Magnetic fields of high voltage power lines and risk of cancer in Finnish adults: nationwide cohort study

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Abstract

Objective—To investigate the risk of cancer in association with magnetic fields in Finnish adults living close to high voltage power lines.

Design—Nationwide cohort study.

Subjects—383 700 people who lived during 1970–89 within 500 metres of overhead power lines of 110–400 kV in a magnetic field calculated to be $\geq 0.01 \mu\text{T}$. Study subjects were identified by record linkages of nationwide registers.

Main outcome measures—Numbers of observed and expected cases of cancer, standardised incidence ratios, and incidence rate ratios adjusted for sex, age, calendar year, and social class—for example, by continuous cumulative exposure per $1 \mu\text{T}$ year—with 95% confidence intervals from multiplicative models for all cancers combined and 21 selected types.

Results—Altogether 8415 cases of cancer were observed (standardised incidence ratio 0.98; 95% confidence interval 0.96 to 1.00) in adults. All incidence rate ratios for both sexes combined were non-significant and between 0.91 and 1.11. Significant excesses were observed in multiple myeloma in men (incidence rate ratio 1.22) and in colon cancer in women (1.16).

Conclusions—Typical residential magnetic fields generated by high voltage power lines do not seem to be related to the risk of overall cancer in adults. The previously suggested associations between extremely low frequency magnetic fields and tumours of the nervous system, lymphoma, and leukaemia in adults and breast cancer in women were not confirmed.

Introduction

The epidemiological evidence for a carcinogenic effect of magnetic fields comes from three parallel lines of research: firstly, studies on childhood cancer in the vicinity of power lines^{1–6}; secondly, studies on adult cancer in relation to electrical occupations or measured magnetic fields from occupational sources^{7–14}; and, thirdly, studies on adult cancer in relation to magnetic fields from non-occupational sources including power lines.^{15–26}

Eleven epidemiological studies have so far been published on adult cancer in relation to residential magnetic fields. Of them, seven studies with conflicting results and at most modest increases in risk have assessed exposures to power lines^{15–22} and four to electric blankets.^{23–26} Three studies have included all types of cancer^{15–17, 21} whereas four were restricted to haematological malignancies or leukaemia,^{18–20, 23} one included both leukaemia and brain tumours,²² two were on breast cancer in women,^{25, 26} and one was limited to testicular cancer.²⁴

We investigated the effect of 50 Hz magnetic fields on the occurrence of several types of cancer. High voltage power lines were chosen as the source of magnetic fields merely because there were existing documents from power companies that allowed the retrospective estimation of exposure to magnetic fields. A nationwide exposure register was created on personal exposures to 50 Hz magnetic fields from high voltage power lines over a

period of 20 years (1970–89) in Finland, which made it possible to investigate several types of cancer in one population based cohort study. We present the results on the relation between magnetic fields of high voltage power lines and risk of cancer in adults.

Subjects and methods

ASSESSMENT OF EXPOSURE

The exposure assessment of this study was based on calculations of the average annual magnetic fields (magnetic field densities) separately for each of the years 1970–89 at all buildings located closer than 500 metres from 110 kV, 220 kV, and 400 kV overhead power lines in Finland. The baseline exposure data included the locations of buildings (exact coordinates included in the Central Population Register) and power lines (in basic maps, scale 1:20 000), as well as the voltage, apparent power, and tower types of the 110–400 kV power lines (from power company records). These data cover about 18 000 km—that is, 90% of the total length of respective power lines in Finland.

In the calculation of magnetic fields, variables such as current, typical spatial locations of phase conductors in power lines, and the shortest distance to the central point of the building were taken into account. Currents were calculated from operational/nominal voltages and apparent powers of all power lines. The exposure assessment is more thoroughly described in earlier publications.^{4, 27}

RECORD LINKAGES

Further data collection was based exclusively on the linkages of nationwide registers (that is, person and building data files of the Central Population Register, Population Census 1970, and Finnish Cancer Registry). The study cohort consisted of all people who had lived in a building with a calculated magnetic field of ≥ 0.01 microtesla (μT) for any period between the years 1970–89. This means that the study population comprised both people with clearly increased exposures to residential magnetic fields of power lines and those who had been exposed only to typical residential background levels. The group with least cumulative exposure ($<0.2 \mu\text{T}$ years) served as the internal reference group in some of the cancer analyses. As the result of several successive record linkages, the summary data files of the study ended up including the following information: dates of birth and death, sex, residential history with dates of moving in and out of the building, history of exposure with calculated average annual magnetic fields for each of the calendar years between 1970–89, social class, and cancer data including primary sites, histological codes, and dates of diagnosis for all incident primary tumours.

