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Exposure to Extremely Low Frequency Electromagnetic Fields during Pregnancy and the Risk of Spontaneous Abortion: A Case-Control Study

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ABSTRACT

Background: Exposure to extremely low frequency electromagnetic fields is increasingly common, but the potential influence on pregnant women has not been thoroughly investigated.

Methods: In this case-control study, 58 women who had an unexplained spontaneous abortion at < 14 weeks gestation and 58 matched pregnant women >14 weeks gestation were enrolled in 2012. The women completed the questionnaire, which was used to collect data about socioeconomic and obstetric characteristics, medical and reproductive histories. Then, to evaluate the extremely low frequency electromagnetic fields, we determined the magnitude of electromagnetic fields in the participants' houses by an exposure level tester (3D EMF tester/ Model: ELF-828; Taiwan). The instrument covers a limited frequency range (30 HZ to 3 KHZ).

Results: The magnitude of extremely low frequency electromagnetic fields in the participants' houses was significantly different between the two groups ($P < 0.001$).

Conclusions: Extremely low frequency electromagnetic fields exposure is probably related to early spontaneous abortions.

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Introduction

Widespread concerns have been raised about exposure to extremely low frequency electromagnetic fields (ELF-EMF) from sources used for mobile telecommunication, video display terminals (VDTs), power lines, medical and industrial applications, and house hold appliances¹⁻⁶. Much of this concern arises because new technologies are introduced without provision of public information about their nature or discussion of the debate within the scientific community about possible health consequences. Indeed, mobile phone use has increased dramatically with falling costs, and developing countries are establishing mobile telecommunications rather than the more expensive fixed-line systems¹. Thus, if there is an impact on health from mobile telephones, it will affect everyone in the world. The major focus of research has been on radio-frequency (RF) radiation, mainly generated by the phone, but some scientists are concerned about the possible impact of ELF-EMF generated by supply currents in the phone^{1,7}. The device

with the largest power consumption is the front-end amplifier. Consequently, the corresponding ELF-EMF has a spectrum similar to the pulse structure of RF signals.

The public discussion of the health hazard of ELF-EMF exposure has focused on the possible association with cancer, and cardiovascular and immune systems, and less attention has been paid to evaluating the health hazards of ELF-EMF exposure on reproductive health such as spontaneous abortions⁸⁻¹¹. We therefore designed a case-control study to determine the effects of ELF-EMF on spontaneous abortions.

Methods

For the evaluating the effects of ELF-EMF on spontaneous abortions, a case control study was chosen. Due to lack of knowledge about these effects, a pilot study on 100 participants was carried out. Then, based on primary data, with a significance level of $\alpha = 0.05$ and power of 1-

$\beta=0.80$, a sample size of 50 participants for each group was calculated. From May 2012 to Dec 2012, 58 women who had an unexplained spontaneous abortion at < 14 weeks gestation as case group immediately after abortion and 58 pregnant women at 14 weeks gestation who referred to the prenatal clinic of the same hospital as control group were enrolled. Gestational age was calculated based on the last menstrual period and was confirmed by an ultrasonography examination. The pregnant women in the control group matched with maternal and paternal ages, pre-pregnancy BMI, relatives of the spouse, duration from last delivery, educational level, occupation and history of previous abortions or preterm labor.

The inclusion criteria were as follows: (a) singleton pregnancy; (b) 18-35 years of age; (c) free of chronic diseases, such as diabetes, hypertension, and cardiovascular diseases; (d) free of any genetic disorders (the woman, her husband, and first-degree relatives); (e) spontaneous pregnancy without the use of assisted reproductive technology; (f) no vaginal bleeding in the first trimester of pregnancy in the control group; (g) lack of fetal malformations; (h) no history of birth defects in previous pregnancies; and (i) no cigarette smoking

The women completed the questionnaire, which was used to collect data about socioeconomic and obstetric characteristics, medical and reproductive histories. Another questionnaire was used to collect data on the environmental exposure to ELF-EMF. Then, for accessing to objective data for evaluation the ELF-EMF originating from the various sites, we determined the magnitude of electromagnetic fields in the participants' houses by an portable exposure level tester (3D EMF tester/ Model: ELF-828; Taiwan). This exposure level tester is an innovative measure for ELF electromagnetic fields quantitative radiation which can be delivered to participants by environmental sources in milliguss (mG). The instrument can handle practically any level of measurement requested in the low frequency range, simply and precisely. The instrument covers a limited frequency range (30 HZ to 3 KHZ).

The procedure was approved by the Ethics Committee of Tarbiat Modares University. All of the women participated voluntarily and provided written, informed consent.

Statistical analysis

Demographic and obstetric characteristics, as well as the exposure parameter of ELF were compared between the two groups using t-tests and chi-square tests. A logistic regression model was used to assess the association between spontaneous abortions as a binary dependent factor and the ELF-EMF exposure and suspected risk factors for spontaneous abortions as independent factors. A $P<0.05$ was considered statistically significant. All confident intervals were calculated at the 95% level.

