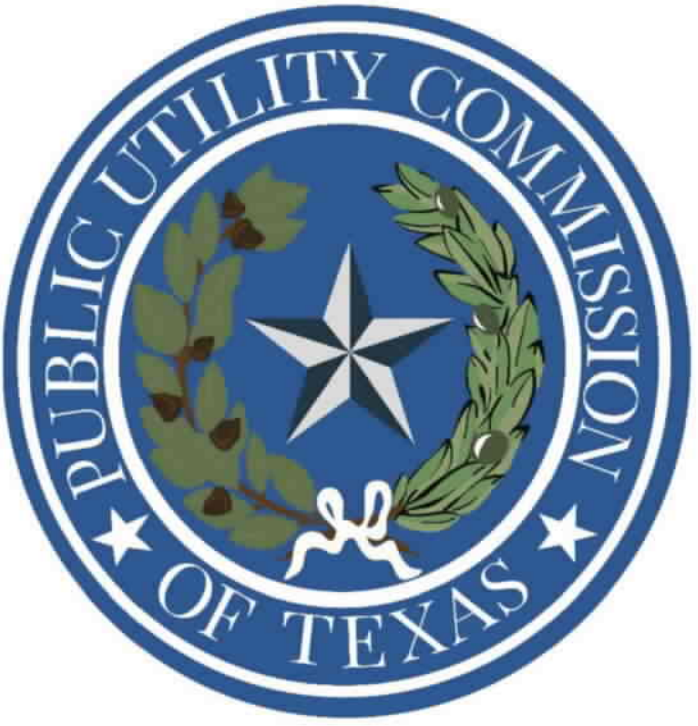

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Is living near power lines bad for our health?

Ray Copes, MD,
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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.[1] 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 30 000 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 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.

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Living near Power Lines

People use so many technologies today and they take most of those for granted. It is really difficult to live without those technologies – you will have a hard time cooking your meal without your microwave, you will feel bored without your TV, and you just cannot see in the dark without any lights.

All these technologies require electricity to operate, and as more and more people are using these technologies, the demand for electricity is increasing too, which has resulted in the increase in the number of transmission towers and overhead wires. What people don't understand is that living near power lines will expose them to the electrical and magnetic energy produced by these high-voltage wires. Long-term exposure can cause several health problems.

Is Living near Power Lines Really Bad?

A simple answer is YES. Some research has already showed evidence of how long-term exposure to these high-voltage wires can lead to several health problems. Here are the most common issues you may experience when living near power lines.

1. Childhood Leukemia

One of the first studies was conducted in 1979 in which researchers studied any relationship between incidence of leukemia in children living near high-voltage power lines and towers. They chose a residential area inside Denver, Colorado to conduct the study and compared the electromagnetic field (EMF) radiation effects on people living at various distances from high-voltage wires and transmission towers. The results were shocking as children living close to power sources were more at risk for childhood leukemia. However, no evidence has been provided to establish a direct connection between childhood leukemia and EMF.

2. Cancer

Another research study conducted in Australia looked for any connection between the incidence of cancer in people living near power lines and transmission towers. The research showed that those who lived within 50 m radius of a power source had 166% of chances to develop cancer as compared to those who lived at least 300 meters away from a power source. This confirmed that there is a connection between exposure to power sources and cancer.

3. Depression

A research conducted on the psychological effects of living close to power lines showed exposure to extremely low frequency EMF might contribute to the number of depression-related suicides in people living close to those power sources. EMF was responsible for disruption in circadian rhythm cycles, alteration in melatonin and serotonin neurotransmitter levels in people living close to those areas.

In addition to these effects, many other published papers have discovered links between living near power lines and a number of other health concerns, including brain cancer, Alzheimer's disease, Lou Gehrig's disease, miscarriage, breast cancer, birth defects, fatigue, hormonal imbalances, decreased libido, sleeping disorders, heart disease, neuro-degenerative disease and more.

Why Is Living near Power Lines Bad?

Power lines are used to transfer high-voltage electric current from place to another, but when the current flows through the lines, it creates two separate fields around them – a magnetic field and an electric field, both of which are important components of the electromagnetic field. This electromagnetic radiation is responsible for creating negative effects on human body. The magnetic component is even more dangerous because it gives out more EMF. The strength of this magnetic field usually depends on how much current flows through the wires, the voltage and the configuration of those wires.

What Is the Safe Distance to Live near Power Lines?

Ideally, you should be as far from power lines as possible. If you're within 50 of a 765 kv line or transmission tower, you're more likely to develop cancer and experience increase in triglyceride. When the distance is 507 m, you may experience abnormal EEG's. When you're at least 834 m away from it, you may end up developing issues related to decreased calcium flow. A distance of 1400 m may still result in altered biorhythms, and you may still experience issues related to stunted growth even if you're 2000 m away from a transmission network.

