Original Article

The Effect of Electromagnetic Waves on the General Health of Zahedan Gas Power Plant Personnel

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Abstract

Introduction: With ever improving technology and increasing the use of high-voltage power in industrial environments, concerns about the destructive effects of electromagnetic waves on human health have increased. Thus, the present study aims to evaluate the effects of electromagnetic waves on the general health of Zahedan gas power plant personnel.

Materials & Methods: The present case-control study investigated the health of people at one point of time and their amount of exposure to electromagnetic waves at the same time. The data collection tool in this study was a 28-item general health questionnaire (GHQ-28). After measuring the electromagnetic waves at distances of 1, 1.5, and 3 meters at high voltage power substations and data extraction, the data were fed into SPSS software and then analyzed by descriptive statistics, t-test, and chi-square.

Results: In this study, the age and experience variables were not significantly different in two groups ($p> 0.05$). The strongest magnetic fields in high voltage power substations were at a distance of 1 meter in the substation 607 (28/1 mG) and in precision tool work units (7.03 mG). The results showed that the depressive and general health symptoms were significantly different between the exposed and unexposed groups ($p = 0.04$), however, the difference was not significant in terms of physical performance, anxiety, and social performance ($p> 0.05$).

Conclusion: Although the level of exposure was lower than the standard level determined in Iran, the significant difference of the general health and depression between the two groups, explains the necessity of conducting more studies in this regard. Also by reducing the exposure time and increasing people's awareness, it is possible to take important steps to reduce exposure and complications.

Keywords: Electromagnetic Waves, General health, Power plant, Power substation

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Introduction

Nowadays, technology progress has provided more convenience for people, but this progress has also caused adverse effects on human life, which are crucial. These effects could be due to several chemical, Physical, Biological, Ergonomics, etc. factors [1]. The man is exposed to multiple electromagnetic waves every day caused by the natural or man-made sources, such as diagnostic radiation, nuclear power stations, and television receivers.

Electromagnetic field causes thermal and non-thermal effects that can have devastating effects at both cellular and molecular levels. The fields as a stress factor can cause structural and functional changes in hormone as well as immune levels and affect organ systems including the reproductive system [2]. Usually magnetic fields are created by the electrical current through wires and electrical systems that have high electrical power, such as power transmission cables, electric drills and etc. [1]. The technology progress and the use of electronic devices despite creating welfare, have many biological threats. During the past 25 years the purpose of most studies was to adress the fundamental question asking whether the electromagnetic fields can affect human health.

During these years, scientists have conducted numerous laboratory studies on the biological effects of electromagnetic fields most of which were conducted in vitro conditions [3]. Several epidemiological studies were conducted investigating the relationship between occupational and non- occupational exposures especially exposure to ELF fields to determine risk of cancer, including leukemia, brain tumors, and breast cancer [4]. The study conducted by Gamberala showed that people who work in high voltage substations and are thus exposed to electromagnetic fields, have symptoms such as depression, obsession, interpersonal relations and social sensitivity, paranoid, anxiety, and aggression [5]. Another study conducted by Pearce et al. showed that those who work close to 50 Hz electromagnetic fields of power lines suffer from mental negative effects including depression, lack of control of the senses, suicide and so on [6]. Also, Wijngaarden et al. study in the field of exposures to electromagnetic fields showed that the rate of suicide in people working in places associated with electromagnetic fields has increased which might be due to the increased prevalence of depression among this group [7]. Another study indicated that a large number of employees (78.2%) exposed to magnetic fields and noise in power plant, had mental disorders [8].

Nowadays, due to the progress of science and technology, the use of electronic devices in people's lives has increased resulting in exposing human to electromagnetic fields. So, the effects of electromagnetic fields on human health must be considered seriously. Because of the harmful

effects of electromagnetic waves on the health of workers, we investigated the effects of electromagnetic waves on mental health of Zahedan gas power plant personnel.

Materials and Methods

The research population and type of study: The present case-control study determines the health of people at one point of time and their amount of exposure to electromagnetic waves at the same time. Age, work history, and shift works were matched between the two study groups. The total number of eligible personnel working in gas power plant was 150, among whom 120 individuals were investigated. 30 individuals were unexposed to high voltage electricity posts due to their job requirements and 90 individuals were unexposed.The inclusion criteria was at least 1 year of work experience, lack of specific congenital disease, no history of vascular and neurological - psychological disease, and they should not have two jobs at the same time. If any employee lacked such conditions s/he was excluded from the study.

