



A REVIEW OF CURRENT INFORMATION ON THE HEALTH EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS

I. Introduction

This document was prepared in response to concerns raised regarding the placement of a new 230 kV transmission line through the communities of East and West St. Paul. Construction of the line was approved in 1999 but recently citizen groups from the R.M.s of East and West St. Paul have expressed concern regarding the possible health effects of this additional high voltage power line. In addition, residents in other parts of the Winnipeg Health Region have raised concerns about existing power lines. This report is part of the review done for the Medical Officers of Health at the Winnipeg Regional Health Authority.

II. Electrical Power Basics

The power line in question uses high voltages, 230 kV (1kV=1000 V), to carry energy efficiently over long distances. Most outlets in our homes use a voltage of 120 V. The power carried by the high voltage lines is “stepped down” to a lower voltage at substations and transformers.

All power lines, electrical wiring, and appliances produce electric and magnetic fields (EMFs). EMFs are invisible lines of force surrounding any electrical device. Electric fields are easily shielded by even human skin, but magnetic fields are not easily shielded. Both electric and magnetic field strength decrease quickly the further away you move from the appliance or power line.

Electric fields are produced by anything that is plugged in, **magnetic fields are produced by anything that is plugged in and turned on.** Turning the appliance on causes current to flow, which generates the magnetic field. The strength of the magnetic field generated depends on how much current is flowing. The current flowing in your toaster is a constant amount, but the current flowing in a high voltage power line is not constant. It will change depending on how much electrical power it has to deliver. For example, at 5:00 p.m. on a winter's day, demand will be very high as furnaces are on, lights are on both at home and in offices, people are starting to prepare dinner, etc. The current carried will be high, and the magnetic field stronger. At 3:00 a.m. on a day in September, demand will be low as lights are off, no furnaces or air conditioners are operating, etc. Current will be low, so the magnetic field generated around the line will be weaker.

Point readings, obviously, may not give an accurate estimate of a person's total EMF exposure. A point reading may be very high at one moment but, even one half-hour later, the reading may be very different.

Concerns have been raised about an increase in magnetic field strength with the addition of another power line. Some people believe that adding another line will simply increase the magnetic field strength. That is, if the magnetic field strength right now is 2, and the new line produces a field strength of 1, the resulting field will be 3 (these numbers are used for illustration, they are not actual readings). However, this is not the case. The magnetic field strength will not simply increase with the addition of another line. In fact, overall the magnetic field strength may be unchanged by the addition of another line. The waves of energy that the power lines produce interact with each other, sometimes increasing magnetic field strength, and sometimes decreasing magnetic field strength. A complex calculation must be done to estimate the magnetic field strength produced by the addition of another power line.

Magnetic field measurements

Magnetic field intensity is measured in units of gauss (G) or tesla (T). Tesla is the internationally accepted scientific term. One tesla equals 10,000 gauss, 1 T = 10,000 G. Since most environmental EMF exposures involve magnetic field intensities that are only a fraction of a tesla or a gauss, these are commonly measured in units of microteslas (μ T) or milligauss (mG). A milligauss is 1/1000 of a gauss. A microtesla is 1/1,000,000 of a tesla. One milligauss is equal to 0.1 microtesla.

II. Biological Effects of EMFs

Electromagnetic fields may have effects on living creatures. The magnetic fields produced by power lines (and our toasters) can produce electric currents in the body. However, these currents are weaker than the currents produced by the activity of our brains, nerves and hearts. Our body uses electric currents to send messages between our nerves. But, some suggest that the currents produced by EMFs may be to our bodies like a familiar voice in a crowd is to our ear. It is not just more noise, but may be able to exert a unique effect.

Summary of Information:

- **Health effects** associated with EMF have not been documented.
- **Biological effects** seen are usually at much higher MF strengths than people would normally be exposed to
- **IF** EMFs are carcinogenic (and it's a big if), it is likely as a promoter, not an initiator. That is, they do not start the complex series of steps that can lead to cancer, but they may make some of the steps easier for the body to take, once things have started.

The difference between health effects and biological effects may seem difficult to understand. What it means is that we may see some changes in cells in the laboratory under very artificial conditions. But, when we look at animal and human experiments, we do not see any change in their actual health. That is, exposure to EMFs has not given any animals or people cancer. Here are some details regarding the biological effects of EMFs.

Calcium

There has been a suggestion that EMF changes calcium levels in cells. This was reported as a result of a study using a magnetic field strength much higher than people would normally be exposed to, even close to a power line. Different researchers have not been able to repeat these results. In addition, the results from the one study that did show this finding have been discredited. The scientist was found guilty of professional misconduct for falsifying some of the graphs in the two key papers

Breast cancer

A recent study reported that 1.2 mT magnetic fields reduced the [desired] effect of tamoxifen and melatonin on breast cancer cell growth. These are cells grown in a dish in the laboratory, not actual breast cancers in people or animals. Only one laboratory has found these results. For scientific studies, results are not generally accepted until more than one laboratory has the same results. Again, the same scientist who was found guilty of professional misconduct did the initial studies that reported this effect.

Two studies have shown increased cases of breast cancer in rats. These rats were given a cancer-causing drug and then exposed to very strong magnetic fields (100 mT - about 250 times stronger than the highest levels we see in our homes) for 24h/day for three months. Very strong magnetic fields may make it easier for cells to become cancerous, once they've been given a cancer-causing agent. This has not been shown for any other type of cancer, including leukemia.

