

Health problems from radiation of high-voltage facilities

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ABSTRACT

Aims: The aim of this study was to survey the health problems caused by exposure to high-voltage facility radiation.

Materials and Methods: Sampling included workers exposed to electromagnetic fields at high-voltage facilities. The strength of the electric and magnetic fields was determined by a field meter. A questionnaire was used to evaluate the prevalence of subjective and psychological symptoms. Statistical descriptive used and data analyzed by a Student's t-tests.

Results: This study indicates that increased symptoms among the exposed workers including depression, anxiety, hostility, paranoia, inter-sensitivity, and obsession-compulsion. Some of the self-reported symptoms were, headache (53.5%), fatigue (35.6%), difficulties in concentration (32.5%), vertigo/dizziness (30.4%), attention disorders (28.8%), nervousness (28.1%), and palpitations (14.7%). A significant relationship was observed between the exposure to the electromagnetic field and psychological symptoms ($P < 0.05$).

Conclusion: Radiation of high-voltage facilities probably increased the risk of mental disorders and intensified them in susceptible workers, especially depression. This finding confirmed the results obtained in provocative studies that indicated an increase in the risk of psychological symptoms, which was put forth by several investigators. Observation of occupational health and other control measures play an important role in decreasing the symptoms.

Key words: Electromagnetic fields, high-voltage facilities, non-ionizing radiation, psychological symptoms

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INTRODUCTION

The number of people complaining about different symptoms that may be associated with exposure to electromagnetic

fields has increased rapidly in the past few years. Exposure to an electromagnetic field (EMF) due to an occupational or residential place being exposed to high-voltage facilities (20 – 400 Kv), transmission lines near the home, and daily use of electricity, has adverse effects on peoples' health. Numerous research studies and scientific reviews have been conducted to address this question.^[1,2,3,4] The goal of this study is to survey the health status of workers serving in places of high-voltage facilities.^[1]

Electromagnetic field radiation is composed of both electric fields and magnetic fields. Electric fields are produced by

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voltage and increase in strength as the voltage increases. Electromagnetic fields result from the flow of current through wires or electrical devices and increase in strength as the current increases. Electric fields can shield or get weakened by materials that conduct electricity, even by materials that conduct poorly, including building materials and human skin. In contrast, magnetic fields are not easily shielded and can pass through the human body, where they can potentially affect the biological systems.^[2]

Extremely low-frequency magnetic fields are ubiquitous, as they are present wherever there is electricity. However, the amount of extremely low frequency magnetic fields in the environment has increased due to electricity demand, advancing technology, and changes in work practices. Extremely low-frequency magnetic fields (ELF) Electromagnetic are part of non-ionizing radiations, in the range of 3 Hz to 3000 Hz.^[3] In many parts of the world, the frequency of electric power is 50 Hz.

Exposure to magnetic fields in homes is relatively consistent throughout the world, with the GMs between 0.55 mG and 1.1 mG. Occupational exposures can be much higher, with exposures up to 100 mG near electrical conductors. Magnetic field exposures average 4 mG to 6 mG for electricians and electrical engineers, 10 mG for power-line employees and greater than 30 mG for welders, railway engine drivers, and sewing machine operators.^[1,3]

The extensive use of electrical power may account for studying the potential development of biological system impairments much more than before. The impacts of unwanted exposures to EMF have been addressed in literature, but studying the effects of long-term and protected exposure have recently been considered. However, the existing data, especially in human studies, is limited or below the occupational reference level of 10000mG (ACGIH 2011) and are considered harmless.^[4] In addition to reports of specific EMF-related health problems, such as amyotrophic lateral sclerosis, Alzheimer's disease, insomnia, headaches, sexual dysfunction, chronic fatigue, learning and memory problems and assorted other maladies have been found to result from EMF exposure.^[5,6] Switchyard workers exposed to EMF, were compared with salesmen and clerks for evidence of chromosomal anomalies. Results show that a significant increase in the number of chromosomal aberrations in switchyard workers and an increased tendency towards malformations among their children.^[6] Survey the reproductive hazards at high voltage substation showed malformations among children of workers.^[5,6,7]

