

Research proposal

The Effect of In Utero Exposure to Electromagnetic Radiation from Laptop  
Computers

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Infant Development

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# **The Effect of In Utero Exposure to Electromagnetic Radiation from Laptop Computers**

## **Specific Aims**

With the increase of popularity and common use of devices such as laptop computers and cell phones, the safety of radiation emitted by these devices has become an issue of increasing concern. It is surprising therefore that there is not enough research to make us aware of all its harmful effects. Health issues are increasing in subsequent generations and if some of these are linked to radiation exposure, we should know so that we can avoid them.

It is known that Electro Magnetic Field (EMF) from wireless devices does have adverse effects on the human body. This has been determined largely from research on cellular phones that shows that exposure to this radiation causes adverse effects in rats.<sup>6, 10, 11</sup> Laptops emit the same type of Electromagnetic Field, especially due to their wireless capabilities or Wi-Fi. Radiation emitted from laptops is known to penetrate the human body and may cause the same type of harm.<sup>5</sup>

If there are harmful effects due to penetration of the human body by EMF from laptops, the developing fetus would be more vulnerable to harm than a developed adult<sup>8</sup>. The current study aims to find out whether prolonged use of laptops by pregnant women would expose the fetus to amounts of radiation significant enough to affect its health in utero and in later life. If so, this study aims to find out what these health concerns could be by conducting a longitudinal study that measures the level of exposure in utero and then follows the child's health records to 21 years of age. The aim is to link this study with the National Children's Study in order to have a detailed survey of large sample over such a long period of time.

## **Background and Significance**

### **What is EMF?**

Radiation is emitted from wireless devices in the form of Electro Magnetic Field (or EMF). EMF refers to waves transporting electromagnetic energy<sup>1</sup>. Different types of waves exist in the Electromagnetic Spectrum<sup>2</sup>. This study is concerned with micro waves (1GHz to 1THz in frequency<sup>3</sup>) and radio waves (3Hz to 1GHz in frequency<sup>4</sup>), two of lowest frequency wave forms in the spectrum. These are the types of waves usually emitted from most wireless devices. It is the lower frequencies of these that are harmful to the human body.

Laptop computers emit many different types of radiation from different parts. The two potentially harmful forms of these are the electromagnetic field caused by the computer screen and the radiation given off by the Wi-Fi capability of the computer. As far as the radiation from the screen is concerned, depending on the distance or proximity of the user to the screen, it can cause significant exposure to EMF.<sup>5</sup> However, the radiation emitted by laptop and LCD screens is much lower than that produced by Cathode Ray Tube (CRT) desktop monitor screens. Therefore, this study focuses mainly on the radiation emitted by the wireless connection or Wi-Fi.

### **Why is it harmful?**

Wi-Fi signals from laptop computers are very similar to radiation emitted by cellular phones. Both consist of electromagnetic waves within the micro wave and radio wave range, however at different frequencies. Cell phones operate in the 850 MHz to 1900 MHz range which is known to be harmful to health as showed by many studies discussed later. However, Wi-Fi usually transmits its signal at frequencies in the range of 2.4GHz to 5 GHz which is considerably higher than the frequencies used for cell phones and allows more data to be carried. It is

important to note that it is *not* this higher frequency of Wi-Fi that damages our health. The wireless signal, oscillating at 2.4 to 5 GHz, moves much too fast for the body to recognize. So this wave isn't doing the damage.<sup>5</sup>

However, anytime any data or information is transmitted through the wireless signal, the data is packaged and “piggy-backed” onto the first wave. This creates a second carrier wave and this wave is called the information-carrying radio wave, or ICRW. It is the ICRW that is producing the harm. It oscillates in a much lower frequency (Hz) range that is easily recognized by the body. When the ICRW comes in contact with the human body, cells in the body recognize this wave and respond to it as if this carrier wave was some type of foreign invader.<sup>5</sup>

Different cells in the body respond to radiation differently. Research suggests that cell response to mobile phone radiation may be genome or proteome dependent.<sup>6</sup> Often when cells in the body detect this radiation, their cell membranes respond by becoming hard and inflexible. This occurs because the active transport channels shut down as the cell tries to protect itself. This hardening effect of the cell membrane also causes the cell to lose its permeability, meaning needed nutrients cannot get inside the cell. As a result, the cell does not receive enough nourishment.<sup>5</sup>

Since the cell membrane is hardened and less permeable, toxins and free radicals build up inside the cell that are waste products of the natural part of our daily metabolism. These toxic products cannot escape the cell and therefore, damage the mitochondria in the cell. The mitochondria are where energy for the body is produced. When this energy-producing process is damaged the cell begins to lose its ability to function.<sup>5</sup> This leads to apoptosis (i.e. programmed cell death or the self-destruction of cells<sup>7</sup>).