Miscarriage/Fertility

Some people are concerned that EMFs can cause miscarriage and problems in pregnancy. There is no convincing evidence that this is the case. Studies that have shown effects are usually flawed.

Melatonin

Melatonin is a natural tumour suppressor. Melatonin levels in our blood depend on many things, including our exposure to light, and they vary every day. Low melatonin levels have not been shown to cause cancer. It has been suggested that EMFs can reduce levels of melatonin in our blood. Three recent studies looked at melatonin levels in women. One compared melatonin levels in women living near power-lines to those living away from power-lines. This study found no difference in melatonin levels in the two groups, except for women over 60 years and overweight women. Women over 60 years and overweight women living near power lines had slightly decreased levels compared to women over 60 years and overweight women living away from power lines. A second studied melatonin levels related to EMF exposure. This study found lower melatonin levels in women with higher bedroom magnetic field exposure ($>0.2\mu\text{T}$), but only in women on certain medications, and only during months with few hours of darkness. However, this study found no difference in melatonin levels based on age or weight. A recent study with human volunteers exposed to very strong magnetic fields (238 mG) showed no reduction of melatonin levels. These inconsistent findings make it difficult to say exactly what, if any, effect EMF has on human melatonin production.

Some animal studies have shown a reduced melatonin with EMF exposure. But, the reduced melatonin has not been followed by more cancer in these animals. Many of the positive studies involved rodents, which are nocturnal, so it may not be relevant to animals, like humans, that are not nocturnal. Of the two best studies, one showed reduced melatonin, and one showed no reduction.

III. Epidemiology

Epidemiology is the study of associations. Epidemiology is what first suggested that cigarettes might be harmful to human health many years ago. We are usually trying to link an “exposure” (cigarette smoking, EMF, high-fat diet, etc.) with a disease. Epidemiology is not able to give proof of cause and effect, but can only point at associations. The difference between “proof” and “association” may seem fuzzy, but the distinction is very important

Some epidemiological studies can suggest associations that have nothing to do with the disease in question. For example, using epidemiology, it could be argued that coffee drinking is associated with lung cancer. Since many smokers are also heavy coffee drinkers, studies that are not done properly could suggest coffee drinking caused lung cancer. This is why something called “control” is so important for these types of studies. A well-controlled study does everything possible to make sure the two groups being compared (for example - those with lung cancer, and those without) are the same in every way except for the “exposure” (e.g. cigarette smoking).

As with most scientific studies, no epidemiological study is perfect. Unfortunately, in many of the studies done regarding EMF, the two groups (for example - children with leukemia, and those without) are not identical in every other way except EMF exposure, despite the researchers' best efforts. So, while their findings cannot be ignored, it does make them less convincing. Another problem with EMF studies is that there are many different ways to measure EMF exposure. More recent studies have adopted a more consistent way to measure EMF exposure, but comparisons of different studies can be difficult.

With EMFs, the only association that is consistent is an association with childhood leukemia and very high EMF exposure. There have been at least 28 studies looking at EMF exposure and childhood leukemia. Nineteen of these studies have shown no association between EMF exposure and childhood leukemia, and nine have shown an association.

Recently two large pooled studies (analysis that uses data from many other studies) have demonstrated a consistent, statistical association between relatively high exposures to magnetic fields (greater than 0.4 μ T), and a doubling of risk of childhood leukemia. This association does not appear to be due to chance.

Assessment of epidemiological studies and of statistical associations requires us to consider what we call "biological plausibility". Basically this means, does the association make sense? For example, it makes more sense that smoke you inhale into your lungs and hold there over and over again could cause lung cancer, than that drinking coffee could have this effect. However, we also needed to learn about all of the toxins in cigarette smoke and how they affected our lungs before we could say that cigarette smoke caused lung cancer.

Although scientists do not have a good understanding of what causes childhood leukemia, there is no known "biologically plausible" way in which EMF could lead to leukemia.

V. Conclusions

There is a statistical association between exposures to relatively strong magnetic fields (greater than 0.4 μ T), and an increased likelihood of having childhood leukemia in epidemiological studies.

There is evidence of biological effects of EMFs on cellular and animal systems, but this is generally at levels of EMF several times (up to 10,000 times in some studies) greater than the usual residential exposure. There is no biological evidence that exposure to EMFs leads to health effects. For example, studies showing decreased melatonin levels in lab animals have NOT shown increased levels of cancer in these same animals. There has never been a laboratory study showing that EMF exposure causes leukemia.

VI. Recommendations

1. Given the ubiquity of exposure to EMFs, the difficulty with accurately measuring exposure, and the lack of evidence regarding health effects, there is currently insufficient evidence to warrant regulation of personal exposure to EMFs. However, individuals can take steps to reduce their exposure to EMF in the home and in the workplace.
 - Increase the distance between yourself and the EMF source – sit at arm's length from your computer terminal; stand back from an appliance when it is in use.
 - Correct any household wiring problems
 - Avoid unnecessary proximity to high EMF sources – don't let children play directly under power lines or on top of power transformers for underground lines
 - Reduce time spent in the field – turn off your computer monitor and other electrical appliances when you are not using them.
2. The public should be provided with balanced, clear and comprehensive information on potential EMF risks, as well as suggestions for safe and low cost ways to reduce exposures.
3. Local authorities and the public should be consulted when siting new power lines. Obviously power lines must be sited in a way that provides power to consumers. Siting decisions should also take into account esthetics, public sensibilities and ways to reduce peoples' exposure.