The following primary sites of cancer were selected to be studied: overall cancer, stomach (code 151 in the *International Classification of Diseases*, seventh revision), colon (153), rectum and rectosigmoid (154), pancreas (157), larynx and epiglottis (161), lung and trachea (162.0–1), breast in women (170), uterine corpus (172), ovary (175), prostate (177), testis (178), kidney (180), bladder, ureter, and urethra (181), melanoma of the skin (190), non-melanoma of the skin (191; excludes basal cell carcinomas), nervous system (193), thyroid

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gland (194), non-Hodgkin's lymphoma (200, 202), Hodgkin's disease (201), multiple myeloma (203), and leukaemia (204-208). Gliomas (code 47, American Cancer Society *Manual of Tumor Nomenclature Coding*) and meningiomas (code 46) were analysed separately from other tumours of the nervous system. Breast cancer in men was not included because only four cases were expected to occur in the whole cohort.

STATISTICAL ANALYSES

The personal histories (between 1 January 1970 and 31 December 1989) of exposure to residential magnetic fields were summarised in the measure of cumulative exposure, which in this study refers to the sum of the products of residential magnetic field (in μT) and length of such exposure (in years). Cumulative exposure was categorised by using the exposure cut off points of 0.2, 0.4, 1.0, and 2.0 that were selected a priori on the basis of the distribution of cumulative exposure in the study population to set apart study subjects with different exposures. The dates of entering each exposure category were defined for each study subject and only the exposures before the date of diagnosis were considered in the cancer analyses.

For determination of incidence rates, the calculation of person years began on 1 January 1974 at the earliest or, if later, at birth or when the subject moved into a building with a calculated magnetic field of $\geq 0.01 \mu\text{T}$. Person years from those aged less than 20 years were excluded from the analyses. Calculation of person years ended at death or on 31 December 1989. The observed numbers of cases and person years at risk were calculated by age (five year age groups), sex, calendar period (1974-81; 1982-90), exposure category (<0.20 ; $0.20-0.39$; $0.40-0.99$; $1.00-1.99$; $\geq 2.00 \mu\text{T}$ years), and social class (I (highest); II; III; IV; unknown). Each exposure category was determined by cumulative exposure up to the date of diagnosis, death, or 31 December 1989. The social class variable was used only in the incidence rate ratio analyses. The expected numbers of cases were calculated by multiplying the specific number of person years for the category by the corresponding incidence of cancer in Finland. The standardised incidence ratios were calculated by dividing the observed number of cases by the number expected. The 95% confidence intervals were defined under the assumption that the observed number of cases followed the Poisson distribution.

The purpose of conducting the incidence rate ratio analyses in addition to the standardised incidence ratio analyses was, firstly, to use the least exposed group as the reference (instead of the general Finnish population) and, secondly, to adjust for potential confounding by social class. Multiplicative Poisson regression with specific numbers of observed cases and person years at risk for each category was used to take exposure and confounding variables into account simultaneously; the incidence rate ratios were estimated from these models. The significance of a variable was assessed by a likelihood ratio test; the criterion of significance was set at the 5% level. A model with sex, age, calendar period, exposure, and social class was fitted (see previous paragraph for categories). Exposure and age were treated as both numerical and categorical variables; exposure was additionally treated as a dichotomous variable (in the results section, however, the incidence rate ratios for categorical and dichotomous exposure are presented in only a few cases of special interest). The calculated means of cumulative exposure within each exposure category (0.05, 0.28, 0.62, 1.38, and $5.04 \mu\text{T}$ years) were used as numerical estimates of exposure. The highest cut off point was set at $1.0 \mu\text{T}$ years in the analysis of Hodgkin's disease and $0.4 \mu\text{T}$ years in the analysis of testicular cancer, however, because the number of expected cancer cases in the highest

exposure category would otherwise have been less than two. Addition of the age square term was also attempted when we used a numerical age variable. The possibility of effect modification by sex, age, and social class was investigated by fitting the corresponding interaction term. When appropriate, the specific incidence rate ratios for each category of confounder were also estimated from models.

