- There is growing speculation that the values of homes near major power lines will soon begin to decrease because of this threat

Transmission substations, (which often look like a fenced-in thicket of metal structures. Maybe you see one near your home, school or office.):

- Contain circuit breakers, switches and transformers
- Decrease the voltage coming from high voltage transmission lines
- Connect to local, lower voltage distribution lines.
- Reroute power to lines that serve local markets
- Suspected cause of cancer clusters for nearby residents

Lower voltage distribution lines, (or local power poles, which are everywhere):

- Are smaller than the huge high voltage lines
- More likely to be seen in residential areas
- Sometimes buried
- Risk varies with strength of voltage

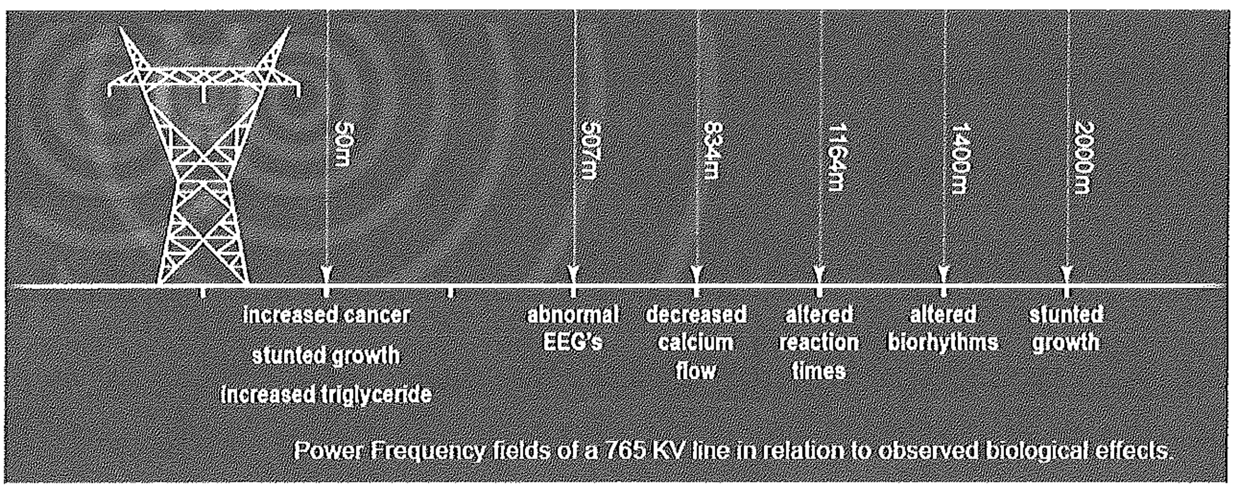
Transformers, (those barrel-like metal trashcans mounted on power poles are EMF factories.):

- Reduces the voltage to the 120-/240 current needed by the nearby homes
- The typical power line feeding the transformer is carrying 4000 to 13,000 volts
- Creates a strong field extending up to a 1/4 of a mile
- The strength of this field decreases significantly with distance (the further away you are the better, even if you are still within a quarter mile)
- Health risk depends on strength of incoming power line

Buried lines and transformers (Recognizable by a metal box located on the ground near the street.):

- Some people contend that burying power lines can mitigate EMF dangers.
- Other experts note that while burying power lines will shield the electric component of the electromagnetic field (EMF), the magnetic component can still pass through the earth—and walls and human or animal bodies.

Research on Power Lines and Health



Living Next To Power Lines Increases The Risk Of Cancer
After hundreds of international studies, the evidence linking EMFs to cancers and other health problems is loud and clear. High Voltage power lines are the most obvious and dangerous culprits, but the same EMFs exist in gradually decreasing levels all along the grid, from substations to transformers to homes.

From the British Medical Journal, June, 2005:
Researchers found that children living within 650 feet of power lines had a 70% greater risk for leukemia than children living 2,000 feet away or more.

From Epidemiology, 2003 Jul;14(4):413-9:
"Several studies have identified occupational exposure to extremely low-frequency electromagnetic fields (EMF) as a potential risk factor for neurodegenerative disease."

From Epidemiology, 2002 Jan;13(1):9-20
There is "strong prospective evidence that prenatal maximum magnetic field exposure above a certain level (possibly around 16 mG) may be associated with miscarriage risk."

From the Internal Medicine Journal, 2007
In a study of 850 lymphoma, leukemia and related conditions, researchers from the University of Tasmania and Britain's Bristol University found that living for a prolonged period near high-voltage power lines increased the risk for these conditions later in life.

