Big Data and Computing Visions

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Big. Data. Comp. Vis. Vol. 1, No. 1 (2021) 7–14.

Paper Type: Original Article

Identification, Evaluation and Prioritization of Hazards Caused by High Voltage Power Towers in Urban Areas

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Citation:

Afzali Behbahani, N. (2021). Identification, evaluation and prioritization of hazards caused by high voltage power towers in urban areas. *Big data and computing visions, 1* (1), 7-14.

Received: 02/11/2020 Reviewed: 24/12/2020 Revised: 09/01/2021 Accept: 03/03/2021

Abstract

In recent years, industrial advances in human societies have led to the rapid growth of electrical technology and its production and transmission, and this has led to an increase in power networks and the use of high voltages. While the energy from a high voltage power tower is not visible or palpable, it also has effects on human health and even the environment, depending on the intensity of the electromagnetic fields generated and the duration of exposure and human distance from these energy sources. It has a life that is sometimes very destructive. Therefore, the purpose of this study is to identify and evaluate the hazards caused by high voltage power towers in residential areas in order to prioritize and manage hazards to reduce or eliminate them. Therefore, at first, the power transmission process, equipment used in it and the safety, health and environmental hazards resulting from it, were identified and evaluated by the parameters of the Failure Modes and Effects Analysis (FMEA). Also, considering that one of the most important problems in the vicinity of residential areas with high voltage power transmission lines is the effects of magnetic field beams created around it, in order to determine the intensity of the magnetic field, 3D EMF TESTER device was used. Finally, the identified risks were scored based on the parameters of the research method and RPN was calculated for each. Then, with the help of SPSS software, the level of risk was calculated and the identified items were prioritized and analyzed based on it. According to the results, the highest RPN values were related to health risks and all risks in this group were in emergency situations.

Keywords: High voltage power transmission lines, Risk assessment, Electromagnetic field, RPN.

1 | Introduction

Since the transmission lines and high-pressure installations and substations are close to human life, research on the harmful effects of electric and magnetic fields around these installations on the environment has attracted the attention of scientific around the world. Electricity generation has been going on for about a hundred years, and radio waves have been transmitted for seventy years, and radar was first used fifty years ago. In fact, it was not until 1950 that significant amounts of magnetic and electrical energy entered our living environment, and since then issues of environmental protection exposed to electromagnetic fields have intensified. In power supply networks, power transmission lines are used to transfer the generated energy to the consumption centers. These lines

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10.22105/bdcv.2021.142091

are usually divided into four categories according to their voltage level. High level voltages (230 and 400 Kv) are used outside of urban and rural areas and usually near power plants as well as to transfer electricity from power plants to consumption centers. In the vicinity of cities and consumption centers, the voltage level of the transmitted power is reduced by step-down transformers (up to 132 Kv and 63 kv) and inside the cities to the voltage level of 33, 20 or 11 (Kv), which is the safe level of electricity in cities and used by subscribers is reaches [1]. However, in some parts of urban and residential centers, high voltage power lines (230 and 400 Kv) are used, which will pose risks to the environment and human health. Epidemiological studies performed on people who lived near electricity tower or in the workplace near electromagnetic fields have been shown in some studies to be carcinogenic or pathogenic to electromagnetic fields, especially in the case of anemia. Depression and suicide although it is considerable that the carcinogenicity of electromagnetic fields has not been confirmed [2]. Electromagnetic waves emitted from these high voltage power towers with a voltage of 1000 volts or higher can affect the health of residents around the power tower who live up to a radius of 20 or 50 meters. Therefore, the risks arising from them can be identified and evaluated. Risks must first be identified in order to suggest ways to deal with and eliminate the risk and set your own health safety goals and programs [3]. Risk assessment is an organized and systematic method for identifying risks and risk estimation for ranking decisions to reduce risk to an acceptable level [4], which has different methods with a range of qualitative to quantitative methods [5]. Environmental risk assessment is an important tool in environmental management in order to reduce project risks and achieve sustainable development, which is now considered in the planning and policy-making of most countries [6]. Ali Mohammadi and Adl [7] have compared the safety of furnaces in two gypsum production plants by the method of failure analysis and its effects (FMEA). Were examined and their existing and possible defects were identified. Nezhadali et al. [8] Also conducted a study entitled "safety assessment of spherical reservoir of liquefied gas using FMEA and ETBA methods" during which 30 reservoirs were examined and their potential failure cases were identified. Ebrahimzadeh et al. [3] evaluated the potential hazards of Shiraz refinery using hazard Analysis (FMEA) method and its effects and identified and prioritized the most important risks. In the present study, using the above method, the risks created by high voltage power transmission lines in a residential area were identified and leveled. Many studies have been conducted on the hazards of power line development and the effects of electromagnetic waves. The study of the intensity of electromagnetic fields around high voltage sources in hospital wards of Hamedan is the title of a study conducted by Rostampour et al. [9]. In this study, using the calibrated HI-3603 calibrator, the intensity of electromagnetic fields around the high voltage sources in the radiology wards of hospitals in Hamadan was investigated [9]. Nasiri et al. [10] have also conducted a study to investigate the emission of electromagnetic waves caused by BTS antennas of 900 MHz band in Tehran. During this study, according to the location of BTS antennas in the city, the power density of the wave's electromagnetism was measured around 63 antennas based on the standard IEEE Std 1.95 method and the 4333-Hi device. In the present study, after determining the high voltage power towers in the study area, the magnitude of the resulting magnetic field is measured and its effect on the health of the inhabitants of the region is presented. Then, the evaluation of health, safety and environmental hazards of the mentioned lines in the study area was performed based on the method of Failure Modes and Effects Analysis (FMEA).

