SHORT REPORT

Risk of selected birth defects by maternal residence close to power lines during pregnancy

K G Blaasaas, T Tynes, R T Lie

Occup Environ Med 2004;**61**:174–176. doi: 10.1136/oem.2002.006239

Aims: To evaluate selected birth outcomes from a published Norwegian cohort study in a nested case-control design with improved exposure data.
Methods: Two controls matched for sex, year of birth, and municipality were selected randomly for children with the following defects: central nervous system (CNS) defects, cardiac defects, respiratory system defects, oesophageal defects, and clubfoot. The distances between maternal addresses, during pregnancy, and power lines were obtained from maps mainly of scale 1:5000. The magnetic fields in the residences were estimated based on distance, current, voltage, and configuration.
Results: The highest increased risks were seen for hydrocephalus (OR 1.73, 95% CI 0.26 to 11.64) and for cardiac defects (OR 1.54, 95% CI 0.89 to 2.68).
Conclusion: This study does not support the hypothesis that residential exposure to electromagnetic fields from power lines causes any of the investigated outcomes.

Several studies of possible effects of low frequency electromagnetic fields on human health have been carried out.[1] Most attention has been given to the occurrence of cancer. A number of studies regarding reproductive outcomes have been reviewed by Robert,[2] but represent no convincing evidence that electromagnetic field exposure of pregnant women or their partners is associated with reproductive outcomes. Two recent studies from California suggest an effect of maximum field exposure on the risk of fetal loss.[3 4] However, most previous studies are quite small and would not have enough statistical power to detect effects on risks of specific birth defects. Animal models do not indicate that low frequency electromagnetic field exposure has serious reproductive effects.[5]

In an earlier Norwegian study of reproductive outcomes among workers in occupations exposed to 50 Hz magnetic fields, increased risks of selected central nervous system defects were found.[6] Indications of increased risks of clubfoot and respiratory system defects were also seen. Another cohort study[7] indicated an increased risk of oesophageal defects and reduced risks of cardiac and respiratory defects among children whose mothers lived close to power lines during pregnancy, but no effects were seen on the risk of neural tube defects. This study was based on distance measured through geographical information systems (GIS). However, a study comparing GIS based distance measurements and measurements made on maps mainly of scale 1:5000 and on site measurements showed that map based distances correlated better with on site measures than GIS based data.[8] Based on this fact, we have assessed the risk of central nervous system defects, clubfoot, oesophageal defects, cardiac defects, and respiratory system defects by maternal residential exposure to magnetic fields from power lines in a nested case-control study within the previously reported cohort. Our motivation for choosing these sites was the findings in the two previous Norwegian cohort studies.[6 7] In the present study we used data based on measurements on maps, mainly of scale 1:5000, to determine distances between Norwegian residences and power lines and to calculate the magnetic fields in the houses.

METHOD

The Medical Birth Registry of Norway comprises all Norwegian births with at least 16 weeks of gestation. Notification is compulsory, and is performed by midwives within the first week after birth. Any diagnosis available at that time should be reported. We used the registry as our source of ascertainment. Since the registry only captures diagnoses within the first week after birth, ascertainment is assumed to be poorer for internal defects such as cardiac defects than for external defects like spina bifida with an estimated ascertainment of 80%.[9]

The birth defects included in the analyses were: central nervous system (CNS) defects, cardiac defects, respiratory system defects, oesophageal defects, and clubfoot. These outcomes were selected based on results of earlier investigations regarding magnetic fields and reproductive outcomes.[6 7] Children could be registered with up to three different types of malformations. We did not consider multiple defects as a separate category. However, when considering spina bifida and hydrocephalus, those with a recorded anencephalus were not included. Similarly, children with hydrocephalus in combination with spina bifida were not counted as hydrocephalus cases.

The Norwegian person identification number is recorded for child and mother of all births in the registry. Through the mothers' personal identification numbers, Statistics Norway identified all mothers registered in The Medical Birth Registry of Norway who had lived in a corridor around each power line, broad enough to include all potentially exposed houses, on 1 January 1980 or later. The corridor ranged from 25 m on each side of a 25 kV line to 300 m on each side of a 420 kV line. In the period 1986 to 1997, exact new addresses were updated on 1 January annually. Due to the lack of exact address information in the period 1981 to 1985, births during this period were excluded. A woman entered the cohort the first year she was registered in a residence within the corridor and left when she moved out. The child was regarded as exposed if the mother lived in an exposed residence for more than half the pregnancy.