- People who lived within 328 yards of a power line up to age 5 were five times more likely to develop cancer as an adult.

- People who lived within 328 yards of a power line at any point up to age 15 years were three times more likely to develop cancer as an adult.

Dr. David Carpenter, Dean of the School of Public Health (SUNY), believes that up to 30% of all childhood cancers come from exposure to high voltage power lines.

Even the Environmental Protection Agency (EPA) cautions citizens that "There is reason for concern" and advises "prudent avoidance" of high voltage power lines.

The California Department of Health concluded that EMFs were responsible for an increase in childhood leukemia, adult brain cancer, Lou Gehrig's disease and miscarriage in the 2002 report, "An Evaluation of the Possible Risks From Electric and Magnetic Fields (EMFs) From Power Lines, Internal Wiring, Electrical Occupations and Appliances."

The studies cited above and dozens of other epidemiological studies specifically link high voltage power lines with:

- Brain tumors
- Leukemia
- Birth defects
- Lymphoma

- DNA Damage from EMF
- Impact of EMF on Children
- Male Fertility Impacted by EMFs
- Electro-Sensitivity
- BioInitiative Report
- Professional Concern about EMFs

| Sitemap

full load current will flow through this return path. This return path can be another set of wires on the transmission structure (sometimes referred to as a dedicated metallic return or dedicated metallic neutral). At this time. Clean Line intends to utilize a dedicated metallic return.

Is there sound associated with the line? How much and what will it sound like?

- At the edge of the right-of-way, the sound associated with the line should be in the same range as a whisper. Audible noise is produced by corona on transmission line conductors. Corona is an electric discharge from the conductor caused by ionization of the air. This sizzling or crackling sound is called random noise. Random noise results from a multitude of small snapping sounds at corona points on the conductor.

HEALTH AND SAFETY

What is EMF?

- EMF stands for electric and magnetic fields. Electric fields are produced by voltage, and voltage is the electrical pressure that drives an electric current through a circuit. Magnetic fields are produced by current, and current is the movement or flow of electrons. EMFs are naturally present in the environment and are present wherever electricity is used, for example a toaster, cell phone, a battery operated device, a lamp, a computer, etc. The earth has both magnetic fields produced by currents in the molten core of the planet and an electric field produced by electrical activity in the atmosphere, such as thunderstorms.

What health effects are associated with electric and magnetic fields (EMF)?

- There are no known long-term health impacts from the EMF associated with a transmission line. The magnetic field of a DC line is similar in nature to the natural magnetic field of the Earth (the same field that allows a compass to work), and the strength of the magnetic field while standing beneath the conductors is comparable to the strength of the Earth's field. The static electric field of a DC line when standing beneath the conductors is ten times weaker than the static electric charge you may get from walking across a carpet on a dry winter day.
- For more information on electric and magnetic fields and HVDC transmission, please contact us to request a fact sheet or visit our website.

What is stray voltage?

- The term "stray voltage" can refer to several phenomena involving the creation of an unintended electric potential difference (voltage) between two conductive surfaces. In areas where power lines traverse agricultural land, the term often refers to the development of a potential difference between the grounded neutral conductor of a power line (a wire that usually carries minimal current) and the ground to which it is connected, causing current to flow on the grounded neutral. This current, in turn, can develop a potential difference with nearby conductive material present in agricultural operations.
- Under normal operation and with proper safety measures in effect, stray voltage remains below levels that affect the health or behavior of persons or animals. Under non-standard operating conditions, or when safety measures are not in place, voltage may increase such that persons or animals may be affected if they contact conductive material and an elevated current is induced.
- There is also no stray voltage from a DC line. DC transmission lines do not induce voltages on neighboring vehicles, structures, fences, or other conductive materials or nearby surfaces.

Are there any studies that would suggest harm to people or animals either short-term or long-term from the transmission line?

- Several studies have assessed the impacts on agricultural operations of stray voltage, along with electric and magnetic fields, corona and air ions. According to an epidemiological study of 500 herds of Holstein dairy cattle, herd health, measured using multiple indicators, did not differ between periods before and after a nearby +/- 400 kV direct current line was energized. These results did not vary based on the herd's distance from the high voltage direct current power line. Another study conducted by Oregon State University titled "Joint HVDC Agricultural Study" determined that no differences were found between cattle and crops raised under +/-500 kV direct current lines and those raised away from the lines. A report by the Western Interstate Commission for Higher Education also determined that a +/-

Exhibit from Sherry Christopher RN, BSN