In addition, cells lose their ability to communicate with one another. Loss of communication between cells leads to the inability of the body to adequately respond to stress, injury, or invasion. This radiation can also damage DNA inside the cell. Fragments of DNA may break off and form micronuclei. Micronuclei are precursors to cancer formation.<sup>5</sup>

Therefore, exposure to EMF radiation can lead to significant physiologic changes and a multitude of symptoms due to damaging effects. Studies show that when a pregnant woman is exposed to radiation, this radiation (especially the more penetrating lower frequencies) is also absorbed by the fetus<sup>8</sup>. This can expose the fetus to the same type of harmful effects that occur in adults.

The above are the mechanisms by which most of these harmful effects occur. Research exists on many specific effects of exposure, including in utero exposure. However, there is limited awareness as to all the possible effects. Since different cells respond differently, there could be many unexplored effects. The importance of this research lies in confirming existing health effects and discovering potential new ones.

### **Factors affecting the harmfulness of radiation**

Knowledge of the different types of effects on cells does not imply that any exposure to radiation would lead to a cascade of the above mentioned damaging effects. However, the type and amount of damage caused depends on various factors.

One important factor as mentioned earlier is the frequency of the radiation in question. The lower the frequency, the more recognizable it is by the body and therefore, the more harmful it is<sup>5</sup>. Extremely low frequency (ELF) electromagnetic field is known to be very damaging and

falls in the radio waves category<sup>5</sup>. ICRWs may fall in this category. Studies show that though the fetus absorbs less than the mother, even for the fetus lower frequencies are absorbed more<sup>8</sup>.

Another important factor is the proximity or distance from the source of radiation. The nearer a person is to the electromagnetic field, the more waves pass through the body and thus more cells are damaged.<sup>5</sup> Therefore, if a pregnant woman works with her laptop in her lap or on her belly most of the time that would result in a significant amount of exposure to EMF.

Duration of exposure to the radiation also has a major influence on harmfulness. It is very high levels of exposure that cause most documented health effects. But this does not mean that lower exposures are harmless. They could be causing milder problems that we are unaware of. Thus far, a “safe” level of exposure has not been determined and we hope that this research may be able to lead to this discovery.

The body part or type of cells exposed to radiation would affect the type of harm incurred<sup>6</sup>. In the case of the fetus, the stage of development may even be an important factor that determines the type and severity of health defects that result. For example, if high exposure occurs during the critical period for a certain health problem, it may lead to a greater likelihood of developing that problem.

Younger children and especially fetuses, since they are still developing, would be more vulnerable to harm for a variety of reasons. They have softer skulls which would lead to more penetration of radiation. They also have a greater percentage of water in their head because their brains are not fully developed and this would cause more conduction of the electromagnetic signal. Furthermore, since they are not fully developed, their body would be less likely to defend itself from a harmful stimulus like radiation.<sup>5</sup>

## **Known effects of EMF**

Certain consequences of exposure to EMF and radio and micro waves have been documented by many studies. Many of these are studies on animals because certain effects are difficult or not possible to test in humans. Some of the documented effects include adverse effects on fertility, blood-brain barrier permeability, development of tumors and the release of histamine.

Electromagnetic radiation is a powerful carcinogen, although several years can elapse between exposure and the appearance of a tumor. The contribution of radiation to the total number of human cancers is probably small compared with the impact of chemicals, but the long latency of radiation-induced tumors and the cumulative effect of repeated small doses make precise calculation of its significance difficult.<sup>9</sup> This study may help to identify the role of in utero exposure in the likelihood of developing cancers or tumors in later life. The mechanism by which radiation causes a tumor in an adult may lead to some other disorder in the case of a developing fetus. This study can also help identify these other disorders.

Different studies show that radiation negatively impacts fertility in both males and females<sup>10, 11</sup>. In utero exposure to cell phone radiation in rats reduces number of ovarian follicles in female offspring. This study is one of the few that examines in utero exposure and alludes to the possibility that the same may occur in humans.