2 | Intruducing the Stydy Area

The study area is Hasirabad region located in the east of Ahvaz city in Khuzestan province (in Iran). In terms of the eight divisions of Ahvaz Municipality, it is considered as District 7. According to the latest census, this area has a population of 240,148 people and due to high population density, the progress of urban construction to the standard areas of power transmission lines and the interference of residential areas and uses with these lines. Also, the number of high voltage towers in the area was selected as the study area. The study area map is shown in *Fig. 1*.

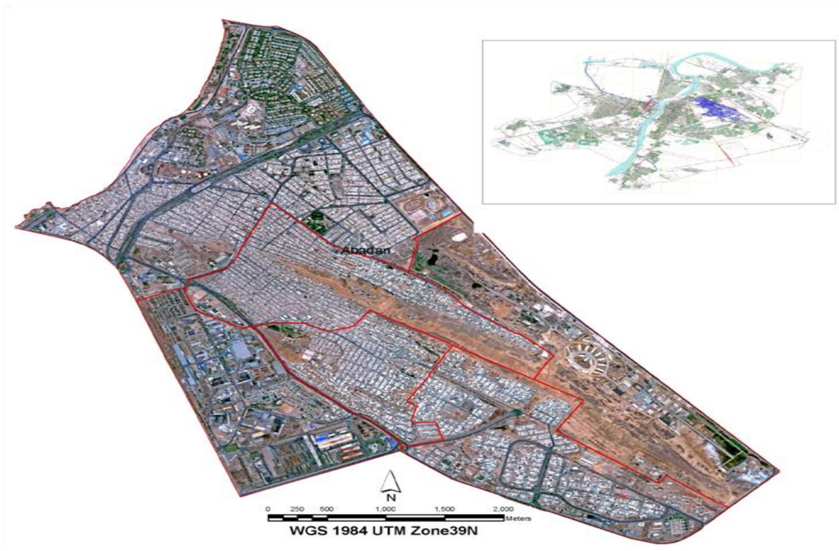

Fig.1. Geographical location of Hasirabad region in Ahvaz city.

3 | Research Method

In this study, first, the study area was determined and the intensity of the magnetic field emitted from the high voltage power tower in the desired area was measured. The existing risks were then identified and evaluated and prioritized by the FMEA method.

