Gezondheidsraad
Health Council of the Netherlands

The Minister of Housing, Spatial Planning
and the Environment (VROM)

Subject	: High-voltage power lines
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Dear Minister,

On 27 November 2007, you asked the Health Council of the Netherlands a number of questions concerning high-voltage power lines and health. The questions were in response to a statement from the Council of State on the proposed construction of a sports park under a high-voltage power line near Zutphen, and a statement by the court in interlocutory proceedings at the District Court of The Hague, concerning an end connection of a high-voltage power line in Voorschoten. The questions were:

1. To what extent can the measurements recommended by the Council of State be used to make a scientifically well-founded assessment of the risk in situations in which there has been no long-term exposure of the kind referred to in the recommendation of the Ministry of Housing, Spatial Planning and the Environment of 2005?
2. Is there sufficient scientific basis for using the product of the duration of exposure and the size of the magnetic field as a measure of the health risk? Or do you see other possibilities for indicating such a connection?
3. Is sufficient scientific information available to indicate what increase in the magnetic field above 0.4 microtesla would lead to a ‘significant’ increase in the risk of childhood leukaemia?

I have submitted these questions to the Health Council's Electromagnetic Fields Committee for an answer. The Committee informed me as follows, after incorporating comments of the Health Council’s Standing Committee on Radiation and Health.

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In summary, the Committee's conclusions are as follows:

- Measuring the strength of the magnetic field at places where people remain for long periods is often the first step in estimating the level of exposure to those fields. However, using these estimates to determine the size of the risk involves many uncertainties. Epidemiological studies showed an increased risk of leukaemia among children living at locations where the field strength was higher than 0.3–0.4 microtesla (µT). However, no indications of a causal mechanism have been found in experimental research. The possibility cannot be excluded that a factor other than exposure to a low-frequency magnetic field could explain the association found in epidemiological research.
- It is not possible to say at what level of exposure the risk is 'significantly' increased compared to that at exposure to 0.4 µT.
- All the studies involved people who had lived for at least one year at the location where the field strength was determined. On the basis of this, 'long-term' may be deemed to mean 'for at least one year involving a stay of at least around 14–18 hours per day'.
- There is no scientific substantiation for the use of the product of the duration and level of exposure as a cumulative 'dose' for determining the size of the risk. The studies used an average exposure over a certain period and the conclusions were based on this. It is especially important to be extremely cautious with using a 'dose' when the field strength is much higher than the investigated range and the characteristics of the exposure pattern, if any, that are causally linked to the risk are not known.

The questions you asked the Health Council are concerned with interpreting the scientific data that form the basis for the recommendation the Ministry of Housing, Spatial Planning and the Environment made in 2005 on high-voltage power lines and children. Before answering the questions, the Committee provides a brief summary of the scientific facts.[1]

Risk assessment from epidemiological studies

Around 20 epidemiological studies have been conducted into the relationship between childhood leukaemia and living in the proximity of overhead power lines. The design and quality of the studies have been rather varied. Two analyses were published in 2000 which combined the raw

[1] A recent comprehensive review of the scientific data is given by the World Health Organisation (WHO) in de monograph "Extremely Low Frequency Fields" (Environmental Health Criteria 238; see http://www.who.int/peh-emf/publications/elf_ehc/en/index.html).

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data of various studies into one analysis. These pooled analyses included data from studies with a more or less similar design and of an adequate scientific quality. The two pooled analyses included largely the same, but also partially different studies, and they analysed the data in a different manner. Nevertheless, the results agree well.

Ahlbom and co-workers carried out two types of pooled analyses.[2] The data were first divided into four field-strength categories: < 0.1 µT, 0.1–0.2 µT, 0.2–0.4 µT, > 0.4 µT. It was only for the > 0.4 µT category that a significantly increased relative risk was found of 2.0 (95% confidence interval 1.27–3.13) compared to the < 0,1 µT category (the reference group). Ahlbom made no further differentiation in the > 0.4 µT exposure category. The entire group of leukaemia patients in this category comprised 44 people. This number was composed of the patient numbers from nine individual studies, in which the numbers per study varied from 0 to 13. In a few individual studies a distinction was made between exposure categories higher than 0.4 µT, but this resulted in numbers that were too low to conduct a meaningful analysis. The data were also analysed with the field strength as a continuous variable. This resulted in a relative risk of 1.15 (1.04–1.27) per 0.2 µT increase in magnetic field strength. The publication did not indicate the field strength to which this continuous risk increase can be extrapolated. On being asked, Ahlbom also said that it is not possible to say anything about this. [3]

The Netherlands National Institute of Public Health and the Environment (RIVM) used this risk factor in a report of 2001 to calculate the risk up to an exposure level of 1.0 µT.[4] The wide 95% confidence interval resulted in a large margin of uncertainty for the higher exposure levels.

