

## Cell Phones and Cancer Risk

### Why has there been concern that cell phones may cause cancer?

There are two main reasons why people are concerned that cell (or mobile) phones might have the potential to cause certain types of cancer or other health problems: Cell phones emit radiation (in the form of radiofrequency radiation, or radio waves), and cell phone use is widespread. Even a small increase in cancer risk from cell phones would be of concern given how many people use them.

Brain and central nervous system cancers have been of particular concern because hand-held phones are used close to the head and because ionizing radiation—a higher energy form of radiation than what cell phones emit—has been found to cause some brain cancers. Many different kinds of studies have been carried out to try to investigate whether cell phone use is dangerous to human health.

However, the evidence to date suggests that cell phone use does not cause brain or other kinds of cancer in humans.

### Is the radiation from cell phones harmful?

Cell phones emit radiation in the radiofrequency region of the electromagnetic spectrum. Second-, third-, and fourth-generation cell phones (2G, 3G, 4G) emit radiofrequency in the frequency range of 0.7–2.7 GHz. Fifth-generation (5G) cell phones are anticipated to use the frequency spectrum up to 80 GHz.

These frequencies all fall in the nonionizing range of the spectrum, which is low frequency and low energy. The energy is too low to damage DNA. By contrast, ionizing radiation, which includes x-rays, radon, and cosmic rays, is high frequency and high energy. Energy from ionizing radiation can damage DNA. DNA damage can cause changes to genes that may increase the risk of cancer.

The NCI fact sheet [Electromagnetic Fields and Cancer](#) lists sources of radiofrequency radiation. More information about ionizing radiation can be found on the [Radiation](#) page.

The human body does absorb energy from devices that emit radiofrequency radiation. The only consistently recognized biological effect of radiofrequency radiation absorption in humans that the general public might encounter is heating to the area of the body where a cell phone is held (e.g., the ear and head). However, that heating is not sufficient to measurably increase core body temperature. There are no other clearly established dangerous health effects on the human body from radiofrequency radiation.

## **Has the incidence of brain and central nervous system cancers changed during the time cell phone use increased?**

No. Investigators have studied whether the incidence of brain or other central nervous system cancers (that is, the number of new cases of these cancers diagnosed each year) has changed during the time that cell phone use increased dramatically. These studies found:

- stable incidence rates for adult gliomas in the United States (1), Nordic countries (2) and Australia (3) during the past several decades
- stable incidence rates for pediatric brain tumors in the United States during 1993–2013 (4)
- stable incidence rates for acoustic neuroma (5), which are nonmalignant tumors, and meningioma (6), which are usually nonmalignant, among US adults since 2009

In addition, studies using cancer incidence data have tested different scenarios (simulations) determining whether the incidence trends are in line with various levels of risk as reported in studies of cell phone use and brain tumors between 1979 and 2008 (7, 8). These simulations showed that many risk changes reported in case-control studies were not consistent with incidence data, implying that biases and errors in the study may have distorted the findings.

Because these studies examine cancer incidence trends over time in populations rather than comparing risk in people who do and don't use cell phones, their ability to observe potential small differences in risk among heavy users or susceptible populations is limited. Observational/epidemiologic studies—including case-control and cohort studies (described below)—are designed to measure individual exposure to cell phone radiation and ascertain specific health outcomes.

## **How is radiofrequency radiation exposure measured in studies of groups of people?**

Epidemiologic studies use information from several sources, including questionnaires and data from cell phone service providers, to estimate radiofrequency radiation exposure in groups of people. Direct measurements are not yet possible outside of a laboratory setting. Estimates from studies reported to date take into account the following:

- How regularly study participants use cell phones (the number of calls per week or month)
- The age and the year when study participants first used a cell phone and the age and the year of last use (allows calculation of the duration of use and time since the start of use)
- The average number of cell phone calls per day, week, or month (frequency)
- The average length of a typical cell phone call
- The total hours of lifetime use, calculated from the length of typical call times, the frequency of use, and the duration of use

## **What has research shown about the link between cell phone use and cancer risk?**

Researchers have carried out several types of population studies to investigate the possibility of a relationship between cell phone use and the risk of tumors, both malignant (cancerous) and nonmalignant (not cancer). Epidemiologic studies (also called observational studies) are research studies in which investigators observe groups of individuals (populations) and collect information about them but do not try to change anything about the groups.