3.1 | Risk Assessment

The risk assessment steps were performed as follows diyagram that showm in *Fig. 2*:

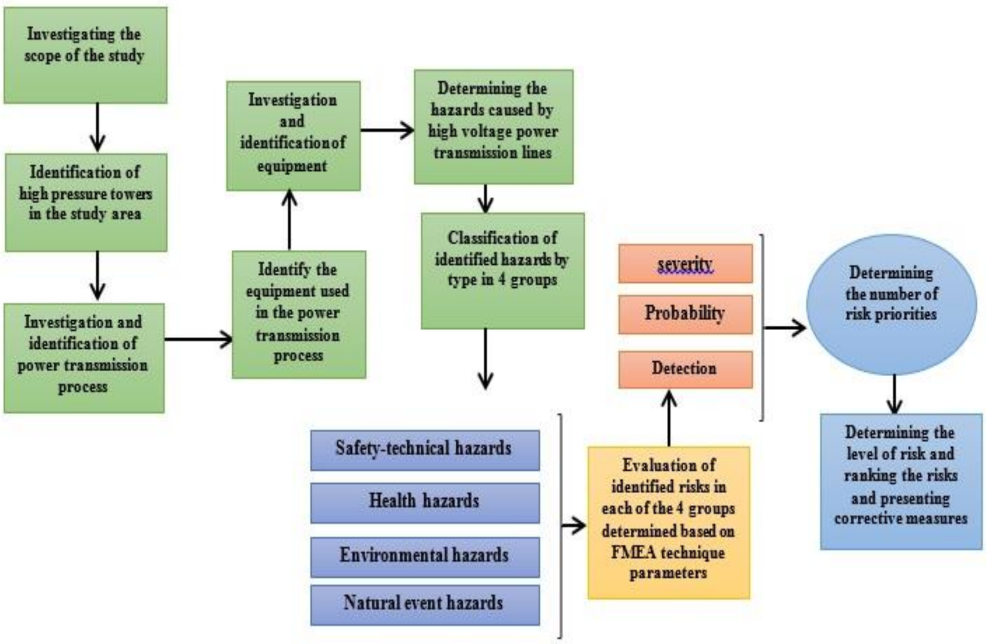

Fig.2. Diagram of research steps.

3.1.1 | Step One: Identify and Evaluate Risk

First, the process of power transmission and the equipment used in it were studied through interviews with experts in the safety-technical department and engineers of Ahwaz Electricity Company and the study of relevant books. After that, defects and errors of each equipment that lead to technical problems and defects

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in other equipment as well as injuries and human casualties were identified. Finally, the obtained risks were written for evaluation in the FMEA method worksheet. In this project, risk assessment was performed based on the brainstorming method. According to this method, the experts of safety and technical department, the expert of HSE unit and the engineers of Ahwaz Electricity Company during the meetings, according to the environmental conditions of the region as well as the statistics of accidents in the electricity company, commented on all risks and finally After consulting with each other, they reached a single conclusion and set a value for each risk. Risk valuation is based on the impact intensity ranking table, risk probability and degree of risk detection in the FMEA method. Then, the risk priority number was calculated by multiplying the three factors of degree of severity, degree of probability of occurrence and degree of detection for all errors:

$$\text{Risk priority} = \text{Severity} \times \text{Probability} \times \text{Detection}.$$

3.1.2 | Second Step: Analysis and Prioritization of Risk

In general, there is no RPN basis in the FMEA method with which data can be compared and risk levels can be determined. Therefore, in this study, statistical methods were used to determine the level of risk and data analysis. For this purpose, first a risk index or risk assurance was determined and then based on those risk levels were determined. Therefore, first the mean of RPNs and then their standard deviation was calculated as follows:

Formula for calculating the average of RPNs:

Formula for calculating the average of RPNs as shown in *Eq. (1)*.

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} xi = \frac{x_1+x_2+\ldots+x_N}{N}. \quad (1)$$

And then the standard deviation of the data was calculated according to formula as shown in *Eq. (2)*.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(X_i - \bar{X})^2}. \quad (2)$$

Finally, using the standard deviation, the scatter of RPN values around the mean value was calculated and the low and high limits of risks were obtained. Then, by comparing the obtained RPN values with the statistically determined risk levels, the identified risks were prioritized.

3.1.3 | Third Step: Secondry Risk Assessment

In the FMEA method, after determining the level of risks, in order to reduce the level of risk and also to reduce the risks arising from the risks, after providing corrective measures, the risk priority number is recalculated.