The association between human offspring sex ratio (proportion male) at birth and parental exposure to EMF tend to produce significant excesses of daughters. There are a few studies that have shown a change of offspring sex ratio because of parental exposure to EMF ,but others have not.^[8,9]

Fathers working in industries with high EMF exposure have

offspring with higher rates of brain and spinal cord tumours.^[10]

EMF exposure is etiologically associated with the occurrence of Alzheimer's disease (AD) among workers.^[14] The work-related exposure to ELF magnetic fields in participants of the Study of Dementia in Swedish Twins was not significantly associated with dementia or AD but may increase the risk of dementia with an earlier onset and among former manual workers.^[11,12]

An investigation on rats showed impact renal function affected by the perfusion of kidney due to long term exposure to electric and magnetic fields.^[13]

In evidence that exposure of men to EMF is associated with fatigue, headaches, dizziness, impaired memory, nausea, loss of strength in limbs, respiratory difficulties, sleep disturbances, and reduced libido. Such reports may be dismissed as subjective.^[5,6,11]

The neuropsychological tests in adults living near transmission lines in New Zealand indicated the performance , memory and attention measures was unrelated to exposure, but significant linear dose-response relationships were found between exposure and some psychological variables. In particular, higher time-integrated exposure was associated with a more adverse psychiatric symptom. These associations were found to be independent of the participants' beliefs about the effects of electromagnetic fields.^[14,15]

Yousefi (1997) research in Iran is the first studying the effects of electromagnetic fields on the employees in the 63, 230, and 400 kV areas indicated that increasing symptoms of depression, anxiety, paranoia, and obsession in these people may be related to their work conditions and mental disorder. Although, the rate of psychiatric problems among the workers was significantly higher than that in the controls, there was no significant relationship between the intensity of the field and duration of the exposure.^[6,14]

In electrical utility workers with occupations in exposure to EMFs, was found an increased rate of suicide in postulated that long term exposure to EMFs contribute to increasing melatonin secretion and depressive symptoms.^[6,17,18]

The association between residential proximity to overhead transmission lines of 60 Hz high voltage (22 -500 kV) and mental health, have examined in Japan, and concluded that the mental health status was not significantly associated with the distance between the subject's residence and the closest high voltage transmission lines.^[19,20]

An association between exposure to EMFs and suicide was found in younger but not older workers.^[16,17] Higher rates of depressive symptoms and suicide have been found to result from EMF exposure. There is increasing evidence to suggest that neuropsychiatric problems may also result from EMR.^[5,18,21,22] Studies considering debate on the adverse effect on health of

electromagnetic field have yielded variable results in animals and humans. The goal of this study was to survey the health problems from radiation of high-voltage facilities.

MATERIALS AND METHODS

This is a case-control study, using a convenience sampling method. Sampling consisted of 103 employees included 79 workers exposed to electromagnetic fields at high-voltage facilities. The control group was selected from the male staff of the administrative sections; they were not occupationally exposed to electromagnetic fields or not residence of transmission line. Both the case and control groups were matched regarding sex, age and employment conditions.

The strength of the electric and magnetic fields at different parts of the high-voltage facilities was determined by means of a field meter (model Hi 2104 Holaday Company).

After permission from the ethical committee of the University, the workers became informed about the study and completed mental health checklist SCL 90 during an interview.

The symptom checklist SCL-90-R, a valid and reliable instrument, was used to evaluate the mental status. Prevalence of psychological symptoms in nine different subscales, including somatization, obsession and compulsion, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychotic symptoms were measured. Subjects were asked to indicate the amount they were bothered by each of the symptoms over the past week on a five-point Likert scale, ranging from 'not at all' (0) to 'extremely' (4). A high score in a given dimension indicated high expression of the corresponding distress. In addition to the nine dimensions, three supplementary indices could be calculated. It is generally assumed that SCL-90-R is a valid and reliable instrument for the identification of psychopathological conspicuousness.^[23,24,25]

The self-report questionnaire was used to assess different subjective symptoms, including attention disorders, difficulties in concentration, headache, fatigue, nervousness, palpitations, vertigo, and dizziness.^[3,6]

Statistical analysis used: The mean and standard deviation and the 95% CI were derived from conditional logistical regression, and the student's t-tests compared the mean models with the SPSS16 system software.