Two main types of epidemiologic studies—cohort studies and case-control studies—have been used to examine associations between cell phone use and cancer risk. In a case-control study, cell phone use is compared between people who have tumors and people who don't. In a cohort study, a large group of people who do not have cancer at the beginning of the study is followed over time and tumor development in people who did and didn't use cell phones is compared. Cohort studies are limited by the fact that they may only be able to look at cell phone subscribers, who are not necessarily the cell phone users.

The tumors that have been investigated in epidemiologic studies include malignant brain tumors, such as gliomas, as well as nonmalignant tumors, such as acoustic neuroma (tumors in the cells of the nerve responsible for hearing that are also known as vestibular schwannomas), meningiomas (usually nonmalignant tumors in the membranes that cover and protect the brain and spinal cord), parotid gland tumors (tumors in the salivary glands), skin cancer, and thyroid gland tumors.

Four large epidemiologic studies have examined the possible association between cell phone use and cancer: Interphone, a case-control study, and three cohort studies, the Danish Study, the Million Women Study, and the Cohort Study on Mobile Phones and Health (COSMOS). The findings of these studies are mixed, but overall, they do not show an association between cell phone use and cancer (9–23).

## Interphone Case-Control Study

**How the study was done:** This is the largest case-control study of cell phone use and the risk of head and neck tumors. It was conducted by a consortium of researchers from 13 countries. The data came from questionnaires that were completed by study participants in Europe, Israel, Canada, Australia, New Zealand, and Japan.

**What the study showed:** Most published analyses from this study have shown no increases overall in brain or other central nervous system cancers (glioma and meningioma) related to higher amounts of cell phone use. One analysis showed a statistically significant, although small, increase in the risk of glioma among study participants who spent the most total time on cell phone calls. However, for a variety of reasons the researchers considered this finding inconclusive (11–13).

An analysis of data from all 13 countries reported a statistically significant association between intracranial distribution of tumors within the brain and self-reported location of the phone (14). However, the authors of this study noted that it is not possible to draw firm conclusions about cause and effect based on their findings.

An analysis of data from five Northern European countries showed an increased risk of acoustic neuroma in those who had used a cell phone for 10 or more years (15).

In subsequent analyses of Interphone data, investigators investigated whether tumors were more likely to form in areas of the brain with the highest exposure. One analysis showed no relationship between tumor location and level of radiation (16). However, another found evidence that glioma and, to a lesser extent, meningioma were more likely to develop where exposure was highest (17).

## Danish Cohort Study

**How the study was done:** This cohort study linked billing information from more than 358,000 cell phone subscribers with brain tumor incidence data from the Danish Cancer Registry.

**What the study showed:** No association was observed between cell phone use and the incidence of glioma, meningioma, or acoustic neuroma, even among people who had been cell phone subscribers for 13 or more years (18–20).

## Million Women Cohort Study

**How the study was done:** This prospective cohort study conducted in the United Kingdom used data obtained from questionnaires that were completed by study participants.

**What the study showed:** Self-reported cell phone use was not associated with an increased risk of glioma, meningioma, or non-central nervous system tumors. Although the original published findings reported an association with an increased risk of acoustic neuroma (21), it was not observed with additional years of follow-up of the cohort (22).

## Cohort Study of Mobile Phones and Health (COSMOS)

**How the study was done:** This large prospective cohort study conducted in Denmark, Finland, Sweden, the Netherlands, and the United Kingdom used data on health, lifestyle, and current and past cell phone use obtained from a questionnaire completed by participants when they joined the study. That information was supplemented with cancer occurrence data obtained from linkage to national cancer registries and cell phone records obtained from mobile network operators.

**What the study showed:** Among 264,574 participants with a median follow-up of just over 7 years, the cumulative amount of mobile phone call-time was not associated with the risk of developing glioma, meningioma, or acoustic neuroma (23). No associations with cancer risk were seen in the heaviest mobile phone users or among those with the longest history of mobile phone use (15 or more years).