In addition, there is evidence of miscarriages in female physical therapists exposed to this radiation.<sup>13</sup> Even though the physical therapists are exposed to greater amounts than from laptops, this finding gives us a valid reason to look for harm caused by lower amounts.

Microwave radiation is also proven to increase permeability of the blood-brain barrier (BBB) in rats.<sup>14</sup> This could cause serious adverse outcomes in humans due to harmful toxins

being able to enter the brain. Increased exposure of the fetus to teratogens due to this could lead to an increase in health issues in later life.

Another effect of EMF is that these frequencies can trigger the release of chemicals from mast cells. Mast cells in the skin can release chemicals that cause symptoms of allergic reactions. Mast cells also release Histamine which is responsible for other symptoms of allergies such as runny nose, watery eyes, inflammation and difficulty breathing. Histamine also constricts the airway leading to worsening of the symptoms of asthma. Owing to the increase in the incidence of asthma in recent years, it is important to investigate the role of EMF radiation in relation to it.<sup>5</sup>

Furthermore, there is research that links electromagnetic radiation to psychological problems like mood disorders<sup>5</sup> and autism<sup>12</sup>. One study suggests that this radiation may accelerate autistic spectrum disorders<sup>12</sup>. With all these known adverse effects of electromagnetic radiation, it seems very important to investigate further. It is important to confirm animal research in humans so that future generations can be protected from the adverse effects of radiation exposure.

### **Research Design and Methods**

In order to investigate the effect of in utero exposure to radiation, a longitudinal study model is proposed. A large sample of pregnant women will be surveyed through pregnancy and their level of exposure to laptop radiation measured and quantified. The offspring will then be followed till adulthood so that a correlation can be established between the level of in utero exposure and occurrence of health problems. The study aims to look at the relationship between exposure and the number of health problems an individual develops, as well as, the relationship

between specific health problems and exposure. The longitudinal nature of the study would allow researchers to connect in utero exposure to long-term effects and effects that emerge later in life.

This study will be linked with the National Children's Study (NCS) being conducted by the National Institute of Child Health and Human Development. The NCS is a 21-year prospective study of a 100,000 American Children that will seek information on environmental risks and individual susceptibility factors that cause disease and health problems in children such as asthma, birth defects, adverse birth outcomes obesity and a number of psychological disorders. The study will follow children from conception to 21 years of age, in which banks biological and environmental samples will be established to be analyzed later. Even genetic material will be collected from each mother and child to look at gene-environment interactions.<sup>12</sup>

The NCS includes adjunct studies with exterior funding<sup>12</sup>. The current study would operate as an adjunct study and produce its own results that the NCS could use as well as be able to use the other results produced by the NCS. The NCS is an ideal set up for the current study to be conducted in because it will analyze a large and representative sample of American children for such a wide range of disorders. It would be beneficial for the NCS to include radiation exposure as a potential environmental factor influencing health because pregnant women and children today are increasingly surrounded by wireless devices. Radiation in addition to chemicals and genetic factors may be the cause for many diseases we do not know the causes to. Also, the other factors analyzed by the NCS would serve as controls for the current study in analyzing the effect of radiation. Most importantly, working with the NCS would substantially decrease the cost of conducting this study independently and resources available for this study can be focused towards ensuring accuracy of results, for example by using equipment to accurately measure the amount of exposure to radiation.

The sample for this study will be part of the sample for the NCS. This study will recruit 50,000 of the children from the NCS. The NCS will be conducted in a total of 105 sites across the United States. 79 of these are metropolitan areas (urban suburban and small cities) and 26 rural locations.<sup>12</sup> For analysis this sample of 50,000 will be divided into five sub-groups ranked on their level of exposure. To have relatively equal representation in each sample sub-group, the current study will try to select an equal number of sites from each level of urbanization. So, for example, rural sites would constitute about one-fifth of the sample as they are likely to have little or no exposure to radiation. This lowest exposure group would serve as a control group for the current study. Also, it would be aimed to choose enough larger metropolitan cities in order to have an adequate representation of extremely high exposure participants in the study.