For every child in the corridor registered in The Medical Birth Registry of Norway with one of the defects to be included in the analyses, born in 1980 or between 1 January 1986 and 31 August 1997, two controls matched for sex, year of birth, and municipality were selected randomly. The

Abbreviations: GIS, geographical information systems; CNS, central nervous system

Main messages

- The Medical Birth Registry of Norway provides a good opportunity to evaluate birth outcomes in offspring of mothers residing near high voltage power lines.
- Residential exposure to magnetic fields had no impact on the outcomes evaluated.

Policy implications

- The present results do not call for any efforts towards mothers living close to power lines.

distances between residence and power line were measured on maps, mainly of scale 1:5000. Maps have earlier been shown to be better correlated with actual distances than GIS based distances[8] as used in our previous publication.[7] Information on currents of each power line was obtained from the different power companies. By use of a computer program (Teslaw) developed at SINTEF Energy, Norway, estimations of magnetic fields in the residences under study were performed. The program presents the result as μT root mean square magnetic field strength. This is the sum of the vectors for the individual conductor in a given situation integrated over one period. The calculations took account of height of towers, distance between phases, ordering of phases, distance between the power line and the house, and average load on the power line. Distance to the power lines was defined as the distance from the closest corner of the house to the mid-point between the outer phases of a line. A residence was regarded as exposed if the estimated magnetic field was 0.1 μT or above.

Odds ratios (OR) for the exposed compared to the unexposed with 95% confidence intervals (CI) were obtained from conditional logistic regression for 1 to 2 matched data adjusting for mother's age and highest family education. The analyses were carried out for CNS defects, heart defects, respiratory defects, clubfoot, and oesophageal defects. Significance levels were set to 5% for each hypothesis test, and no attempts were made to adjust for multiple comparisons. The statistical software used was EGRET for Windows 2.0.31.[10]

RESULTS

Of a total of 744 324 births in Norway in the period of investigation, 128 680 were within the corridor from whom we found 465 cases and selected 930 controls.

The highest ORs were found for hydrocephalus and cardiac defects (table 1). Lowest ORs were found for spina bifida and oesophageal defects.

DISCUSSION

This investigation showed no significant increased or decreased risk for the defects evaluated.

Comparing these results with our findings in the earlier residential cohort study,[7] the excess risk of oesophageal defects and the reduced risks of cardiac and respiratory defects was not reproduced in the present study. Neither do the present results support earlier findings regarding maternal occupational exposure and birth defects.[6]

For spina bifida, oesophageal defects, and clubfoot there is a shift from increased to decreased risk, in the present study compared to the previous residential cohort investigation, although only the risk of oesophageal defect was significant in the previous study. For hydrocehalus and cardiac defects we observed a shift from decreased to increased risk, significant only for cardiac defects in the previous study. For respiratory system defects, the reduced risk was closer to unity compared to the previous study. The distance measurements in this study are more accurate[8] than in the previous study. We therefore consider the results in this study more reliable.

Information of the mothers' addresses only once a year in the study period was one important limitation in this study. Another critical problem was the limited number of cases and subsequent limited statistical power.

Residential exposure based on calculated magnetic fields from power lines only with no personal measurements, may have introduced some exposure misclassification, but a previous dosimeter study among children living close to a power line in Norway, showed that the magnetic fields from the line is the major source of exposure.[11] This should be the case for adults too. In comparison with other countries, like Sweden, the contribution of ground currents to magnetic fields in homes is minor in Norway because of a different grounding system.

The Norwegian birth registry only includes birth defects identified at the maternity ward in the hospital during the first week after birth. The majority of birth defects are probably detected shortly after birth. However, defects diagnosed later, such as cardiac defects, are less likely to be detected and might therefore be seriously underreported in the registry.