Results

The distribution of demographic and potential confounders for spontaneous abortions is presented in Table 1. As shown, there were no significant differences in maternal and paternal ages, relatives of the spouse, pre-pregnancy BMI, history of abortion or preterm labor, duration from last delivery, occupation and educational status between the two groups. The magnitude of electromagnetic fields determined by the mentioned tester in the participants' houses was significantly different between the two groups ($4.03\pm 3.11\text{mG}$ in case group versus of $1.40\pm 1.46\text{mG}$ in control group, $P<0.001$). Logistic regression analysis revealed a significant association between the magnitudes of electromagnetic fields with the risk of spontaneous abortions when adjusted for maternal age, paternal age, history of abortion and relatives of the spouse 1.85 (1.38- 2.47; $P<0.001$).

Discussion

Exposure to electromagnetic fields (EMF) is increasingly common, but the potential influence on health has not been thoroughly investigated, especially in pregnant women. There is limited knowledge on the association between electromagnetic fields exposure during pregnancy and reproductive outcomes¹²⁻¹⁹. Some studies have reported increased risk of spontaneous abortions and congenital malformations, although these results were derived from poorly designed studies. Electromagnetic fields may produce biological stress and free radicals, which can make a susceptible population prone to congenital malformations and tissue and cell damage¹⁸. Long-term exposure to electromagnetic fields may be linked to even higher levels of oxidative stress, with the aforementioned corresponding changes.

This study demonstrated an increased risk of spontaneous abortions associated with extremely low frequency electromagnetic fields during pregnancy, and confirmed the results of other researches^{2,12}. Lee conducted a nested case-control study to evaluate the association of residential and personal magnetic fields with spontaneous abortions¹². He reported personal magnetic field maximum exposure is associated with the risk of clinical spontaneous abortions.

There was one main limitation to that study; specifically, the magnetic field measurements were obtained months after the first trimester and the occurrence of the spontaneous abortions. Perhaps the behavior and magnetic fields of women who had spontaneous abortions were different from the pregnant controls.

Our findings are inconsistent with the results of some studies^{16,17,19}. Some mechanistic and animal studies do not support an association between electromagnetic fields and spontaneous abortions.

Table 1: Comparison of the maternal characteristics between case group (n=58) and control group (n=58) using *t*-test of Fisher's exact test for continuous variables and Chi-square test for categorical variables

Parameters	Cases		Controls		P value
	Mean	SD	Mean	SD	
Maternal age (years)	26.96	4.77	28.38	4.13	0.092
Paternal age (years)	31.10	4.35	32.31	5.80	0.214
Duration from last delivery (years)	06.09	3.92	07.16	3.49	0.277
Pre-pregnancy BMI (kg/m ²)	25.05	6.91	24.12	6.07	0.446
Parameters	Number	Percent	Number	Percent	P value
Familial relationship between parents					0.689
Present	17	29.3	20	34.5	
Absent	41	70.7	38	65.5	
History of previous abortion					0.798
Present	10	17.2	8	13.8	
Absent	48	82.8	50	86.2	
History of preterm labor					1.000
Present	1	1.7	0	0.0	
Absent	57	98.3	58	100	
Occupation					0.966
Housewife	47	81.3	48	82.7	
Employee	11	18.7	10	17.3	
Educational status					0.440
Lower than university	40	68.9	43	74.2	
University	18	31.1	15	25.8	

Several potential limitations need to be kept in mind when one interprets the results of the current study. First, the study did not assess all the unknown risk factors for spontaneous abortions, such as balanced chromosomal abnormalities in one of the parents. Second, the study only evaluated magnetic field exposure in the participants' houses and exposure to ELF-EMF at work may be higher than at home. Although, occupation which can reflect the time outside of the home, was closely matched between the two groups.

Current study also had strengths. The magnetic field measurements were obtained shortly after the spontaneous abortions occurred in the case group and in the early of second trimester in the control group. This led to a better evaluation about the environmental conditions and lifestyles of the participants. The association between ELF-EMF and risk of spontaneous abortions against potential confounders was supported by evidence that despite adjustment for many known or suspected risk factors, the estimate was not significantly altered.

Although the mechanisms underlining the effects of ELF-EMF radiation on the risk of spontaneous abortions are not well understood, early embryos are known to be sensitive to environmental exposures. An adverse effect during early fetal development at the cellular level by ELF-EMF radiation could conceivably result in fetal death. Electromagnetic fields evaluated in this study may originated from the several appliances, such as VDTs, hair dryers, lighting lamps, microwave ovens, power lines, and use of cell phones. The electromagnetic fields in VDTs, hair dryers, power lines, lighting lamps and microwave ovens are extremely low frequency magnetic fields, but EMF in cell phones, and cellular base station are both ELF and RF. Based on the distance from outside

the body to inside the uterus, the exposure reaching the fetus is likely to be extremely low in electromagnetic radiation in high frequency, but because of the allegation that there may be particular windows of frequency, wave shape, and intensity of low frequency electromagnetic radiation that may be deleterious, it is possible to disregard extremely low frequency EMF exposures as having deleterious reproductive effects.

Conclusion

Despite the lack of a clear understanding of the underlying mechanisms, our result suggests that ELF electromagnetic field exposure is probably related to early spontaneous abortions, thus further study is warranted.

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Conflict of interest statement

There is no conflict of interest to be declared.

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