Results

The study cohort consisted of 383 700 people (189 300 men) who contributed a total of 2.5 million person years after the age 20. Altogether 275 000 (11%) person years were associated with a cumulative exposure of $\geq 0.40 \mu\text{T}$ years (table 1). There were 8415 observed cases of cancer (4082 in men). Table 2 shows the numbers by primary site.

Risk of cancer in whole cohort—There was a decrease of 2% in the risk of overall cancer in the whole study cohort compared with the general Finnish population; the decrease was of similar magnitude in men and women. All standardised incidence ratios specific for a primary site were between 0.90 and 1.10 with the exception of laryngeal cancer (standardised incidence ratio 0.85; 95% confidence interval 0.66 to 1.08). The only significant standardised incidence ratio was observed for lung cancer which was decreased by 7% compared with the general Finnish population (0.93; 0.87 to 0.98).

RESULTS FOR SPECIFIC CANCERS

The following paragraphs summarise the results; the observed risks of cancer with categorical and continuous cumulative exposure (that is, change in risk given per $1 \mu\text{T}$ year increase in exposure) are presented in more detail in tables 2 and 3.

Haematological malignancies—Overall, the risks of non-Hodgkin's lymphoma, Hodgkin's disease, multiple myeloma, and leukaemia did not vary by level of magnetic field. The incidence rate ratio for non-Hodgkin's lymphoma was 1.03 (table 3). For multiple myeloma, a significant excess risk (1.22) was observed in men but a non-significant decrease in risk (0.87) was observed in women (table 3).

Tumours of the nervous system—No association was observed between the risk of tumours of the nervous

Table 1—Distributions of person years by exposure and covariates

Study variable	Person years (%)
Cumulative exposure (μT years)*:	
<0.20	2 040 700 (80.2)
0.20-0.39	222 800 (8.8)
0.40-0.99	170 200 (6.7)
1.00-1.99	61 700 (2.4)
≥ 2.00	47 800 (1.9)
Sex:	
Men	1 222 800 (48.1)
Women	1 320 300 (51.9)
Age (years):	
20-35	977 500 (38.4)
35-49	811 700 (31.9)
50-64	466 700 (18.4)
≥ 65	287 200 (11.2)
Calendar period:	
1974-81	643 500 (25.3)
1982-90	1 899 600 (74.7)
Social class:	
I	177 500 (7.0)
II	639 600 (25.2)
III	1 283 600 (50.5)
IV	322 600 (12.7)
Unknown	119 800 (4.7)
Total	2 543 100

*Total is 2 543 200 because of effect of rounding.

Table 2—Numbers of cases of cancer by primary site according to cumulative exposure to magnetic fields of high voltage power lines in adults. Figures are numbers of observed cases; standardised incidence ratios (95% confidence intervals)