The NCS recruits women of child-bearing age who are planning pregnancy, not planning pregnancy or are in the first trimester of pregnancy<sup>12</sup>. The current study will examine their medical history as well as their history of exposure to laptop radiation when they are recruited. After they are pregnant, they will be given a detailed questionnaire at the end of every trimester that will estimate their exposure during that trimester. The questionnaire would include questions regarding whether they use a laptop, the duration of use in the last trimester, proximity to the body, where it is placed (lap or on belly or near it) and for how long it is kept there.

As controls for exposure, questionnaires should include questions about proximity to other radiation sources such as where the woman works (to determine whether there are significant radiation sources there), whether she keeps her cell-phone near or on her belly most of the time, whether she is receiving any radiotherapy and how many times she got an ultrasound scan. Also, to control for any radiation exposure from the laptop screen, part of the sample can be given (or encouraged to use) screen covers that shield from radiation.

Since questionnaires can compromise on accuracy depending on people's self-report, an electronic device can be used to measure radiation exposure during pregnancy. But due to the cost of these devices they cannot be used with the entire sample, so they will only be used to confirm accuracy of the questionnaires. This can be done by using them to measure exposure in 5,000 women in addition to the questionnaire.

This radiation measuring device is a novel technology that can be plugged into the USB port of a computer and has sensor plate attached to it that would be fixed to the base of the laptop. This sensor would be able to sense when the laptop is placed on a person's lap or other part of their body. It would be equipped with an RF (Radio Frequency) meter that would measure the amount of low frequency (harmful) radiation emitted by the laptop when in contact with the body. It would record the duration of exposure on a computer program on the laptop. This information would be collected by researchers every trimester and can be compared to the duration of exposure estimated from the questionnaires.

Since the exposure of the fetus cannot directly be measured, the current study will measure the exposure of the mother during pregnancy. It is assumed that the amount of exposure of the fetus will be directly proportional to the amount of exposure of the mother. One way to measure fetal harm could be to examine the placenta after birth to look for signs that may indicate an increase or decrease in permeability. We could use this to determine a relationship between level of radiation exposure and the amount of harmful substances allowed to pass through the placenta.

After 21 years, the results will be evaluated in terms of the number of health problems developed by an individual and the occurrence of specific health conditions, both compared to the level of radiation exposure in utero. This study will look at all possible health issues

documented by the NCS including the number of miscarriages, psychological and intelligence testing such as IQ tests at appropriate ages and diseases caused by genetic mutations where the reason for the mutation is unexplained. At this point any confounding results due to exposure to other environmental or genetic factors taken into account by the NCS can be controlled for. This study will try to isolate health problems that correlate with high levels of radiation exposure in the absence of other possible causes.

In addition to the diseases and health problems examined by the NCS, the current study will examine health records for any signs of reproductive problems (as far as can be done within 21 years), such as the age of onset of puberty.

The NCS also takes into account privacy and consent. Privacy of individual health records and information will be maintained by the current study as well. The NCS gains the children's consent when they are old enough to understand it.

### **Predicted Results and Future Research**

It is predicted that increased exposure to laptop radiation in utero will result in a higher number of health issues throughout life. The group with the highest exposure to laptop radiation in utero is predicted to have the most health problems. It is also predicted that specific health concerns will be significant in high exposure level groups. We predict that these may include a higher incidence of miscarriage, asthma, psychological conditions such as autism, incidence of tumors or cancer and adverse effect on the reproductive system. There are other possible outcomes of very high exposure as well. Those with extremely high exposure may have a lower

IQ compared to others, there may be a higher prevalence of genetic disorders and a higher likelihood of mood disorders.

Which trimester the exposure occurred in could influence which disease is seen in later life. It is predicted that there will be a trend that would lead to evidence of a certain disorder due to exposure during a certain trimester. Further research could investigate whether the timing of exposure falls into a certain critical period for a disorder and determine whether exposure to radiation during the critical period for a disorder causes a higher likelihood for developing that disorder.

It is predicted that this research may be able to estimate a “safe” level of electromagnetic radiation from laptops. Within the five groups we will be able to see what level of exposure begins to cause significant health problems that do not seem to have other causes. A threshold level for this radiation can thus be determined.

Since decrease in fertility seems to be an important finding of animal studies that test for the effects of radiation exposure, an important future study could be to follow these individuals further in their lives to see if there is any effect on fertility or ability to reproduce. Even a subset of the current sample can be followed, such as the very high exposure and very low exposure ones and their reproductive abilities compared.

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