Data collection tools: Data collection tools in this study was a 28-item general questionnaire (GHQ-28) presented by Goldberg and Hillier [9]. With its multiple nature and self-controlled design this questionnaire analyzes mental health and mental disorders in society [8].Validity and reliability of the Farsi version of the questionnaire were confirmed in another study [10]. 28-item form of these questionnaires consists of 4 scales with 7 questions measuring 4 categories of non-psychotic disorders including: somatization, anxiety, social dysfunction, and depression. Questions are in 4 item Likert scale format scored from 0 to 3. Each subscale score was calculated by the sum of the 7related questions' scores. Table 1 presents the cut scores in each GHQ dimension and general health score. In order to say that a subject has the symptom the cut score of 6 or higher, or the total score of 22 was determined.

Table 1: GHQ questionnaire Cut scores in each of the subscales

subscales	Scores subscales	Scores Total questionnaire
No or minimum value	0-6	**0-22**
Slight	7-11	**23-40**
Moderate	12-16	**41-60**
Severe	17-21	**61-84**

Also, in order to measure electromagnetic waves, gauss meter devise model HI-3604 ELF Survey Meter made in USA (Holaday Industries) was used. The HI-3604 ELF Survey Meter was

designed to evaluate both electric and magnetic fields associated with 50/60Hz power lines, line-powered equipment, and appliances [11].

Exposure standards: The standard of exposure to electromagnetic fields was determined according to the Tables of the manual. Based on ACGIH standard, the limit of exposure to the electromagnetic field was 10 G (Gauss)(12), also based on Iranian standard the allowed exposure rate for people was 100 Microtesla and 500 for occupational exposure within the 50 Hz frequency [13].

Data extraction and analysis method: First, after the required coordination, the General Health Questionnaire (GHQ) was distributed among the exposed and unexposed groups. After filling out the questionnaire by these people, the demographic information and general health status of each person were extracted. Then, by applying the electromagnetic measurement devise, the same interval was measured at 1, 1.5, and 3 Meters distances [14] from high voltage electricity substations. Further, the results of measurement were reported in mG for electromagnetic waves in the SI (International System of Units) system based on the measurement device manual. To perform the statistical analysis, the moderate and severe groups were combined in this study because of the low frequency of the sever group. Data analysis was performed in SPSS V.22 using Chi-square tests and t-tests at the significance level of 0.05.

Results

According to data from Table 1, the age and years of experience were not significantly different. The minimum age of subjects in both groups was 21 years while the maximum age was 55. The number of smokers in the exposed and unexposed groups were 16 (53.3%) and 40 subjects (44.4%), respectively which no significant difference was observed between them (p = 0.398). Also, 16 (53.3%) and 41 subjects (45.6%) of the exposed and unexposed groups were working in the morning shift, respectively (p = 0.460).

Table 2: The demographic information of the exposed and unexposed groups in Zahedan Power Plant

Variable	Exposed Group			Unexposed Group			p
	Min	Max	Mean ±SD	Min	Max	Mean ±SD	
Age (year)	23	55	36.87±8.0	21	52	35.97±7.5	**0.661**
Work history (year)	2	27	12.90±6.63	1	29	11.87±6.5	**0.504**

Figure 1 presents the electromagnetic waves of high voltage electricity subsections at 1, 1.5, and 3 meters in milli Gauss. The maximum intensity of electromagnetic

waves was within 1 meter related to the subsection 607 (28.1 mG) and the lowest one was related to T1 (1.2 mG). At the distance of 1.5 m Busbar 203 (29.1 mG) had the maximum waves while the subsection 64 (7.7 mG) had the minimum ones.