Primary site	Exposure (μ T)				
	<0.20	0.20-0.39	0.40-0.99	1.00-1.99	≥ 2.00
All sites (n = 8415)	6393;0.98 (0.96 to 1.01)	877;0.98 (0.91 to 1.04)	695;0.97 (0.90 to 1.04)	230;0.89 (0.78 to 1.01)	220;0.92 (0.81 to 1.05)
Stomach (n = 633)	470;0.99 (0.90 to 1.08)	73;1.11 (0.87 to 1.39)	60;1.13 (0.86 to 1.45)	11;0.58 (0.29 to 1.03)	19;1.06 (0.64 to 1.86)
Colon (n = 444)	324;0.97 (0.86 to 1.08)	45;0.96 (0.70 to 1.28)	45;1.17 (0.86 to 1.57)	12;0.87 (0.45 to 1.51)	18;1.40 (0.83 to 2.22)
Rectum (n = 313)	239;0.99 (0.87 to 1.12)	37;1.08 (0.76 to 1.18)	25;0.90 (0.58 to 1.33)	3;0.30 (0.06 to 0.88)	9;0.96 (0.44 to 1.82)
Pancreas (n = 341)	254;1.04 (0.92 to 1.18)	39;1.12 (0.80 to 1.53)	27;0.95 (0.63 to 1.39)	13;1.27 (0.68 to 2.18)	8;0.83 (0.36 to 1.84)
Larynx (n = 66)	47;0.80 (0.59 to 1.07)	10;1.23 (0.59 to 2.77)	3;0.47 (0.10 to 1.37)	3;1.30 (0.27 to 3.81)	3;1.39 (0.29 to 4.06)
Lung (n = 1122)	853;0.94 (0.88 to 1.00)	119;0.93 (0.77 to 1.11)	90;0.88 (0.71 to 1.08)	28;0.77 (0.51 to 1.11)	32;0.91 (0.62 to 1.29)
Breast (n = 1229)	945;1.05 (0.98 to 1.12)	130;1.06 (0.88 to 1.25)	87;0.89 (0.71 to 1.10)	44;1.22 (0.89 to 1.64)	23;0.75 (0.48 to 1.13)
Corpus uteri (n = 251)	182;0.94 (0.81 to 1.08)	24;0.87 (0.56 to 1.30)	34;1.54 (1.07 to 2.15)	4;0.50 (0.14 to 1.27)	7;0.99 (0.40 to 2.03)
Ovary (n = 263)	207;1.03 (0.90 to 1.18)	19;0.71 (0.43 to 1.11)	22;1.04 (0.65 to 1.57)	7;0.91 (0.36 to 1.87)	8;1.21 (0.52 to 2.39)
Prostate (n = 557)	400;0.97 (0.88 to 1.08)	66;1.09 (0.84 to 1.39)	59;1.22 (0.93 to 1.57)	10;0.59 (0.78 to 1.09)	22;1.22 (0.77 to 1.85)
Testis (n = 38)	32;1.00 (0.68 to 1.14)	1;0.31 (0.01 to 1.70)	4;1.60 (0.44 to 4.10)	1;1.12 (0.03 to 6.26)	—;0 (0.00 to 5.51)
Kidney (n = 258)	191;0.91 (0.78 to 1.04)	29;0.97 (0.65 to 1.40)	27;1.12 (0.74 to 1.63)	5;0.58 (0.19 to 1.34)	6;0.75 (0.28 to 1.63)
Bladder (n = 300)	237;1.08 (0.95 to 1.23)	29;0.92 (0.62 to 1.33)	17;0.67 (0.39 to 1.08)	11;1.22 (0.61 to 2.19)	6;0.68 (0.25 to 1.49)
Skin, melanoma (n = 245)	179;0.94 (0.81 to 1.09)	21;0.87 (0.54 to 1.33)	28;1.47 (0.98 to 2.12)	10;1.45 (0.69 to 2.66)	7;1.19 (0.48 to 2.46)
Skin, non-melanoma (n = 234)	177;1.01 (0.87 to 1.17)	20;0.92 (0.56 to 1.42)	26;1.44 (0.94 to 2.12)	6;0.93 (0.34 to 2.02)	5;0.80 (0.26 to 1.88)
Nervous system (n = 301)	238;0.94 (0.82 to 1.06)	35;1.10 (0.77 to 1.53)	16;0.64 (0.37 to 1.04)	5;0.55 (0.18 to 1.28)	7;0.92 (0.37 to 1.89)
Thyroid (n = 151)	122;1.01 (0.84 to 1.21)	8;0.55 (0.24 to 1.09)	10;0.89 (0.43 to 1.64)	7;1.71 (0.69 to 3.52)	4;1.20 (0.33 to 3.08)
Non-Hodgkin's lymphoma (n = 273)	208;1.02 (0.89 to 1.17)	34;1.33 (0.92 to 1.86)	12;0.54 (0.28 to 0.95)	10;1.25 (0.60 to 2.29)	9;1.25 (0.57 to 2.37)
Hodgkin's disease (n = 73)	61;1.01 (0.77 to 1.30)	5;0.75 (0.24 to 1.75)	4;0.78 (0.21 to 2.00)	3;1.64 (0.34 to 4.76)	—;0 (0.00 to 2.51)
Multiple myeloma (n = 112)	82;0.94 (0.75 to 1.17)	12;0.96 (0.50 to 1.68)	10;0.98 (0.47 to 1.81)	3;0.82 (0.17 to 2.40)	5;1.46 (0.47 to 3.40)
Leukaemia (n = 203)	156;0.96 (0.82 to 1.13)	23;1.06 (0.68 to 1.60)	15;0.87 (0.49 to 1.43)	5;0.81 (0.26 to 1.88)	4;0.71 (0.19 to 1.81)