## Other Epidemiologic Studies

In addition to these four large studies, other, smaller epidemiologic studies have looked for associations between cell phone use and individual cancers in both adults and children. These include:

- Two NCI-sponsored case-control studies, each conducted in multiple US academic medical centers or hospitals between 1994 and 1998 that used data from questionnaires (24) or computer-assisted personal interviews (25). Neither study showed a relationship between cell phone use and the risk of glioma, meningioma, or acoustic neuroma in adults.
- The CERENAT study, another case-control study conducted in multiple areas in France from 2004 to 2006 using data collected in face-to-face interviews using standardized questionnaires (26). This study found no association for either gliomas or meningiomas when comparing adults who were regular cell phone users with non-users. However, the heaviest users had significantly increased risks of both gliomas and meningiomas.
- A pooled analysis of two case-control studies conducted in Sweden that reported statistically significant trends of increasing brain cancer risk for the total amount of cell

phone use and the years of use among people who began using cell phones before age 20 (27).

- Another case-control study in Sweden, part of the Interphone pooled studies, did not find an increased risk of brain cancer among long-term cell phone users between the ages of 20 and 69 (28).
- The CEFALO study, an international case-control study of children diagnosed with brain cancer between ages 7 and 19, found no relationship between their cell phone use and risk for brain cancer (29).
- The MOBI-Kids study, a large international case-control study of young people ages 10 to 24 years diagnosed with brain tumors, found no evidence of an association between wireless phone use and the risk of brain tumors (30).
- A population-based case-control study conducted in Connecticut found no association between cell phone use and the risk of thyroid cancer (31).

## **What are the findings from studies of the human body?**

Researchers have carried out several kinds of studies to investigate possible effects of cell phone use on the human body. In 2011, two small studies were published that examined brain glucose metabolism in people after they had used cell phones. The results were inconsistent. One study showed increased glucose metabolism in the region of the brain close to the antenna compared with tissues on the opposite side of the brain (32); the other study (33) found reduced glucose metabolism on the side of the brain where the phone was used.

The authors of these studies noted that the results were preliminary and that possible health outcomes from changes in glucose metabolism in humans were unknown. Such inconsistent findings are not uncommon in experimental studies of the physiological effects of radiofrequency electromagnetic radiation in people (11). Some factors that can contribute to inconsistencies across such studies include assumptions used to estimate doses, failure to consider temperature effects, and investigators not being blinded to exposure status.

Another study investigated blood flow in the brain of people exposed to radiofrequency radiation from cell phones and found no evidence of an effect on blood flow in the brain (34).

## **What are the findings from experiments in laboratory animals?**

Early studies involving laboratory animals showed no evidence that radiofrequency radiation increased cancer risk or enhanced the cancer-causing effects of known chemical carcinogens (35–38).

Because of inconsistent findings from epidemiologic studies in humans and the lack of clear data from previous experimental studies in animals, in 1999 the Food and Drug Administration (FDA) nominated radiofrequency radiation exposure associated with cell phone exposures for study in animal models by the US National Toxicology Program (NTP). NTP is an interagency program that coordinates toxicology research and testing across the US Department of Health and Human Services and is headquartered at the National Institute of Environmental Health Sciences, part of NIH.

The NTP studied radiofrequency radiation (2G and 3G frequencies) in rats and mice (39, 40). This large project was conducted in highly specialized labs. The rodents experienced whole-body exposures of 3, 6, or 9 watts per kilogram of body weight for 5 or 7 days per week for 18 hours per day in cycles of 10 minutes on, 10 minutes off. A [research overview of the rodent studies](#), with links to the peer-review summary, is available on the NTP website. The primary outcomes observed were a small number of cancers of Schwann cells in the heart and non-cancerous changes (hyperplasia) in the same tissues for male rats, but not female rats, nor in mice overall.

These experimental findings raise new questions because cancers in the heart are extremely rare in humans. Schwann cells of the heart in rodents are similar to the kind of cells in humans that give rise to acoustic neuromas (also known as vestibular schwannomas), which some studies have suggested are increased in people who reported the heaviest use of cell phones. The NTP plans to continue to study radiofrequency exposure in animal models to provide insights into the biological changes that might explain the outcomes observed in their study.

Another animal study, in which rats were exposed 7 days per week for 19 hours per day to radiofrequency radiation at 0.001, 0.03, and 0.1 watts per kilogram of body weight was reported by investigators at the Italian Ramazzini Institute (41). Among the rats with the highest exposure levels, the researchers noted an increase in heart schwannomas in male rats and nonmalignant Schwann cell growth in the heart in male and female rats. However, key details necessary for interpretation of the results were missing: exposure methods, other standard operating procedures, and nutritional/feeding aspects. The gaps in the report from the study raise questions that have not been resolved.