RESULTS

The average age of the cases and control were 45 ± 5 years, the difference was not statistically significant ($P < 0.001$). The work experiences in 50% of cases were 20 ± 5 years. All population of this study was married.

Some of the subjective self-reported symptoms [Table 1] were as follows, headache (53.5%), fatigue (35.6%), difficulties in concentration (32.5%), vertigo / dizziness (30.4%), attention disorders (28.8%), nervousness (28.1%), and palpitations (14.7%). The Offspring genders in exposed group were (52%) female and (48%) male.

This study indicates [Table 2] that increased symptoms, including, depression, anxiety, hostility, paranoia, inter-sensitivity, and obsession-compulsion were observed among the exposed workers.

A significant relationship was observed between exposure to electromagnetic field and psychological symptoms ($P < 0.05$).

DISCUSSION

Personal exposures measured in this survey were below the threshold limit value (TLV by ACGIH, 2011) of 10000 mG (gauss in the CGS system).^[4]

This recommended Occupational Exposure Limits (OELs) for magnetic field exposures are based on acute effects, such as, induced currents in cells or nerve stimulation, which are known to occur at high exposures, more than 1000 times higher than the magnetic field levels, typically found in occupational settings.^[2,4]

Working in high voltage substation exposed to EMFs at ELF with job experience of more than 10 years can lead to the development of mental disorder as mentioned others.^[10] These fields affect on mental health, and reported that the symptoms of depression, anxiety, paranoid ideation, and

Table 1: Self-reported symptoms of 79 exposed workers

Symptoms	Relative frequency (%)
Headache	53.5
Fatigue	35.6
Difficulties in concentration	32.5
Vertigo / dizziness	30.4
Attention disorders	28.8
Nervousness	28.1
Palpitations	14.7

Table 2: Psychological symptoms of 103 control and exposed workers

Index	Case	Control	P value
	(Mean ± SE)		
Anxiety	0.77 ± 0.66	0.36 ± 0.51	0.0001
Depression	0.94 ± 0.8	0.35 ± 0.51	0.0001
Hostility	0.88 ± 0.67	0.35 ± 0.49	0.0001
Interpersonal sensitivity	1.11 ± 0.81	0.54 ± 0.48	0.0001
Obsessive-compulsion	1.28 ± 0.78	0.34 ± 0.49	0.0001
Paranoid ideation	1.14 ± 0.81	0.4 ± 0.59	0.0001
Phobic anxiety	0.37 ± 0.41	0.33 ± 0.51	0.567
Psychoticism	0.49 ± 0.48	0.26 ± 0.43	0.0006
Somatization	0.97 ± 0.66	0.58 ± 0.65	0.0007

obsession-compulsion were high. These findings related to persons had a job experience of more than 10 years.^[10,11]

Finding in the self-reported symptoms in the exposed group were mentioned by others that exposure of men to EMF is associated with headaches, fatigue, dizziness, attention disorders.^[5,6,9]

The AD and dementia don't found in the exposed workers. That is contradict with is etiologically associated with the occurrence of (AD) among workers and exposure to EMF.^[15]

Although a meta-analysis was found the association to be rather weak and lacking a dose-response effect.^[9]

The Offspring genders in exposed group were (52%) girls and (48%) boys. It seemed that exposure to EMF was associated with reduced sperm counts and testosterone levels in men like reduced in rats were cited in reports.^[11]

The associations between human offspring sex ratio (proportion male) at birth and parental exposure to electromagnetic fields (EMF) tend to produce significant excesses of daughters. There are a few studies that have shown a change of offspring sex ratio because of parental exposure to electromagnetic field, but others have not.^[10,11]

In evidence that exposure of men to EMF is associated with fatigue, headaches, dizziness, impaired memory, nausea, loss of strength in limbs, respiratory difficulties, sleep disturbances, and reduced libido. Such reports may be dismissed as subjective.^[11]