Table 3—Incidence rate ratios (95% confidence intervals) per 1 μ T year increase in exposure by primary site and sex

Primary site	Men	Women	Total
All types	0.96 (0.92 to 1.00)	1.00 (0.97 to 1.04)	0.98 (0.96 to 1.01)
Stomach	0.93 (0.81 to 1.08)	1.05 (0.93 to 1.19)	1.00 (0.91 to 1.09)
Colon	0.95 (0.79 to 1.13)	1.16 (1.03 to 1.29)	1.07 (0.98 to 1.18)
Rectum	0.84 (0.65 to 1.08)	1.05 (0.88 to 1.24)	0.96 (0.83 to 1.10)
Larynx	1.12 (0.89 to 1.41)	—	1.11 (0.88 to 1.39)
Pancreas	0.66 (0.45 to 0.97)	1.12 (0.97 to 1.28)	0.96 (0.84 to 1.10)
Lung	0.99 (0.92 to 1.07)	0.94 (0.77 to 1.16)	0.98 (0.92 to 1.06)
Breast	—	0.95 (0.88 to 1.02)	—
Corpus uteri	—	1.01 (0.88 to 1.17)	—
Ovary	—	1.03 (0.89 to 1.19)	—
Prostate	1.03 (0.95 to 1.13)	—	—
Testis	1.06 (0.55 to 2.05)	—	—
Kidney	0.97 (0.79 to 1.18)	0.94 (0.73 to 1.21)	0.96 (0.82 to 1.12)
Bladder	0.86 (0.70 to 1.05)	1.05 (0.82 to 1.36)	0.91 (0.78 to 1.07)
Melanoma	1.05 (0.86 to 1.28)	1.10 (0.92 to 1.33)	1.08 (0.94 to 1.23)
Skin, non-melanoma	0.90 (0.88 to 1.18)	0.98 (0.80 to 1.21)	0.95 (0.80 to 1.12)
Nervous system	0.94 (0.72 to 1.22)	0.98 (0.81 to 1.20)	0.97 (0.83 to 1.13)
Thyroid	—	1.02 (0.81 to 1.28)	1.05 (0.87 to 1.27)
Non-Hodgkin's lymphoma	0.92 (0.72 to 1.17)	1.12 (0.95 to 1.31)	1.03 (0.90 to 1.18)
Hodgkin's disease	—	0.18 (0.0099 to 3.24)	0.93 (0.62 to 1.40)
Multiple myeloma	1.22 (1.00 to 1.49)	0.87 (0.57 to 1.32)	1.09 (0.91 to 1.31)
Leukaemia	0.83 (0.59 to 1.67)	1.02 (0.81 to 1.28)	0.93 (0.77 to 1.13)

*The adjusted model does not converge.

system and magnetic fields of power lines. This result was consistent for gliomas and meningiomas in men as well as women.

Melanoma of the skin—Melanoma of the skin was the only type of cancer for which the risk was somewhat increased throughout the three highest categories of exposure and in both sexes. The incidence rate ratio was 1.05 for men and 1.10 for women (table 3). The incidence rate ratios (not shown in tables) for the four consecutive levels of exposure were 0.91 (0.58 to 1.43), 1.54 (1.03 to 2.29), 1.52 (0.80 to 2.87), and 1.25 (0.59 to 2.66) in relation to the lowest exposure level.

Oestrogen dependent cancers—The overall risk of breast cancer in women decreased non-significantly with level of magnetic field (0.95; table 3). Risks of cancers of the uterine corpus and ovary did not differ by exposure.