ICNIRP (an independent nonprofit organization that provides scientific advice and guidance on the health and environmental effects of nonionizing radiation) critically evaluated both studies. It concluded that both followed good laboratory practice, including using more animals than earlier research and exposing the animals to radiofrequency radiation throughout their

lifetimes. However, it also identified what it considered major weaknesses in how the studies were conducted and statistically analyzed and concluded that these limitations prevent drawing conclusions about the ability of radiofrequency exposures to cause cancer (42).

## Why are the findings from different studies of cell phone use and cancer risk inconsistent?

A few studies have shown some evidence of statistical association of cell phone use and brain tumor risks in humans, but most studies have found no association. Reasons for these discrepancies include the following:

- **Recall bias**, which can occur when data about prior habits and exposures are collected from study participants using questionnaires administered after diagnosis of a disease in some of the participants. Study participants who have brain tumors, for example, may remember their cell phone use differently from individuals without brain tumors.
- **Inaccurate reporting**, which can happen when people say that something has happened more often or less often than it actually did. For example, people may not remember how much they used cell phones in a given time period.
- **Morbidity and mortality** among study participants who have brain cancer. Gliomas are particularly difficult to study because of their high death rate and the short survival of people who develop these tumors. Patients who survive initial treatment are often impaired, which may affect their responses to questions.
- **Participation bias**, which can happen when people who are diagnosed with brain tumors are more likely than healthy people (known as controls) to enroll in a research study.
- **Changing technology**. Older studies evaluated radiofrequency radiation exposure from analog cell phones. Today, cell phones use digital technology, which operates at a different frequency and a lower power level than analog phones, and cellular technology continues to change (43).
- **Exposure assessment limitations**. Different studies measure exposure differently, which makes it difficult to compare the results of different studies (44). Investigations of sources and levels of exposure, particularly in children, are ongoing (45).
- **Insufficient follow-up of highly exposed populations**. It may take a very long time to develop symptoms after exposure to radiofrequency radiation, and current studies may not yet have followed participants long enough.
- **Inadequate statistical power and methods** to detect very small risks or risks that affect small subgroups of people specifically
- **Chance** as an explanation of apparent effects may not have been considered.

## What are other possible health effects from cell phone use?

The most consistent health risk associated with cell phone use is distracted driving and vehicle accidents (46, 47). Several other potential health effects have been reported with cell phone use. Neurologic effects are of particular concern in young persons. However, studies of memory, learning, and cognitive function have generally produced inconsistent results (48–51).

## What have expert organizations said about the cancer risk from cell phone use?

In 2011, the [International Agency for Research on Cancer \(IARC\)](#), a component of the World Health Organization, appointed an expert working group to review all available evidence on the use of cell phones. The working group classified cell phone use as “possibly carcinogenic to humans,” based on limited evidence from human studies, limited evidence from studies of radiofrequency radiation and cancer in rodents, and inconsistent evidence from mechanistic studies (11).

The working group indicated that, although the human studies were susceptible to bias, the findings could not be dismissed as reflecting bias alone, and that a causal interpretation could not be excluded. The working group noted that any interpretation of the evidence should also consider that the observed associations could reflect chance, bias, or confounding variables rather than an underlying causal effect. In addition, the working group stated that the investigation of brain cancer risk associated with cell phone use poses complex research challenges.

The [American Cancer Society’s cell phones page](#) states “It is not clear at this time that RF (radiofrequency) waves from cell phones cause dangerous health effects in people, but studies now being done should give a clearer picture of the possible health effects in the future.”

The [National Institute of Environmental Health Sciences \(NIEHS\)](#) states that the weight of the current scientific evidence has not conclusively linked cell phone use with any adverse health problems, but more research is needed.

The [US Food and Drug Administration \(FDA\)](#) notes that studies reporting biological changes associated with radiofrequency radiation have failed to be replicated and that the majority of human epidemiologic studies have failed to show a relationship between exposure to radiofrequency radiation from cell phones and health problems. FDA, which originally nominated this exposure for review by the NTP in 1999, [issued a statement on the draft NTP reports](#) released in February 2018, saying “based on this current information, we believe the

current safety limits for cell phones are acceptable for protecting the public health." FDA and the Federal Communications Commission (FCC) share responsibility for regulating cell phone technologies.