Our result were different with Yamasaki ,he concluded that the mental health status was not significantly associated with the distance between the subject's residence and the closest high voltage transmissions line.^[19] because workers in High-Voltage Substations work places, more closely than residential exposed to EMFs with the higher level and different pattern of exposure and it probably increase mental disorder. The study of the association between residential proximity to overhead transmission lines of and mental health showed that the mental health status was not significantly associated with the distance from high voltage transmission lines. These studies confirmed our results but were different in place and kind of exposure.^[12,15,19,20,21]

In the exposed group anxiety, depression, hostility, interpersonal sensitivity, paranoid ideation, obsession-compulsion, psychoticism, somatization, had high mean scores and Phobic anxiety had the least scores. Regarding the other studies adverse effects of the electromagnetic field radiation on workers health was confirmed through the study.^[14,15,18,20,22]

The study doesn't identified suicide among exposed electrical utility workers. in survey the occupations in exposure to

EMFs, have founded an increased rate of suicide in postulated that long term exposure to EMFs contribute to increasing melatonin secretion and depressive symptoms.^[6,16,17]

In psychological symptoms, the exposed group had higher mean scores than the control group. It has been indicated that increasing symptoms of depression, anxiety, paranoia, and obsession in these people may be related to their work conditions.^[10,11,14,25]

Consistency with other knowledge, work-related exposure to ELF was significantly associated with mental health special in the electric hypersensitive group, agree with other findings.^[14,16,17,22]

In the exposed group score of anxiety, depression, hostility, interpersonal sensitivity, paranoid ideation, obsession-compulsion, psychoticism, somatization were significantly more than control ($p < 0.05$). It may be related to lonely and susceptibility job of workers that were mentioned in the literature.^[14,16,17] As would be expected, the severity of the investigated conditions is somewhat lower in the present study of non patients than in previous studies of patients.^[26,27] Psychological treatment with cognitive-behavioral methods can help to prevent the mental disorders.^[27,28]

Future research on the effects of exposure to EMFs on mental disorders and depression is warranted to examine more closely the temporal pattern of exposure and mental disorder.

CONCLUSION

These results are consistent with previous findings regarding the hypothesis that exposures to electromagnetic fields might cause adverse health effects may have been limited by inadequate controlling for confounders or inadequate measurement of exposures in which many controversial issues are raised. Chronic exposure to an electromagnetic field caused by high voltage utility probably increased the risk of mental disorders and intensified them in susceptible workers, especially depression. Observation of occupational health and safety, and other control measures add to offer consulting and psychotherapy play an important role in decreasing symptoms. Two major obstacles to quality research have been inadequate exposure assessment and insufficient sample size. More research is needed to clarify whether daily environmental EMF can cause health problems.

REFERENCES

1. Yousefi HA, Shirani M. Non-ionizing radiations and health problems. Proceeding of the 8th International scientific conference health, work and social responsibility. Roma: International Occupational Hygiene Association (IOHA); 2010.
2. NIEHS [2002]. Electric and magnetic fields associated with the use of electric power. [www.niehs.nih.gov/health/topics/agents/emagnetic-field]. [Last accessed on Dec 2009].
3. WHO [2007]. Extremely low frequency fields. Environmental Health