Colon cancer—The risk of colon cancer increased with exposure in women (1.16; 1.03 to 1.29) but not in men (0.95; 0.79 to 1.13) (table 3). In women the risk was highest in the highest exposure category with ≥ 2.0 μ T years (2.03; 1.15 to 3.58).

Other types of cancer—We found no association between level of magnetic field and cancers of the stomach, rectum, testis, prostate, kidney, bladder, and thyroid gland and non-melanoma of the skin. The consecutive incidence rate ratios specific for category of exposure for laryngeal cancer were 1.0, 1.51, 0.57, 1.59, and 1.68 (all non-significant) and the incidence rate ratio was 1.11 per 1 μ T year increase in exposure (table 3). In pancreatic cancer there was a significant decrease in men (0.66) but not in women (1.12).

Discussion

METHODOLOGICAL ISSUES

The present study is the first nationwide study on the relation of residential magnetic fields and cancer in adults, and its number of exposed cases exceeds the numbers of the previous residential cohort studies^{17 21} by fivefold to 25-fold. The assessment of exposure took into account historical exposures over a period of 20 years. More than 20 types of cancer were screened for an association with magnetic fields. The interpretation of the results is a challenging task, partly because one risk estimate out of 20 is expected to differ from null (at 95% significance) because of chance alone. The magnitude of the observed risks and presence of a dose response, significance, consistency, and biological plausibility have all to be considered in the evaluation of the results.

In the analyses with continuous cumulative exposure, the incidence rate ratios were presented for a unit change of only 1 μ T year, which, however, represents the actual exposure differences within the study cohort. The assessment of exposure in our study has been discussed in greater detail in some previous publications.^{4 27 28}

The data collection was entirely on the basis of nationwide registers, which set limits to the information available on potential confounders. Unlike the earlier residential cohort studies, our study adjusted the risk estimates for social class in addition to age, sex, and calendar period. This did not materially change the risk estimates of cancer. Social class in Finland has been shown to be a good proxy of a variety of lifestyle factors associated with causes of cancer,²⁹ but obviously there is some residual confounding in the present analyses. The accuracy of the population registration system in Finland is high, the coverage of cancer registration is virtually complete,³⁰ and the record linkage procedures

reliable.³¹ Therefore, technical reasons are not likely to bias the results. The cohort is also a part of the reference population. Those exposed $\geq 0.2 \mu\text{T}$ years, however, make up only some 2% of the total population—that is, the diluting effect in the standardised incidence ratios is negligible.

FINDINGS

Overall, we found no major increases—or no increases at all—in the risks of cancer associated with magnetic fields of high voltage power lines for the 21 primary sites investigated. This observation is quite consistent with the findings of the previous epidemiological studies where the observed relative risks have most often been close to unity.

Magnetic fields have previously been associated with several types of cancer such as leukaemia, lymphoma, tumours of the nervous system, breast cancer, melanoma, and prostate cancer, but the outcome event, if any, has remained more or less obscure. In addition to the various epidemiological observations, some theoretical papers have attempted to bridge the gaps between laboratory observations and epidemiological cancer studies with regard to susceptible types of cancer. For instance, the melatonin hypothesis suggests a link between electromagnetic fields and hormone related cancers on the basis of the observations of electromagnetic fields reducing melatonin.³² We observed no increase in the risks for cancers of female breast, ovary, uterine corpus, prostate, and testis associated with magnetic fields of power lines.

The risks of haematological malignancies and tumours of the nervous system were also equal to unity. The previously observed or suggested increases in these types⁷ were thus not confirmed. The risks of the cancers of the stomach, pancreas, lung, kidney, bladder, and thyroid gland and of non-melanoma of the skin did not differ by magnetic field exposure.

The risk of melanoma was the only cancer for which we observed some indication of an increase in risk, which has in some studies been related to magnetic fields.^{8 33-37} The magnitude of increase was, however, rather low (relative risk increase less than 10% per $1 \mu\text{T}$ year), and the highest relative risk occurred in intermediate exposure categories. The possible confounding by solar and non-solar risk determinants^{38 39} could not be considered in the statistical analyses because of the lack of information on relevant confounders. If the observed 8% increase in the risk of melanoma was due to extremely low frequency magnetic fields, this would correspond to less than one extra case out of several hundred cases annually in the Finnish population of five million.