What Can You Do to Protect from EMF?

Sometimes, you think there are no visible power lines in your area, but there may still be underground cables posing health risks. Some household products, such as microwave, computer, blender, clothes washer, etc., can also have EMF. It means even if you think you're far from power lines, it is still a good idea to take some protections from EMFs.

- Don't stick with an old appliance because the older it is, the higher EMFs will be emitted through it.
- EMFs are the strongest when you're 2-3 feet from the appliance. Maintain your distance always!
- Don't spend too much of time around electrical appliances in your home.
- Keep cordless phones, cell phones, clocks and other electrical devices at least six feet from where you sleep.
- Buy some EMF products to counter artificial EMFs, which in turn will help restore balance to the fields around you.

Papers

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

Gerald Draper, Tim Vincent, Mary E Kroll, John Swanson

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

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)

	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.

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.

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 ($P<0.01$).

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).

Power lines produce small air ions through a process known as "corona." Fews et al suggest that this could lead to health

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

	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 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.

Table 4 Relative risks for categories of socioeconomic status

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

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 leukaemia[9]) 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

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

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.

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.

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.

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(Accepted 6 April 2005)

bmj.com 2005;330:1290

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Science commentary: Power to confuse

Geoff Watts

Ever since Nancy Wertheimer of the University of Colorado reported her 1979 findings of an excess of cancer in children living near overhead power lines, seldom has a year passed without a flurry of public debate over the safety or otherwise of these ugly (the one thing all parties agree on) but essential installations.

Much of the argument has been about the very existence of the alleged hazard. As recently as last month, the organisers of the 15 year UK childhood cancer study declared that "perceived risk factors such as living near sources of electromagnetic fields . . . are not principal causes, if at all, of leukaemia in children." But a clutch of studies reporting a positive association—of which this week's by Draper and colleagues is the most recent[1]—has encouraged researchers to continue investigating possible mechanisms.

Electrical and magnetic fields can induce currents that might alter the voltages across cell membranes. Magnetic fields might cause the movement of ferromagnetic particles within cells. They might also influence free radicals: atoms with unpaired electrons that are highly reactive and play a part in all sorts of biochemical processes. Low frequency electromagnetic fields have been said to alter the progress of cells through the cell cycle and reduce the effectiveness of the immune system. Power lines might even deflect and concentrate cosmic rays on people living within their vicinity. Evidence to support these and other ideas, however, is at best thin and at worst non-existent.

One of the more recent attempts at identifying a mechanism sidesteps the need to invoke direct effects. For the past 10 years or so, Bristol University physicist Dennis Henshaw has been working on the influence of powerful electric fields on the deposition of airborne particles. The relevance of this to power lines entered public consciousness in 1999 with the publication of two papers by Henshaw and colleagues.[2 3] High energy power systems, they pointed out, cause some breakdown in the surrounding air molecules and so generate positive or negative ions. The systems are designed to minimise this effect, but it does still occur—and any aerosol pollutants that pass through these ion clouds can acquire an electrical charge.

If particles with a charge are inhaled, more of them will stick to the lining of the respiratory system. The data are limited, but one study that used a model of the human airway suggests that deposition could be increased by a factor of around three. A 2004 report by the (then) National Radiological Protection Board conceded the plausibility of the mechanism and suggested some further experiments.[4] Draper and colleagues refer to the Henshaw hypothesis but add that more work will be necessary to rule it in or out.[1]

Like the fluoridation of drinking water and the genetic modification of crops, the debate over power lines seems destined to be with us for a while yet. So, in these risk averse times, and before activists begin blowing up pylons, a bit of perspective might help. In 2002, according to the Child Accident Prevention Trust, more than 36 000 children were hurt in road accidents and around 200 were killed. Another 32 died in house fires. Draper and colleagues reckon that five cases annually of childhood leukaemia may be associated with power lines.

1 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:page nos.
2 Fews AP, Henshaw DL, Keitch PA, Close JJ, Wilding RJ. Increased exposure to pollutant aerosols under high voltage powerlines. *Int J Radiat Biol* 1999;75:1505-21
3 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.
4 National Radiological Protection Board. Particle deposition in the vicinity of power lines and possible effects on health. *Documents of NRPB* 2004;15(1).

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Electric and Magnetic Fields from Power Lines

Radiation Facts

- Scientific studies have not clearly shown whether exposure to EMF increases cancer risk.