The second pooled analysis was conducted by Greenland and co-workers.[5] They likewise divided field strengths into four categories but with a different value for the highest cut-off point: < 0.1 µT, 0.1–0.2 µT, 0.2–0.3 µT, > 0.3 µT. It was only the > 0.3 µT category that produced an increased relative risk in this analysis: 1.69 (1.25–2.29). Greenland and co-workers did not analyse the data with field strength as a continuous variable.

[2] Ahlbom, A, Day, N, Feychting, M, e.a. A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer, 2000; 83(5): 692-698.

[3] Alhbom, A. Personal communication, December 2007.

[4] Van der Plas, M, Houthuijs, DJM, Dusseldorp, A, e.a. Magnetische velden van hoogspanningslijnen en leukemie bij kinderen. (Magnetic fields of high-voltage power lines and childhood leukaemia.) Bilthoven, RIVM, 2001 (RIVM report nr 610050 007; in Dutch).

[5] Greenland, S, Sheppard, AS, Kaune, WT, e.a. A pooled analysis of magnetic fields, wire codes, and childhood leukaemia. Epidemiology, 2000; 11(6): 624-634.

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The results of later epidemiological studies correspond with these pooled analyses.[6]

Determining exposure

Usually the various epidemiological studies did not assess the actual exposure of the subjects, but the strength of the magnetic field in or close to the home was determined by measurement or calculation. This field strength was used as a surrogate for exposure. In the studies that were included in the pooled analyses and in which measurements were made, they were made over 24 or 48 hours. These measurements included contributions made by sources in the home as well as outside (such as overhead power lines). In the studies in which the field strength in the homes was calculated, it was only done so for the field strength caused by high-voltage power lines. The actual field strength would have been higher because of the contribution from sources in the home. Field strength variations in time and place were only taken into account to a limited degree in these measurements and calculations, and the time actually spent in the home was not taken into account. Moreover, exposure outside the home was not determined.[7]

The time-weighted average field strength was used as a measure of the actual exposure of children. However, it is not known whether this is the most relevant measure of exposure for possible impacts on health. Nor does this parameter provide information on the pattern of exposure, such as the occurrence of peaks and troughs.

Duration of exposure

The reference Ahlbom used for the magnetic field strength was the average over a period of one year preceding diagnosis, whereas Greenland used the average over a period of up to three months preceding diagnosis. The actual duration of exposure in the studies that formed the basis for the pooled analyses was usually longer. Some studies considered the entire period from birth (or even conception) until diagnosis as the duration of exposure. Other studies only considered children who had lived at the address of diagnosis for longer than one year. Only a few studies set no

[6] See the WHO report of footnote 1.

[7] A 2004 letter report of the National Institute of Public Health and the Environment (RIVM) provides an overview of how the field strength has been determined in the different epidemiological studies [Kelfkens, G, Pruppers, M. Hoe wordt in epidemiologische studies de magnetische veldsterkte in de buurt van hoogspanningslijnen bepaald en wat is langdurige blootstelling? (How is the magnetic field strength near high-voltage power lines determined in epidemiological studies and what is long-term exposure?) Bilthoven, RIVM, 2004 (RIVM-letter report 330/2004; in Dutch)].

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restrictions to residential stability or to the period of living at the address prior to diagnosis. Before they were diagnosed with leukaemia, most children in the pooled analyses had therefore been exposed to the magnetic fields in the home concerned for at least one year and a considerable number of them for a much longer period.

A study by Friedman and co-workers showed that the daily length of time spent in the home on weekdays can vary from around 14 hours for children age 9-14 to around 18 hours for children younger than nine.[8] The average time spent in the home per day for very young children (below five years old) may be longer than 18 hours per day.

Data from experimental studies

The many experimental studies which have been conducted provided no indications of a mechanism that could form the basis for a causal link between childhood leukaemia and exposure to low-frequency magnetic fields.

Conclusions

The Committee has established the following on the basis of the above facts:

- there is an increased risk of childhood leukaemia in the case of a long-term stay in a home environment with a field strength in excess of 0.3–0.4 μT
- in this regard, 'long-term' should be deemed to mean 'a period of around 14-18 hours per day over a period of at least one year'
- the numbers of observations in the highest field-strength categories are too small to accurately determine a quantitative relationship between field strength and effect
- no statements can be made about a possible risk increase in relation to increased exposure in excess of 0.4 μT
- it is not known which exposure parameters (such as duration and intensity) determine the size of the risk
- no mechanism can be deduced from experimental studies that indicates a causal link between exposure to low-frequency magnetic fields and childhood leukaemia
- the possibility cannot be excluded that factors other than exposure to these fields could explain the identified risk.