The observation of a significant increase in the risk of cancer of the colon in women was not an anticipated finding and may well be due to chance. There is only one previous epidemiological observation of an increase the risk of colon cancer among people exposed to magnetic fields,⁸ whereas three other studies published so far have found no excess risks of colon cancer.^{12 21 40} As to the possible carcinogenic mechanism in colon cancer it has been suggested that the earlier observation of high stores of iron in the body increasing the risk might be explained by iron having a role in catalysing oxygen radicals.⁴¹ On the other hand, 60 Hz magnetic fields have been reported to produce expression of transferrin receptors on human colon cancer cells in vitro⁴²—that is, body iron could act as a cocarcinogen with extremely low frequency magnetic fields.

CONCLUSIONS

In conclusion, the extremely low frequency magnetic fields of high voltage power lines at typical residential levels do not seem to be associated with an increase in

Key messages

- Although small increases in the risk of cancer in children who live near power lines and in adults exposed to magnetic fields from occupational sources have been observed, studies on residential exposures and cancer in adults have been few and inconclusive
- The present population based cohort study among Finnish adults with 8500 observed cancer cases found no increase in the risk of overall cancer in adults exposed to magnetic fields of high voltage power lines
- The previously suggested associations between magnetic fields and tumours of the nervous system, lymphoma, leukaemia, and breast cancer in women were not confirmed
- The results of the present study suggest strongly that typical residential magnetic fields generated by high voltage power lines are not related to cancer in adults
- The possibility of an increase in risk at higher magnetic field levels, or in more specific cancer subtypes, cannot be excluded on the basis of this study

cancer among adults; this holds for the haematological malignancies and for tumours of the nervous system as well as for the group of hormone related cancers in male and female genitals. As to specific cancer types, the role of extremely low frequency magnetic fields in the pathogenesis of myeloma, melanoma, and colon cancer remains uncertain.

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Increasing number and incidence of osteoporotic fractures of the proximal humerus in elderly people

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The most common forms of osteoporotic fractures occur at the distal forearm, spine, and hip. Treating less common fractures (such as those of the proximal humerus, pelvis, knee, and ankle¹) is also demanding and expensive. Yet epidemiological information on these is scarce; no nationwide study of the incidence of the osteoporotic fractures of the proximal humerus has been reported.

Subjects, methods, and results

We defined an osteoporotic fracture of the proximal humerus as a fracture occurring in people aged ≥ 60 that resulted from minimal trauma only—that is, a fall from standing height or less. We selected all such patients admitted to Finnish hospitals in 1970-2, 1974-5, 1978-80, 1983-5, 1988-9, and 1991-3 for primary treatment of first fracture of the proximal humerus from the National Hospital Discharge Register. Previous studies have found the accuracy of the register to be 96-97%.²⁻⁴ The study covered the entire Finnish population. We adjusted for the subjects' age by using the mean population between 1970 and 1993 as the standard population and expressed fracture incidences as the number of cases/100 000 persons/year by sex and by age.

The total number of osteoporotic fractures of the proximal humerus increased steadily during the study period, from 212 in 1970 to 844 in 1993 (an average increase of 13% a year). The mean age of patients also increased, from 72.1 years (1970) to 76.2 years (1993). The age adjusted incidence (per 100 000 people aged

Fig 1—Age adjusted incidence of osteoporotic fractures of the proximal humerus in inhabitants of Finland aged ≥ 60 during 1970-93

≥ 60) of fractures increased during 1970-93 from 50 to 106 in women and from 14 to 41 in men (fig 1).

Comment

We found a steady increase in the age specific incidences for fractures of the proximal humerus in both sexes and in all ages over the course of the study. In Finland not only is the incidence of fractures increasing but also the population at risk is increasing—a development likely to accelerate in the near future. The increasing mean age of patients is likely to mean more problems in treating these fractures, including longer times for healing and rehabilitation and more complications of fractures such as non-unions. Additionally, a higher mean age of patients is likely to increase morbidity and mortality.

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