3.2 | Measuring the Intensity of the Magnetic Field

For this purpose, the 3D measuring device EMF TESTER model EMF - 828 and the measurement method in the NIEHS (National Institute of Environmental Health Sciences) standard were used .Measurement of magnetic field strength at four distances of 15 m, 31 m, 61 m and 91 m from high voltage power transmission lines (voltage level Kv230) and in three directions X, Y, Z, in a 20-meter municipal street in Hasirabad area, and The values obtained were compared with the allowable limits in the NIEHS standard for the voltage level of 230 Kv. The permissible values of the NIEHS standard are given in *Table 1*:

Table 1. Standard levels of magnetic field in µT for power transmission lines (public exposure) NIEHS, 1995.

Line type (voltage level)	Distance from the line			
	15 m	30m	61m	91m
115 Kv	0.7 1.4	0.2 0.4	0.04 0.09	0.02 0.04
230 Kv	0.2 0.4	0.7 1.5	0.018 0.36	0.08 0.16
500 Kv	2.9 6.2	1.3 2.7	0.32 0.67	0.14 0.30

4 | Finding

4.1 | Effects of Electromagnetic Waves

All low and high voltage electrical appliances generate two electric and magnetic fields, and each of these fields contains energy that can affect the body of any living thing, including humans. The higher the voltage of the high-pressure lines, the stronger the magnetic fields can be, which have been proven to have adverse effects on humans and can even have an impact on the environment. According to research, the abundance of electromagnetic waves emitted by the installation of high-voltage power towers in residential areas has caused blood, brain and even disability problems for residents living on the edge of the magnetic field affecting these waves. Ofcourse, the harmful effects of these waves vary depending on the type and intensity of their field, but in general, side effects such as blood and brain disorders caused by these waves have been proven in people who are constantly exposed to it. Due to the fact that white and red blood cells are growing in childhood and adolescence, any mutations and blood mutations can lead to blood disorders and even cancers, so children and adolescents are more exposed than any other age group. According to studies, if the intensity of the magnetic field is higher than the standard and the exposure is done continuously, it can affect many tissues and organs of the body and in more severe cases, cause organ failure. If only part of the body is exposed to radiation, these effects are less serious. If the exposure occurs over days, weeks, months, or years, the risk is still lower. This is because most of the organs in the body can repair some of the damage [11]. Therefore, according to the measurement results, in the study area, because people are constantly in contact with these waves and radiation occurs during the day, the health of people in the long run, is threatened.

4.2 | Result of Magnetic Field Strength Measurement

As the measurement results (that shown in *Table 2*) show, the values obtained at two distances of 61 m and 91 m from the 230 Kv power tower above the lower and upper limit of the standard and at two distances of 30 m and 15 m, the values obtained above the lower limit and close to the upper limit. The values are standard (the unit of measured values is in terms of MicroTesla (µT)).

Table 2. Results of magnetic field strength measurements.

Line type (voltage level)	Distance from the line			
	15 m	30 m	61 m	91 m
NIEHS permissible values for voltage level Kv230	2.00 4.00	0.7 1.5	0.18 0.36	0.08 0.16
Measured values	3.3 µT	1.1 µT	0.70 µT	0.33 µT*

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4.2| Risk Assessment Result

During the power transmission process, 13 components were examined and 41 risks due to breakdowns and defects of these equipment's were identified. The basis for diagnosing breakdowns based on the opinions of HSE experts and according to the statistics of accidents and accidents related to human equipment and errors, visiting the study area as well as worksheets registered in the maintenance and regional electrical equipment of Ahvaz was considered. The equipment used in power transmission was identified as follows: insulator, disconnector, mast, wire, flash, relay, overhead cable, span, jumper, ground wire, clearance, wire guard, power transmission line. The identified risks are divided into four categories based on the causes of occurrence:

1. Natural event risks that are caused due to the failure of the wire and mast component and due to factors, such as wind and storm, flood and earthquake.
2. Environmental risks due to factors such as pollution (dust), bird impact, rain, tree impact and lightning for equipment such as, wire, mast, insulator, overhead cable, FLASH and wire guard.
3. Safety-technical group due to factors such as errors in settings, errors in design calculations, wear and rust, switching, corona phenomenon and wire flash are created for equipment such as wires, relays, insulators, cables, jumpers and disconnectors.
4. Group of health risks for the components of wires, masts and transmission lines and wire guards, which due to factors such as non-compliance with the permitted privacy of transmission lines due to urban construction and people advancing in the area, throwing objects on the transmission network (often by children), wire theft, corner theft and car collision with the mast, cause and cause injuries and human casualties, diseases due to exposure to electromagnetic waves.

