

Grounding Potential Power Line Health Hazards  
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## Abstract

*As urban areas continue to expand, there is a constant need for additional power infrastructure which, in most cases, includes overhead power lines. Both transmission and distribution lines are viewed by many as not only eyesores, but potential health risks. This paper will address numerous studies which have examined the validity of health concerns voiced by the growing number of citizens who fight to keep overhead power lines at a distance.*

## 1. Introduction

On January 21, 2005, the citizens of San Antonio lost an intense and exasperating battle. After two years of public protest, the San Antonio City Council approved the routing of the 60-mile long, 345 kV, Cagnon-Kendall transmission line.

The opposition toward power line construction is nothing new for Texas, and the rest of the country has grown quite used to it as well. Billions of dollars are spent on trials and hearings to discuss plans and suggest alternate methods, but in the end the line gets constructed and there is always someone who feels cheated.

The two year argument against the Cagnon-Kendall line was based on the idea that it would harm the underground aquifer and endanger wildlife in the surrounding environmentally sensitive land. Complaints like this echo across the country along with cries for aesthetics and, most heavily, fears of adverse health effects.

Transmission lines, although not the most eye-appealing structures, are absolutely necessary to civic growth. Besides linking power plants to substations, transmission lines are used to transport power from substation to substation. As cities expand outward, this allows for an efficient extension of the power grid in order to bring electricity to a greater number of homes. Transmission lines in the San Antonio area

carry either 138 kV or 345 kV at 60 cycles per second. The electromagnetic fields caused from these lines are classified as extra-low frequency EMF, or ELF-EMF.

Countless studies have been done on the effects of ELF-EMF on the human body and have produced mixed results. On the positive side, specially pulsed ELF-EMF can be beneficial in healing broken bones. However, many investigations have been conducted which suggest a possible link between high exposure to ELF-EMF and undesirable health effects.

## 2. Exposure

To begin to comprehend the possibility of health effects, one must understand the risks of exposure to these fields, including the differences between magnetic and electric fields. Static magnetic fields, like the field of the earth (measured to be 25-65  $\mu\text{T}$ ), are not attenuated inside the body whereas static and ELF electric fields are. The exposure to ELF-EMF results in the induction of currents and electric fields in the tissues of the body. The characteristics of these induced fields depend on the external field's frequency, magnitude, and orientation as well as the size and shape of the exposed object [1]. The higher the frequency of the external field and the larger the object being affected, the greater the magnitude of the induced field will be in that object [1]. These induced fields can exert forces on moving charges within the tissues of an organism, resulting in the deformation of certain structures and the change in energy levels of some molecules. The induced fields and currents produced by ELF-EMF are very small, and standards exist to keep them at levels below those that naturally occur in the body.

The typical person in the United States is exposed to an average of 0.09  $\mu\text{T}$  in a twenty-four hour period [2]. However, this entire field is not caused by power lines alone. Everyday electronic appliances, usually those with high currents or high-speed electric motors, can also produce high magnetic fields. Microwave ovens, electric washing machines, and dishwashers

have been found to produce magnetic fields of strengths greater than  $0.20 \mu\text{T}$  at 1 meter [3].

The first known scare dealing with the health effects of high-voltage power lines was in 1962, several months after the Soviet Union's first 500 kV lines had been energized. A Russian investigation linked the substation workers' complaints of headaches and fatigue with their lengthy exposure to electric fields [4]. However, the United States disapproved of these findings due to what they saw as insufficient data and inadequate medical diagnoses [4].

### 3. Residential Studies

The first major investigation that dealt with the risks of living near power lines in America jumpstarted a series of over 100 studies performed in an attempt to understand the effects of ELF-EMF on the human body. In 1979, Nancy Wertheimer and Ed Leeper published the results of an epidemiological study stating that children with leukemia in the Denver metropolitan area were twice as likely to live near high current power lines as healthy children [5]. The major fault with this study was that detailed measurements of the strengths of the magnetic fields in question were never made – they were simply estimated using the spatial configuration of the power lines. In 1990, J. Robert Ashley set out on a personal quest to disprove the 1979 study and upon taking measurements in the Denver area, found no correlation between power line geometry and magnetic fields [6]. Due to Ashley's work, the link between ELF-EMF and cancer found in the 1979 experiment was nullified.

However, at the time, the 1979 study by Wertheimer and Leeper created a significant stir in communities across the country. Citizens began to worry about their health and demanded that the matter be looked into more carefully. Many studies in the 1980's followed up on the 1979 investigation and reached varying and unstable conclusions.