In the present population based, nested case-control study, we took advantage of the population registration system in Norway. Furthermore, by defining the study population as adults who had lived in geographical areas crossed by high voltage power lines, we could assume these lines to be the main source of exposure. The design made it possible to

Table 1 Odds ratios of selected birth defects by maternal residential exposure to magnetic fields above 0.1 μT in Norway 1980–1997

	Crude			Adjusted*		
Category of birth defects	No. cases	OR	95% CI	No. cases	OR	95% CI
All CNS defects	51	0.87	0.34 to 2.17	49	0.86	0.33 to 2.29
Anencephalus	13	1.00	0.16 to 6.42	12	1.09	0.15 to 8.08
Spina bifida	19	0.43	0.08 to 2.31	19	0.60	0.10 to 3.47
Hydrocephalus	14	1.88	0.39 to 8.92	13	1.73	0.26 to 11.64
Cardiac defects	103	1.54	0.89 to 2.67	102	1.54	0.89 to 2.68
Respiratory system defects	40	0.84	0.30 to 2.34	39	0.79	0.28 to 2.23
Oesophageal defects	12	0.29	0.04 to 2.32	10	0.41	0.03 to 5.15
Clubfoot	270	0.84	0.57 to 1.23	269	0.82	0.56 to 1.21

*Adjusted for highest family educational level and mother's age.

control for factors associated with area of residence and socioeconomic status.

In conclusion, this study does not support the hypothesis that residential exposure to electromagnetic fields from power lines causes any of the investigated outcomes.

Authors' affiliations

K G Blaasaas, National Institute of Occupational Health, Oslo, Norway
T Tynes, Norwegian Radiation Protection Authority, Østerås, Norway
R T Lie, Section for Epidemiology and Medical Statistics, Department of Public Health and Primary Health Care, University of Bergen, Norway

The Research Council of Norway supported this work

Correspondence to: K G Blaasaas, Norwegian Armed Forces, Joint Medical Services, Bygning 0028A, N-2058 Sessvollmoen, Norway; kblaasaas@mil.no

Accepted 27 March 2003

REFERENCES

1 **Portier CJ**, Wolfe M, eds. *NIEHS Working Group Report. Assessment of health effects from exposure to power-line frequency electric and magnetic fields.* NIH Publication No.983981. Bethesda: National Institute of Health.
2 **Robert E**. Intrauterine effects of electromagnetic fields (low frequency, mid-frequency RF, and microwave): review of epidemiologic studies. *Teratology* 1999;**59**:292–8.
3 **Lee GM**, Neutra RR, Hristova L, *et al*. A nested case-control study of residential and personal magnetic field measures and miscarriages. *Epidemiology* 2002;**13**:21–31.
4 **Li DK**, Odouli R, Wi S, *et al*. A population-based prospective cohort study of personal exposure to magnetic fields during pregnancy and the risk of miscarriage. *Epidemiology* 2002;**13**:9–22.
5 **Brent RL**. Reproductive and teratologic effects of low-frequency electromagnetic fields: a review of in vivo and in vitro studies using animal models. *Teratology* 1999;**59**:261–86.
6 **Blaasaas KG**, Tynes T, Irgens Å, *et al*. Risk of birth defects by parental exposure to 50 Hz electromagnetic fields: a population based study. *Occup Environ Med* 2002;**52**:92–7.
7 **Blaasaas KG**, Tynes T, Lie RT. Risk of birth defects by residence near power lines; a population-based study. *Epidemiology* 2003;**14**:95–8.
8 **Blaasaas KG**, Tynes T. Comparison of three different ways of measuring distance between residences and high voltage power lines. *Bioelectromagnetics* 2002;**23**:288–91.
9 **Lie RT**, Heuch I, Irgens LM. Maximum likelihood estimation of the proportion of congenital malformations using double registration systems. *Biometrics* 1994;**50**:433–44.
10 **EGRET for Windows**. *Software for the analysis of biomedical and epidemiological studies. User manual*. Cambridge, MA: CYTEL Software Corporation, 2001.
11 **Vistnes AI**, Ramberg GB, Bjornevik LR, *et al*. Exposure of children to residential magnetic fields in Norway: is proximity to power lines an adequate predictor of exposure? *Bioelectromagnetics* 1997;**18**:47–57.