



Exposure to Electromagnetic Fields of High Voltage Overhead Power Lines and Female Infertility

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Abstract

Background: Living in the vicinity of high voltage power lines has brought about a range of health woes, but the effect of residential exposure to electromagnetic fields from the power lines on female fertility has not been explored yet.

Objective: To test the hypothesis if residential proximity to high voltage power lines could be associated with the increased risk of female infertility.

Methods: In a case-control study, 462 women with confirmed diagnosis of unexplained infertility or behavioral and environmental factors were assessed between February 2014 and December 2016. Control group comprised of 471 persons with no history of infertility selected using randomized-digit dialing from the numbers registered in a birth registry between 2014 and 2016. The nearest linear distance from high voltage power lines to the participants' residence of cases and controls was measured using a Geographical Information System (GIS) and Google Earth aerial evaluation for high voltage power lines (240–400 kV).

Results: 112 (14.1%) houses were within 500 meters from a high voltage power line. Women living within 500 meters of the lines (OR 4.14, 95% CI 2.61 to 6.57) and 500–1000 meters of the line (OR 1.61, 95% CI 1.05 to 2.47) carried a significantly higher risk of infertility than those women living more than 1000 meters away from the power lines. After adjusting for confounding factors, women living within 500 meters of the lines carried a higher risk (aOR 4.44, 95% CI 2.77 to 7.11) of infertility compared with women living more than 1000 meters of the lines.

Conclusion: The current safety guidelines for electromagnetic fields exposure seems to be not adequate for protecting people from the hazardous effects of the field.

Keywords: Reproductive health; Environment; Risk assessment; Risk factors; Electric power supplies; Geographic information systems

Introduction

Infertility is a significant public health concern in both developed and developing countries.¹ Approximately, 15% of couples in Babol, northern Iran, suf-

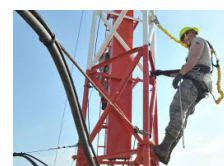
fer from infertility.² A possible risk factor for infertility could be the exposure to air pollution.^{3,4} In recent years, there have been growing concerns for people living in the vicinity of high voltage power lines installed inside or near their residential

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buildings. Currently, Iran has 50 215 km of transmission lines, rating at 400 and 230 kV, as well as 69 304 km of substations, rating 132, 66, and 63 kV, covering 1 648 195 km². Mazandaran and Golestan, two provinces in northern, accommodate 1229 km of 400 kV and 1314 km of 230 kV transmission lines.

Power lines carrying high voltage electricity in both developed and developing countries are the main sources of extremely low frequency electromagnetic fields in homes and workplaces.⁵ It is estimated that people living in the vicinity of high voltage power lines are at higher risk of hazards caused by high level, low frequency electromagnetic fields.⁶ Research also suggests that exposure to electromagnetic field may result in damage to the body system. It is estimated that the field may adversely affect the biological processes.⁷

Many researchers have studied the effects of exposure to magnetic field on the immune system, melatonin hormone, cardiovascular system, cancer, and the central nervous system.⁸⁻¹³ Less attention has so far been paid to assessing the adverse effects of electromagnetic field exposure on infertility. Some studies have failed to find any correlations.¹⁴ Some studies have demonstrated that the distance between

the residence and power lines could be a useful surrogate for the level of exposure to extremely low frequency electromagnetic fields.^{15,16} We, therefore, conducted this study to test if the residential proximity to magnetic field of power lines could be associated with an increased risk of infertility among women.

Materials and Methods

A case-control study was conducted on the residential proximity to magnetic field of power lines associated with infertility in women. Nearly 500 new patients were seen for infertility in Fatemehzahra Infertility Clinic, Babol, northern Iran, between 2014 and 2016. A total of 475 patients signed a written informed consent and agreed to enter the study. The inclusion criteria were the diagnosis of infertility. Infertility was defined as the inability to carry a pregnancy after 12 months despite having a regular unprotected intercourse for at least 12 months.^{2,17} The male infertility, abnormal anatomy, and congenital uterine anomalies of infertility were excluded. We only included those who had unexplained infertility or where the infertility could be attributed to behavioral and environmental factors. We obtained residence addresses (postcode) for 475 eligible cases, 13 cases were excluded from study for not providing clear information on their home addresses.

From the birth registry in Rohani Hospital (Babol, Iran), we selected the control group members. They had no history of infertility and matched for each case using a randomized-digit dialing method. A total of 471 controls was potentially found eligible for being included in this study. We attempted to obtain the postcode and approximate grid reference of the address for all cases and controls by telephone and face-to-face interview. To this end, our dataset included 462 women with infertility

TAKE-HOME MESSAGE

- Infertility is one of the most important public health concerns in the world.
- The effect of electromagnetic fields produced from the power lines on female fertility has not been explored yet.
- Women who lived near power lines are more likely to have infertility.
- The current safety guidelines for chronic exposure to electromagnetic fields are not adequate for protecting people from the hazardous effects of the field and should be revised.

and 471 matched women with no history of infertility, all residents of Babol.

Information about participants including their residence (urban and rural), age and age at marriage, education, job, and duration of their residence were collected from their medical records or during the interview.