Concern persisted, and as part of the Energy Policy Act of 1992, the United States Congress authorized the EMF-RAPID (Electric and Magnetic Fields Research and Public Information Dissemination) Program with the intention to investigate the potential health risks of ELF-EMF exposure. The program, headed by the National Institute of Environmental Health Sciences (NIEHS), ended in December of 1998 and found the scientific evidence linking ELF-EMF exposure to adverse health effects to be weak [2]. The investigation resulted in a conflict between epidemiological and laboratory studies: the epidemiological studies found a somewhat consistent link between increased exposure to the fields and a small increased risk of health effects while

the laboratory studies did not find any correlation between the two [2]. NIEHS concluded that exposure to ELF-EMF could not be declared to be entirely safe, but the evidence that suggested a possible link between exposure and adverse health effects was not adequate enough to justify new aggressive regulations [2].

In 2002, the International Agency for Research on Cancer (IARC) released a report coming to similar conclusions as the EMF-RAPID program. The IARC study pointed out the number of more advanced studies that have occurred since 1979 including reviews, meta-analyses, and pooled analyses, and concluded that the evidence that linked adult and childhood leukemia with ELF-EMF was weak and inconsistent [1]. The IARC explained that the supposed correlation might have been affected by the bias of those hoping for the publication of positive findings, and that this bias combined with chance could easily explain the results. According to the IARC, if the relationship between ELF-EMF and harmful health effects was real, there would be a more significant indicator of the correlation present in the data [1].

Later in 2002, the California Department of Health Services released an evaluation of the risks of EMF exposure based on previously published research. The study concluded that ELF-EMFs "can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage" [7]. The study found no link between EMFs and birth defects, breast cancer, heart disease, Alzheimer's Disease, or depression [7].

In June of 2005, the *British Medical Journal* published the results of the latest epidemiological study in which a team from the University of Oxford's Childhood Cancer Research Group looked at the cases of almost 30,000 children under the age of 15 who were diagnosed with cancer between 1962 and 1995. Children born within 200 meters of a transmission line had a 69% higher risk of leukemia when compared with those born more than 600 meters away [8]. Children born between 200 and 600 meters from a line risked a 23% higher chance [8]. The researchers estimated that five out of about 400 cases of childhood leukemia that arise in England and Wales each year might be related to living near a high-voltage line [8].

### 4. Occupational Studies

Many studies have also been conducted dealing with people who are in constant high exposure to ELF-EMF at the workplace. Thériault of McGill University led a research team that studied 223 000 utility workers at Ontario Hydro, Hydro-Québec, and

Electricité de France who wore personal gaussmeters to their jobs at various times of the year [9]. After analyzing 10 000 days worth of evidence, the team found that the 10% most highly exposed workers had about a 3 fold risk of developing acute myeloid leukemia and a 12 fold risk of developing a certain type of brain cancer [9].

Another investigation, led by Genevieve Matanoski at Johns Hopkins University, studied 50 582 New York telephone workers with a median age of 40 and found a higher risk of leukemia for the younger workers in the group [10]. The group with the highest exposure, cable splicers, had a higher cancer risk for all cancers including leukemia, prostate cancer, and brain cancer [10].

There is also a possible link between breast cancer and high exposure to ELF-EMF. A University of North Carolina study found that female electrical workers had a 40% higher mortality rate from breast cancer than women in other fields [9]. Another investigation, performed by the Cancer Registry of Norway, found that male electrical transport workers had four times the expected rate of breast cancer than the control group [9]. In addition, the fields generated by sewing machines give dressmakers in the United States and Finland about three times the occupational exposure of utility workers, and they were found to have three times the risk of developing Alzheimer's disease than those who are less exposed [9].

## 5. Troubles and Tribulations

As of 1995, nearly 100 studies had been performed dealing with the possible health effects of ELF-EMF. For the many studies that claim a link between ELF-EMF and adverse health effects, there are just as many that attest to the correlation being nonexistent. This leads one to wonder if the studies that have been carried out concerning the subject are even valid to begin with.

One aspect that many studies, including the initial investigation in 1979, failed to account for is the income factor. Areas under power lines are often locations of low-income housing since they are not preferred places of habitation. There is a known relationship between poverty and cancer, and since residences under power lines tend to have less income than the average, the original study was flawed [11]. Wertheimer and Leeper failed to take this important factor into account which may have greatly affected their findings.