According to the results, five risks were in the group of natural events, 16 risks in the category of environmental risks, 13 risks in the safety-technical group and finally seven risks in the category of health risks. The number of risks obtained by group, for each component is presented in *Fig. 3*:

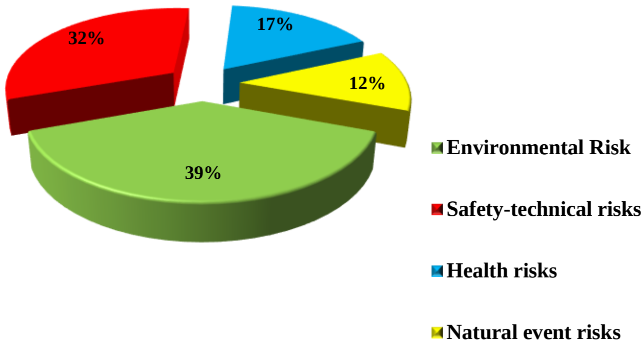

Fig .3. Graph of the percentage of identified risks.

4.3| Result of Calculating the Level of Risk and Their Ranking

Based on the statistical results using SPSS software, the mean for 41 data (risks) was 170.7 and the standard deviation was 88.723. Subsequently, the values of upper limit, medium limit and lower limit of risk were calculated as follows:

High Value: $\sigma + 170.7=259.4$, Low Value: $\sigma - 170.7= 82$.

Accordingly, all risks whose priority number was obtained below the low risk level (RPN <82) are acceptable and have a natural condition (Low Risk) and risks whose priority number is higher than the high-risk level (< RPN259.4), unacceptable and with emergency conditions (High Risk) and finally the risks whose priority number was placed between the upper limit and the lower limit of risk (82 <RPN <259.4), have abnormal conditions and moderate (Middle Risk), are. According to the division, 9 low-level risks, 23 medium-level risks and 9 risk are in high-level. After the first stage evaluation, corrective actions were presented to reduce the level of risks that have emergency and abnormal conditions, and then the second stage evaluation was performed. Thus, all the risks that were in the evaluation of the first stage, in emergency and abnormal conditions, by providing control measures based on environmental conditions and technical and expert opinions, were at an acceptable level and the severity of the effect and the probability of their occurrence were reduced. Based on the results, the highest risk values in the group of environmental risks related to the insulating component with RPN, 320 and the lowest risk values related to the disconnection component with RPN, 60 were obtained. In the natural event risks section, all risks were moderate and the highest risk for the wire component with RPN was 168. In the group of safety-technical risks, the highest amount of risk is for the power transmission line with RPN, 270 and the lowest amount of risk is for FLASH and SPAN with RPN, 80. All identified health risks have a high level of risk and emergencies, the highest of which is related to the RPN 360 wire and power line component. In the risk assessment process, after identifying, quantifying, and prioritizing risks, a risk response plan is needed, which outlines ways to deal with the risks and appropriate opportunities before they occur. According to the results of this study, most of the risks that lead to injuries and casualties are emergency or abnormal. The results of a study using FMEA and JHA methods to analyze the risk of electrical accidents in Saadatabad area of Tehran by Ghayeblo et al. [13] Risk (FMEA) and its effects by Ebrahimzadeh et al. [3], show that most RPNs are related to safety and technology, while the results of the present study, which in a residential area Evaluate power lines and show that health sector risks are the most significant. In connection with the measurement of the magnetic field in the present study, many studies have been conducted, including Malagoli et al. [14], During a study in two residential areas in northern Italy, found that the risk of leukemia with a history of residence in the region The one with a field strength higher than the allowable limit increases to some extent. In most researches in this field, such as this research, the intensity of the field is higher than the allowable limit and therefore there are risks to the health of people living in the area.