[8] Friedman, DR, Hatch, EE, Tarone, R, e.a. Childhood exposure to magnetic fields: residential area measurements compared to personal dosimetry. Epidemiology, 1996; 7(2): 151-155.

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The Committee has used this data to answer the questions in the request for advice.

1. The study recommended by the Council of State into the magnetic field strength at the sports park could provide information on the level of exposure that people would face at the sports park. However, it has not been established that the risk is determined by the intensity or duration of exposure, or a combination of these. Therefore these data cannot be used to make a scientifically well-founded assessment of the risk of spending time at the sports park.
2. There is no scientific substantiation for using any mathematical relationship whatsoever between duration of exposure and magnetic field strength as a measure of the health risk. In the epidemiological studies, the average field strength in the home during a given period prior to diagnosis was used as a measure of exposure, yet it has not been scientifically established that this is a correct measure of the health risk. An increased risk was only found when a considerable part of the day was spent in the home over an extensive period, with a field strength in excess of 0.3–0.4 μT. However, it is unlikely that a sudden increase in risk would occur at an exposure level of 0.3–0.4 μT, as the Committee believes a gradual increase would be more likely from the biological point of view.
3. The scientific data do not enable a determination to be made of whether there is an increase in the risk of childhood leukaemia when the magnetic-field strength increases in excess of 0.4 μT. It is therefore not possible to indicate what increase in the strength of the magnetic field in excess of this level should be considered as ‘significant’. As an illustration of this, calculations show that, for exposure at the sports park, under unfavourable circumstances, the time-weighted annual average of the exposure could be around 0.28 μT; this includes a contribution of 0.07 μT for exposure in the home but no contribution for exposures in other situations.[9] The maximum intensity of exposure at the sports park could increase to around 6 μT. This is a field strength to which children could also be exposed in the street, as a result

[9] Van de Weerdt, DHJ. Beoordeling van het gezondheidsrisico door blootstelling aan extreem laagfrequente magneetvelden van een bovengrondse hoogspanningslijn op het toekomstige sportcomplex ’t Meijerink te Zutphen (Appraisal of the health risk by exposure to extremely low frequency magnetic fields of an overhead high-voltage power line at the future sports complex ’t Meijerink in Zutphen). Apeldoorn: GGD Gelre IJssel; draft report of 27 November 2007 (in Dutch).

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of distribution cables below pavements, for example.[10] Low-frequency magnetic fields of a few microtesla also occur in trains[11] and cars[12]. Using the available scientific data, it is not possible to estimate the health risk of such relatively short duration exposures (as faced during a car ride or time spent at a sports field) to a relatively high field strength.

Yours sincerely,

(signed)

Professor M. de Visser
Vice-President

[10] Lindgren, M, Gustavsson, M, Hamnerius, Y, e.a. ELF magnetic fields in a city environment. Bioelectromagnetics, 2001; 22(2): 87-90.
Paniagua, JM, Jimenez, A, Rufo, M, e.a. Exposure to extremely low frequency magnetic fields in an urban area. Radiat Environ Biophys, 2007; 46(1): 69-76.
Straume, A, Johnsson, A, and Oftedal, G. ELF-magnetic flux densities measured in a city environment in summer and winter. Bioelectromagnetics, 2008; 29(1): 20-28.
Decat, G, Meyen, G, Peeters, E, e.a. Modellering en GIS toepassing voor het bepalen van de blootstelling en het epidemiologisch risico van het 50 Hz magnetisch veld gegenereerd door de ondergrondse hoogspanningskabels in Vlaanderen. Eindrapport. (Modelling and GIS application for the determination of exposure and the epidemiological risk of the 50 Hz magnetic field generated by underground high-voltage power cables in Flanders. Final report.) Mol: VITO, 2007. Report 2007/IMS/R/426. (see http://www.milieurapport.be/default.aspx?PageID=86&ChapID=4643&NodeID=4643; in Dutch)
In the Netherlands, according to EnergyNed, field strengths of 6-8 µT are present directly above distribution cables. These cables are usually located at a depth of 0.5 to 1 metre underneath pavements, cycling paths, carriageways or green areas. (see http://www.energienedweb.nl/Content/Cms/TermPage.aspx?TermPageID=5&TermID=118; in Dutch).
[11] Dr M Beerlage, Kema, Personal communication, January 2008.
[12] Stankowski, S, Kessi, A, Becheiraz, O, e.a. Low frequency magnetic fields induced by car tire magnetization. Health Phys, 2006; 90(2): 148-153.

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