A second problem simply deals with the number of subjects examined in the studies. It is very hard to claim accuracy when only three out of every 10 000 children are diagnosed with leukemia in low exposure

areas and that number rises to six in every 10 000 in areas with higher field strengths [12]. When working with numbers this small, a minute variation due to miscellaneous factors can change the entire outcome of a study [12].

In addition, the results of the studies have been quite frustrating due to the lack of a clear conclusion. Even as studies become more sophisticated, the evidence of risk has remained about the same [9]. Eleanor Adair, chair of IEEE's Committee on Man and Radiation, said, "As studies become better controlled, and study larger populations, the risk ratios are getting smaller. I would be ready to draw a conclusion right now – that there is no link there" [9].

Another issue with the investigations is the lack of a clear control group. The majority of the studies split people into "exposed" and "unexposed" groups based on the proximity of their homes to power lines. However, people do not spend their entire lives in their homes and may work in areas with a much higher magnetic field. Nancy Wertheimer explained the issue with the control groups as "looking on people who smoke Marlboros as exposed and putting all other smokers into the unexposed group" [9].

It is especially difficult to standardize the studies which have been conducted since they vary in how they define "high exposure" areas. Some studies use the magnetic field strength to determine the degree of exposure whereas other studies measure exposure by distance away from the power line. However, distance is a very unreliable method since the magnetic field at a set distance from a power line is going to vary depending on a variety of factors including the voltage and current of the line. To add to the confusion, the studies conducted in the United States have been based predominantly on local distribution lines, whereas the numerous European studies focused on high-voltage transmission lines. Due to these factors, it is quite difficult to come up with a number which separates areas of high exposure from areas of low exposure.

Another issue with the studies that have been performed is that they have all analyzed the same basic characteristics of the magnetic fields – strength and distance. It could be that the cause of the links between cancer and ELF-EMF is something completely different, like the rate of change of the fields or peaks of intensity [9].

In fact, a comprehensive investigation of the health effects caused by *electric* fields is long overdue. In 1992, following a Swedish study that strongly linked proximity to power lines with childhood leukemia, J. Robert Ashley returned to Denver (the location of the initial 1979 experiment) and found through experimentation a fair correlation between

electric fields and line geometry [6]. Expanding on his study, Ashley compared the current densities induced by both types of fields in a person standing directly under a 13.2 kV distribution line and found the current densities induced by the electric field to be much stronger than those induced by the magnetic field [6]. These findings may explain why studies searching to link cancer to magnetic fields have been inconclusive and might suggest a possible correlation between electric fields and adverse health effects.

## 6. Issues of Bias

The Power Line Task Force (PLTF) is an organization comprised of homeowners in the suburbs of St. Paul, Minnesota with the goal of impeding an upgrade to Xcel Energy's 115 kV SE Metro Line. This organization believes that the IARC, National Radiological Board, and the National Institute of Health seem to be extremely cautious in voicing their findings that link adverse health effects to ELF-EMF [13]. They think that since electricity is so vital to society, these government entities are hesitant to release evidence that might jeopardize the prosperity of those not affected while increasing the safety of the minority who are [13]. The PLTF also believes that electric utilities have a large influence over policymakers and can therefore lobby for the advancement of their goals [13]. As in all cases, the possibility of scientific evidence being distorted in order to promote certain agendas cannot be ignored.

## 7. Conclusions

After hundreds of studies, experiments, and research, it is obvious that we still do not understand the effects of ELF-EMF on the human body. Conflicting information runs rampant and it is extremely difficult to obtain reliable data that has not been skewed by bias in one direction or another. Until more concrete answers are established, many have chosen to follow the path of "prudent avoidance", that is, moving away from or limiting exposure to high electromagnetic fields [9]. Of course, prudent avoidance may not be the best long-term solution, but as of now it is cheaper and more realistic than expecting the utility companies to relocate the whole of the nation's power infrastructure due to a myriad of inconclusive evidence. One can hope that with continued research of this unsettled topic, we can one day completely understand the biological effects of ELF-EMF and, if necessary, take action in order to increase the safety and wellbeing of society.

## 8. Originality Statement

The simple question of the health effects caused by power lines has become unnecessarily complicated. Many investigations have been performed, but much of the data is unreliable or conflicts with other studies. The goal of this research was to sift through the majority of the information in order to present the reader with an efficient and impartial response to a question which has no straightforward answer.

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