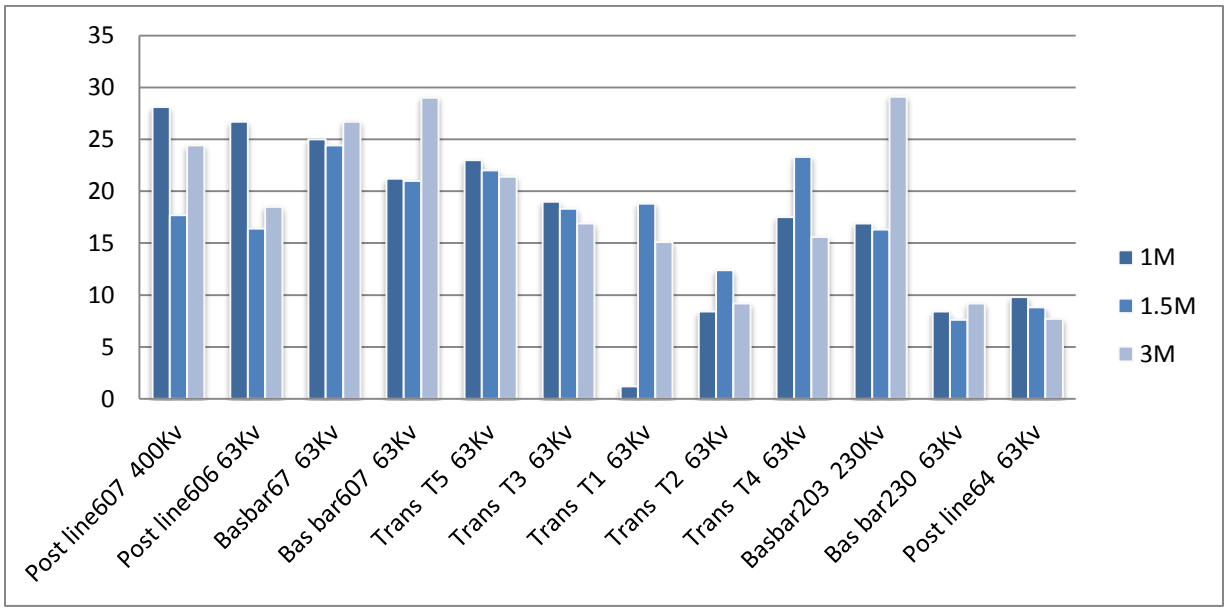

Figure 1: The amount of electromagnetic waves in milli gauss (mG) at different distances (1, 1.5 and 3 meter) in high-pressure gas power substations in Zahedan

Figure 2 presents the amount of electromagnetic waves (mG) in various operating units. The highest intensity of electromagnetic waves is in the precision tools sector (7.03 mG) and the lowest one is in administrative department (0.01 mG).

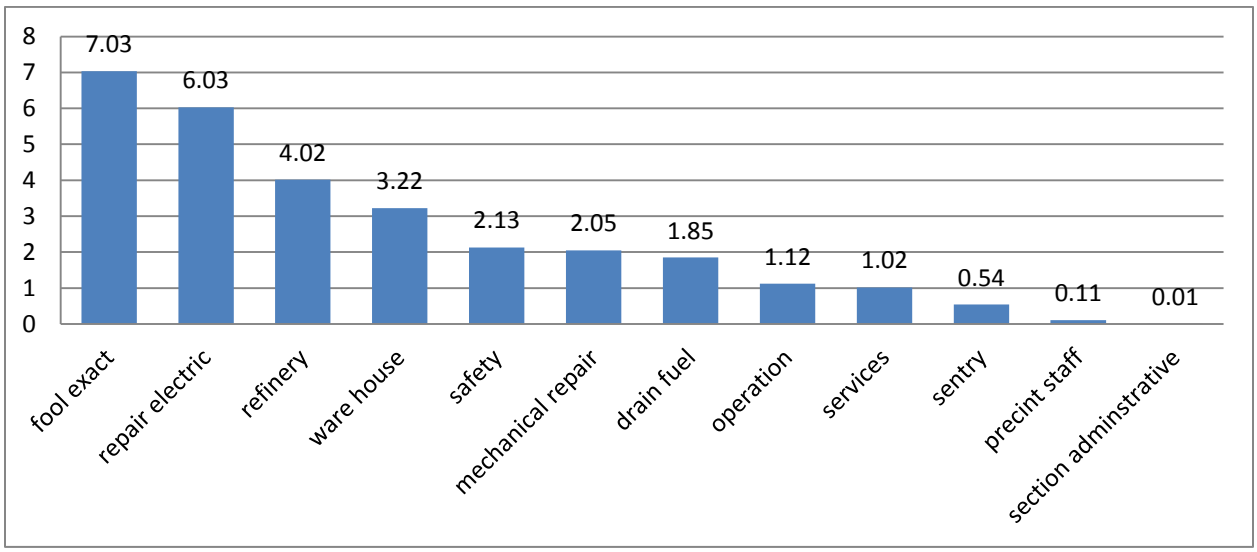

Figure 2: The electromagnetic waves in milli gauss (mG) Plants in different units

Table 3 shows the general health and its dimensions in both exposed and unexposed groups in subscales. In the depression symptoms and total general health, the difference was significant between the two groups while in terms of physical performance, anxiety, and social performance the difference was not significant. In the depression symptoms dimension, 30% of people in the exposed group and 12.2% of people in the unexposed group had moderate and severe depression. Moreover, in the general health, 40% of the exposed group and 20% of the unexposed group had moderate and severe depression.