Electric and magnetic fields, also known as electromagnetic fields (EMF), consist of waves of electric and magnetic energy moving together. These energy fields surround us all the time. The World Health Organization, an agency of the United Nations, classifies extremely low frequency electromagnetic fields as possibly carcinogenic to humans based on limited evidence showing an association with childhood leukemia. However, scientific studies have not consistently shown whether exposure to any source of EMF increases cancer risk. Scientists continue to conduct research on the possible health effects of exposure to EMFs in order to improve health risk assessments and protection programs.

On this page:

About Electric and Magnetic Fields from Power Lines

Electromagnetic Radiation (EMR)

Electromagnetic radiation (EMR) consists of waves of electric magnetic energy moving together through space. An example of electromagnetic radiation is visible light. Electromagnetic radiation can range from low to high frequency, which is measured in hertz, and can range from low to high energy, which is measured in electron volts. Wavelength, another term associated with electromagnetic radiation, is the distance from the peak of one wave to the next.

<https://epa.gov/sites/default/files/2021-05/emf_power_lines_power_lines.png>

This is a picture of a field of grass with some surrounding trees. In the middle of the image there are power lines and their utility poles.

There are two general kinds of electromagnetic radiation: ionizing radiation and non-ionizing radiation. Ionizing radiation is powerful enough to knock electrons out of their orbit around an atom. This process is called ionization and can be damaging to a body's cells. Non-ionizing radiation has enough energy to move atoms in a molecule around and cause them to vibrate, which makes the atom heat up, but not enough to remove the electrons from the atoms.

Electromagnetic Fields (EMF)

Electromagnetic fields associated with electricity are a type of low frequency, non-ionizing radiation, and they can come from both natural and man-made sources. For example, during a thunderstorm the base of a cloud will develop a negative charge while the upper portion of a cloud accumulates a positive charge. This separation of charge leads to an electric field which increases in strength (measured in volts per meter) as the electric potential between the base and upper region of the cloud increases. At the same time, positive charge may begin to pool at the surface of the earth. With sufficient strength, this electric field can lead to a discharge allowing the flow of electricity—the movement of electrons, or current—between the sky and the ground (i.e. lightening). The flow of current generates a magnetic field whose strength is proportional to increases in current (measured in teslas). The image below shows the range of frequencies for different forms of electromagnetic radiation found in the electromagnetic spectrum.

The waves from power lines and electrical devices have a much lower frequency than other types of EMR, such as microwaves, radio waves or gamma rays. However, a low frequency wave does not necessarily mean that it is low energy; a charging cable for a phone produces a low frequency, low energy electromagnetic field, while a high-tension power line can create a much higher energy electromagnetic field that is still low in frequency.

EMR associated with power lines is a type of low frequency non-ionizing radiation. Electric fields are produced by electric charges, and magnetic fields are produced by the flow of electrical current through wires or electrical devices. Because of this, low frequency EMR is found in close proximity to electrical sources such as power lines. As current moves through a power line, it creates a magnetic field called an electromagnetic field. The strength of the EMF is proportional to the amount of electrical current passing through the power line and decreases as you move farther away. Because of this property, the exposure to an electromagnetic field you would receive from a power line decreases with distance.

What You Can Do

If you are concerned about possible health risks from electric and magnetic fields, you can:

- **Increase the distance between yourself and the source.** The greater the distance between you and the source of EMF, the lower your exposure.
- **Limit the time spent around the source.** The less time you spend near EMF, the lower your exposure.

Where to Learn More

Multiple agencies within the federal government regulate EMF. The agency that sets standards for EMF depends on the frequency of the EMF. However, in the United States, there are no federal standards limiting electromagnetic fields from power lines and other similar sources. Some states set standards for the width of right-of-ways under high-voltage transmission lines because of the potential for electric shock.

The World Health Organization (WHO)

The WHO studies EMF and RF and invites scientists from all over the world to collaborate on their research.

Electromagnetic Fields (EMF) <https://www.who.int/peh-emf/en/>
This page discusses the World Health Organization's (WHO's) EMF Project.

Department of Health and Human Services (HHS), National Institutes of Health (NIH), National Institute of Environmental Health (NEIHS)

The National Institute of Environmental Health Sciences (NIEHS)'s mission is to discover how the environment affects people in order to promote healthier lives.

Electric & Magnetic Fields <https://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>
This page includes a link to a report created by NIEHS that addresses EMF from power lines.

The States

Some state radiation protection programs have guidance and information on their state's non-ionizing radiation regulations.

Radiation Control Programs <https://www.crcpd.org/rpmap.aspx>
The Conference of Radiation Control Program Directors (CRCPD)
This webpage provides links and contact information for each state's Radiation Control Program office.

No FEAR Act Data
<https://epa.gov/ocr/whistleblower-protections-epa-and-how-they-relate-non-disclosure-agreements-signed-epa>

Plain Writing
<https://epa.gov/web-policies-and-procedures/plain-writing>

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