5 | Conclution

Observing the privacy of high voltage power transmission lines is one of the most important factors that can reduce the effective risks. Privacy must be specified by the responsible agencies and displayed on posts for public awareness, and people must be aware of privacy and observe this privacy in the construction of housing. Due to the expansion of cities and population growth, the current law should be revised. The range of boundaries should be longer, and before this review, it is better to conduct research in this field and measure the fields at different distances, and then define a new boundary according to the standard.

References

[1] Amini, S. (2009). *Textbook of principles of production, transmission and distribution of electrical energy*. Publications of the Ministry of Energy, Institute of Higher Scientific-Applied Education of Water and Electricity Industry.

[2] Fani, A., Moieni, A., Fani, I., Chehrei, A., Fani, P., & Heidari Bateni, M. (2006). The long-term effects of occupational electromagnetic fields exposure on peripheral blood indexes in workers of aluminum processing factory of Arak. *Journal of Shahrekord university of medical sciences quarterly*, *7*(4), 42-49. (In Persian). http://78.39.35.44/article-1-107-fa.html

[3] Ebrahimzadeh, M., Halvani, G., Mortazavi, M., & Soltani, R. (2011). Assessment of potential hazards by Failure Modes and Effect Analysis (FMEA) method in Shiraz Oil Refinery. *Tkj*, *3*(2), 16-23. (In Persian). http://tkj.ssu.ac.ir/article-1-41-fa.html.

[4] Rezaei, K., Seyedi M., & Nouri, M. (2005). *Failure Modes and Effects Analysis (FMEA)*. Publications of Arotof Iran Co. (In Persian). https://db.ketab.ir/bookview.aspx?bookid=1227610

[5] Norouzi Chegini, M. A., & Jahangiri, M. (2015). *Risk assessment and management*. Fanavaran Publications.

[6] Lari, B. S. M., Jaafarzadeh, H. F. N., & Rafiei, M. (2011). FMEA application in environmental risk assessment: case study of Imam Khomeini port berths dredged. *Journal of wetland ecobiology*, *3*(9), 3-14. (In Persian). https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=260813

[7] Ali Mohammadi, I., & Adl, j. (2008). Comparison of safety of furnaces in two gypsum production plants by fracture analysis and its effects (FMEA). *Journal of occupational health in Iran*, *5*(2), 77-83. (In Persian). https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=102710

[8] Nezhadali, H., Mortazavi, B., & Khavanin, A. (2008). LPG storage spheres risk assessment with FMEA and ETBA methods. *Journal of Kermanshah university of medical sciences*, *12*(37),180-189. (In Persian). https://www.magiran.com/paper/588714?lang=en

[9] Rostampour, N., Almasi, T., Rostampour, M., Arabian, K., & Karami, A. (2012). Assessment of electromagnetic fields around high voltage power supply in Hamadan hospital wards. *IJHE*, *5*(2), 235-244. (In Persian). http://ijhe.tums.ac.ir/article-1-30-fa.html.

[10] Nasiri, P., Monazam, M., Zare, S., Azam, K., Yousefi, Z., & Hematjo, R. (2011). The study of the status of electromagnetic waves resulting from BTS (Base Transceiver Station), 900-megahertz frequency in Tehran. *IJHE*, *4*(3), 331-340. (In Persian). http://ijhe.tums.ac.ir/article-1-64-fa.html.

[11] World Health Organization. (2007). Extremely Low Frequency Fields. Available from http://apps.who.int/bookorders/anglais/detart1.jsp?codlan=1&codcol=16&codcch=238

[12] Oron, P. (1986). Physics and its applications in health sciences. In Sepehri, H. & Mirza Beigi, J. & Pashaei Rad, J. & Moalemi, B. (Eds.). University Publication Center.

[13] Ghayeblo, S., Mojriyan, M., Geraviyan, N., & Khosravi, Sh. (2004, Dec). Risk assessment and analysis in investigating accidents in Saadatabad power area using FMEA and JHA methods. *Proceedings of the 19th international electricity conference*, Tehran. (In Persian). https://civilica.com/doc/20719/

[14] Malagoli, C., Fabbi, S., Teggi, S., Calzari, M., Poli, M., Ballotti, E., ... & Vinceti, M. (2010). Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy. *Environmental health*, *9*(16). https://doi.org/10.1186/1476-069X-9-16

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