- Criteria 238 Geneva: World Health Organization. [Available from: http://www.who.int/peh-emagnetic-field/publications/elf_etc/en/index.html]. [Last accessed on Dec 2009].
4. American Conference of Governmental Industrial Hygienists (ACGIH). Threshold limits Values for chemical substances and physical Agents and Biological Exposure indices. Cincinnati: USA, 2011.
 5. Genius Stephen J. Fielding a current idea: exploring the public health impact of electromagnetic radiation. *Public Health* .2008;122:113-124.
 6. Yousefi H A. assessment of extremely low frequency electromagnetic fields and their health effects on workers at high-voltage substations; school of medical sciences .Tarbiat modares university. 1997 (thesis).
 7. Savitz DA, Olshan AF, Gallagher K. Maternal occupation and pregnancy outcome. *Epidemiology*.1996;7:269-74.
 8. Saadat Mostafa. Offspring sex ratio in men exposed to electromagnetic fields. *J Epidemiol Community Health* 2005;59:339.
 9. James WH. Offspring sex ratios of people exposed to electromagnetic fields. *J Epidemiol Community Health* 2005;59:809-811.
 10. Yousefi HA, Nasiri P. Pourfatholah AA. Psychological effects of occupational exposure to electromagnetic fields. *J Res Health Sci* 2006;6:18-21.
 11. Sobel E, Dunn M, Davanipour Z, Qian Z, Chui H C. Elevated risk of Alzheimer's disease among workers with likely electromagnetic field exposure. *Neurology* 1996;47(6):1477-1481.
 12. Andel R, Crowe M, Feychting M, Pedersen NL, Fratiglioni L, Johansson B, Gatz M. Work related exposure to extremely low-frequency magnetic fields and dementia: results from the population-based study of dementia in Swedish twins. *J Gerontol A Biol Sci Med Sci*. 2010;65(11):1220-1227.
 13. Gholampour F, Owji SM, Javadifar TS. Chronic exposure to extremely low-frequency electromagnetic fields induces mild renal damages in rats. *International journal of zoological research (IJZR)*;2011;7(6):393-400.
 14. Yousefi HA, Nasiri P. Psychological effects of occupational exposure to electromagnetic fields. *J Res Health Sci*. 2006;6:8-21.
 15. Beale IL. psychological effects of chronic exposure to 50 Hz magnetic fields in humans living near extra high voltage transmission lines. *Bioelectromagnetics*.1997;18(8):584-94 .
 16. Baris D, Armstrong BG, Deadman J, Theriault G.A case cohort study of suicide in relation to exposure to electric and magnetic fields among electrical utility workers. *Occup Environ Med* 1996;53(1):17-24 .
 17. Van wijngaarden E, Savitz DA, kleckner RC, Cai J, loomis DP. Exposure to electromagnetic fields and suicide among electric utility workers. *Occup Environ Med*, Apr.2000; 57(4):258-263.
 18. Wilson BW. Chronic exposure to ELF fields may induce depression. *Bioelectromagnetics*. 19889;(2):195-205.17.
 19. Yamazaki S, Sokejima S, Mizoue T, Eboshida A, Kabuto M, Yamaguchi M,et al. Association between high voltage overhead transmission lines and mental health: a cross-sectional study. *Bioelectromagnetics* 2006;27:473-8.
 20. Zys T. Epidemiological studies on neurotic disturbances, anxiety and depression disorders in a population living near an overhead high voltage transmission line (400 kV) .*Psychiatr Pol* 1999;33(4):535-51.
 21. Graham Charles, Cook Mary R, Cohen Harvey D, Riffle Donald W et al. Human exposure to 60-Hz magnetic fields: neurophysiological effects. *Int J Psychophysio* 1999;33(2):169-75.
 22. National Radiation Laboratory. Electric and magnetic fields and your health. New Zealand: Ministry of Health; copyright: 2008.
 23. Derogatis LR. SCL-90-R: Administration, scoring and procedures manual-II. Clinical Psychometric Research, Towson. 1983.
 24. Österberg K, Persson R, Karlson B, Carlsson Eek F, Orbaek P. Personality, mental distress, and subjective health complaints among persons with environmental annoyance. *Hum Exp Toxicol* 2007; 26:231-41.
 25. Helm D, Eis D. Sub grouping outpatients of an environmental medicine unit using SCL-90-R and cluster analysis. *Int J Hyg Environ Health* 2007;210:701-713.
 26. National Institutes of Mental Health. The invisible disease: Depression. Rockville, MD: National Institutes of Health. Available from: <http://www.nimh.nih.gov/publicat/invisible.cfm> [Last cited on 2006 Mar 23].
 27. Hillert L, Kolmodin Hedman B, Dolling BF, Arnetz BB. Cognitive behavioral therapy for patients with electric sensitivity a multidisciplinary approach in a controlled study. *Psychother Psychosom*. 1998;67:302-10.
 28. Harlacher U. Electric hypersensitivity an explanatory model, some characteristics of sufferers and effects of psychological treatment with cognitive-behavioral methods. Lund: Lund University, 1998.

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