All 69 230 km and 400 kV overhead lines forming the National Grid in Mazandaran were assessed. All the geographical data related to cables, lines, electricity towers, and distance from the home to nearby overhead lines were obtained using the electric power companies' Geographical Information System (GIS) databases and Google Earth aerial imagery evaluation for high voltage power lines that was blinded to the status of participants. We calculated the nearest linear distance to any of the high voltage power lines that had existed for at least three years of reproductive age. The studied women were divided into three groups—unexposed (the women living more than 1000 meters away from the lines), those with lower exposure living 500–1000 meters away from the lines, and those with high exposure living within 500 meters of the lines.

Ethics

This case-control study was approved by Babol University of Medical Sciences Ethics Committee. None of the authors had access to any identifying information of the participants. Written informed consents were obtained from all participants.

Statistical Analysis

The age of participants was categorized into <30 and ≥30 years. Age at marriage was categorized as <25 and ≥25 years. The residence of the participants was categorized as “urban” and “rural.”

SPSS® for Windows® ver 16.0 (Chicago, IL, USA) was used for data analyses. Categorical variables were analyzed with χ^2

Table 1: Baseline characteristics of participants in studied groups

Variables	n (%)		
	Infertile group (n=462)	Control group (n=471)	Total (n=933)
Residence			
Urban	249 (53.9)	206 (43.7)	455 (48.8)
Rural	213 (46.1)	265 (55.3)	478 (51.2)
Age (yrs)			
>30	310 (67.1)	307 (65.2)	617 (66.1)
≥30	152 (32.9)	164 (34.8)	316 (33.9)
Level of education (yrs)			
<6	45 (9.7)	54 (11.5)	99 (10.6)
6–12	286 (61.9)	291 (61.8)	577 (61.8)
>12	131 (28.4)	126 (26.8)	257 (27.5)
Age at marriage (yrs)			
<25	71 (52.6)	69 (46.0)	646 (69.2)
≥25	20 (14.8)	27 (18.0)	287 (30.8)
Occupation			
Clerk	56 (12.1)	29 (6.2)	85 (9.1)
Worker	378 (81.8)	378 (80.3)	756 (81.0)
Housewife	394 (85.3)	432 (91.7)	826 (88.5)

test. Logistic regression analysis was used to determine the independent risk factors. A p value <0.05 was considered statistically significant.

Results

A total of 933 women (462 with infertility) participated in this study. The mean age of the participants was 27.7 (SD 5.6, range 16 to 44) years. Most (66.1%) participants aged between 16 and 29 years. The baseline characteristics of the cases and controls are presented in Table 1.

Most of the women (n=725, 322 cases and 403 controls) were considered unexposed, living more than 1000 meters away

Table 2: Association of infertility with the distances between the residence and high voltage overhead power lines

Distances (m)	n (%)		OR (95% CI)	
	Infertile group (n=462)	Control group (n=471)	Crude	Adjusted*
<500	86 (76.8)	26 (23.2)	4.14 (2.61 to 6.57)	4.44 (2.77 to 7.11)
500–1000	364 (78.8)	42 (43.8)	1.61 (1.05 to 2.47)	1.53 (0.99 to 2.37)
>1000	322 (44.4)	403 (55.6)	1	1

*Adjusted for residence, age, level of education, job, and age at marriage

from the high voltage power lines. One-hundred and twelve (14.1%) houses were within 500 meters of a high voltage power lines. Univariate analyses revealed that those who lived near a power line carried a higher risk of infertility—the closer the higher the risk (Table 2). After adjustment for residence, age, level of education, job, and age at marriage, we found that those living within 500 meters of the lines carry a four-fold risk (OR 4.44, 95% CI 2.77 to 7.11) developing infertility compared with those living more than 1000 meters away from the lines (Table 2).

Discussion

We found that those women who lived near power lines were more likely to have infertility. There are only a few human and animal studies investigating factors affecting fertility of people living near the power lines. Animal studies have shown that exposure to electromagnetic fields may have adverse effects on the reproductive endocrine hormones, the gonadal function, the process of embryogenesis, and pregnancy. It may also decrease ovarian reserve, which can lead to infertility.¹⁸⁻²³

In modern societies, humans are inevitably submerged in a sea of various spectrums of electromagnetic fields. The adverse effects of exposure to electromagnetic fields on human depend on the density of the field and the duration of the

exposure.¹⁴ If we assume the effect is transient, moving couples with infertility to places far away from the power lines may be helpful.

To accurately determine the effect of electromagnetic fields from high voltage overhead power lines on infertility, we controlled other risk factors such as residence, age and age at marriage, level of education, and job that are commonly associated with infertility. However, our study had some limitations. The findings of our study may be partly subjective in nature, as we did not directly measure the electromagnetic field strength in residential areas with a low-frequency gauss meter. The findings were mainly based on the distance from a power line. Nevertheless, it is important to mention that measuring exposure human to the electromagnetic field using GIS data, is currently considered a valuable method and that the electromagnetic field generated by power lines is a major source of exposure at home.^{15,24} Furthermore, the cross-sectional nature of the study design did not permit assessment of the temporal and thus potentially causal relation of the exposure and infertility.

Many houses in Iran are located in places where the residents are continuously exposed to electromagnetic fields generated from the nearby high voltage power lines. On the other hand, infertility is a public health priority. If the relationship between exposure to the electromagnetic

field and infertility is confirmed, the findings presented in this study would help to improve the situation. It seems that the current safety guidelines for chronic exposure to electromagnetic fields are not adequate for protecting people from the hazardous effects of the field and they should be revised.

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Conflicts of Interest: None declared.

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