Table 3: General health and its dimensions in both exposed and unexposed groups in Zahedan Gas Power Plant

Dimensions	**Group**	**Subscale N (%)**				**P***
		Noor minimum value	Slight	Moderate	Sever	
Somatic	Exposed	8(26.7)	13(43.3)	8(26.7)	1(3.3)	**0.316**
symptoms	Unexposed	38(42.2)	31(34.4)	18(20.0)	3(3.3)	
Anxiety and sleep	Exposed	10(33.3)	7(23.3)	6(20.0)	7(23.3)	**0.399**
disorders	Unexposed	29(32.2)	32(35.6)	20(22.2)	9(10.0)	
Social function	Exposed	8(26.7)	18(60.0)	3(10.0)	1(3.3)	**0.586**
	Unexposed	17(18.9)	56(62.2)	13(14.4)	4(4.4)	
Depression	Exposed	16(53.3)	5(16.7)	7(23.3)	2(6.7)	**0.040**
symptoms	Unexposed	49(54.4)	30(33.3)	9(10.0)	2(2.2)	
Total General	Exposed	7(23.3)	11(36.7)	11(36.7)	1(3.3)	**0.044**
Health	Unexposed	17(18.9)	55(61.1)	18(20.0)	0(0)	

*P-value compares the exposed and unexposed groups in term of general health dimensions.

Discussion

By comparing the results of the study with exposure ACGIH (10 gauss) and Iran standard in occupational environments (5 gauss) [12, 13], it can be concluded that the amount of magnetic fields in the gas power plants was lower than the limit. However, the depression and general health scores were significantly different between the exposed and unexposed groups. The results of this study are some how consistent with those of Gamberala [5], Pearce [6], Wijngaarden[7], De Vocht [15], and Franco[16]. Although,in Chakeres' study the static magnetic fields had no impact on the mental symptoms of the personnel [17]. Gamberala reported the symptoms of depression, paranoid, and obsession in people exposed to electromagnetic fields [5]. Pearce et al. in a study on the subjects living close to power transmission lines and high voltage substations

realized the mental side-effects in such people including depression, suicide, lack of control of senses and etc. [6]. Wijngaarden in a case-control study found that the increased rate of suicide in people exposed to electromagnetic fields can be associated with high rates of depression [7]. De Vocht and Franco reported significant differences in the incidence of symptoms such as dizziness, nausea, difficulty in concentration, and forgetfulness between the two groups (15 and 16).

In the same regard, in this study, no significant differences were observed in the somatic symptoms, anxiety symptoms, sleep disorders, and social functioning. According to the results of Touitou et al.'s study the level of melatonin in individuals exposed to electromagnetic fields can be expressed as an index for sleep disorders [18] that should be considered in future studies. in another study it was mentioned that the exposure to magnetic fields with the intensity of 10 mG can reduce sleep duration [19], the main cause of which was reported as the reduced level of melatonin secretion in people that is inconsistent with the present study. According to NIOSH studies exposure to electric and magnetic fields with extremely low frequency can change the level of some endocrine hormones in humans and can be associated with complications such as reduced concentration and perception as well as depression [20].

Given the age, years of experience, shifts, and reducing the confounding factors, more studies should be performed to analyze the effects of electromagnetic fields on general health. The exposure to magnetic fields may exacerbate mental disorders in the workplace. In this study, no significant relationship was observed between increase of distance from the source and decrease in the amount of magnetic fields. One of the reasons might be the proximity of High-voltage substations to each other. Karpowicz [21] and Martin [22] showed that the amount of magnetic fields was reduced by increasing distance from the source which is inconsistent with our results. Korpinen and Paakkonen [23] showed that the occupational exposure to electromagnetic waves at High-voltage substations of 110 kV has not exceeded the limit of International Commission standard against non- ionizing radiations. According to De Vocht [15] the 8-hour occupational exposure was about 40 Militesta that was more than the standard limit; this is in contrast with the results of this study. Another result achieved through this research can be high levels of electromagnetic fields (regardless of HV power substations) in high precision units and electrical repairs. One of the reasons is the proximity of the substations to HV power substations, transformers, and high voltage switchboards in these units.

Conclusion

In general, based on the significant difference of general health in both groups and due to the fact that the use of protection at high voltage

electrical substations is an impractical and uneconomical solution, better results can be obtained in reducing the subjects' exposure. Increasing the distance from these fields can help reducing exposure and its resulting complications. In addition, designing educational programs to reduce exposure of workers and increase public awareness is useful for system improvement. Despite the fact that exposure rate of the personnel was lower than the determined level by the state, according to the significance of the general health and depression between the two groups, it is necessary to conduct more studies in this regard.

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