The [US Centers for Disease Control and Prevention \(CDC\)](#) states that no scientific evidence definitively answers whether cell phone use causes cancer.

The [Federal Communications Commission \(FCC\)](#) concludes that currently no scientific evidence establishes a definite link between wireless device use and cancer or other illnesses.

In 2015, the European Commission Scientific Committee on Emerging and Newly Identified Health Risks concluded that, overall, the epidemiologic studies on cell phone radiofrequency electromagnetic radiation exposure do not show an increased risk of brain tumors or of other cancers of the head and neck region (9). The committee also stated that epidemiologic studies do not indicate increased risk for other malignant diseases, including childhood cancer (9).

## **Has radiofrequency radiation from cell phone use been associated with cancer risk in children?**

There are theoretical considerations as to why the potential health effects of cell phone use should be investigated separately in children. Their nervous systems are still developing and, therefore, more vulnerable to factors that may cause cancer. Their heads are smaller than those of adults and consequently have a greater proportional exposure to radiation emitted by cell phones. And, children have the potential of accumulating more years of cell phone exposure than adults.

Thus far, the data from studies of children with cancer do not suggest that children are at increased risk of developing cancer from cell phone use. The first published analysis came from a large case-control study called CEFALO, which was conducted in Europe. The study included 352 children who were diagnosed with brain tumors between 2004 and 2008 at the ages of 7 to 19 years. They were matched by age, sex, and geographical region with 646 young people randomly selected from population registries. Researchers did not find an association between cell phone use and brain tumor risk by amount of use or by the location of the tumor (29).

The largest case-control study among children, a 14-country study known as MOBI-Kids, included 899 young people ages 10 to 24 years who were diagnosed with brain tumors between 2010 and 2015. They were matched by sex, age, and region with 1,910 young people who were undergoing surgery for appendicitis. Researchers found no evidence of an association between wireless phone use and brain tumors in young people (30).

# Which US federal agencies have a role in evaluating the effects of or regulating cell phones?

The National Institutes of Health (NIH), including the National Cancer Institute (NCI), conducts research on cell phone use and the risks of cancer and other diseases.

FDA and FCC share regulatory responsibilities for cell phones. FDA is responsible for testing and evaluating electronic product radiation and providing information for the public about the radiofrequency energy emitted by cell phones. FCC sets limits on the emissions of radiofrequency energy by cell phones and similar wireless products.

## Where can I find more information about radiofrequency radiation from my cell phone?

The dose of the energy that people absorb from any source of radiation is estimated using a measure called the specific absorption rate (SAR), which is expressed in watts per kilogram of body weight (52). The SAR decreases very quickly as the distance to the exposure source increases. For cell phone users who hold their phones next to their head during voice calls, the highest exposure is to the brain, acoustic nerve, salivary gland, and thyroid.

The FCC provides information about the SAR of cell phones produced and marketed within the previous 1 to 2 years. Consumers can access this information using the phone's FCC ID number, which is usually located on the case of the phone, and the FCC's [ID search form](#). SARs for older phones can be found by checking the phone settings or by contacting the manufacturer.

## What can cell phone users do to reduce their exposure to radiofrequency radiation?

FDA has suggested some steps that concerned cell phone users can take to reduce their exposure to radiofrequency radiation:

- Reduce the amount of time spent using your cell phone.
- Use speaker mode, head phones, or ear buds to place more distance between your head and the cell phone.
- Avoid making calls when the signal is weak as this causes cell phones to boost RF transmission power.

- Consider texting rather than talking, but don't text while you are driving.

Use of wired or wireless headsets reduces the amount of radiofrequency radiation exposure to the head because the phone is not placed against the head (53). Exposures decline dramatically when cell phones are used hands-free. For example, wireless (Bluetooth) devices (such as headphones and earbuds) use short-range signals that typically transmit radiofrequency waves at power levels 10–400 times lower than cell phones (54).

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## Related Resources

[Electromagnetic Fields and Cancer](#)

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**Reviewed:** April 4, 2024

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## A Close Look at Cell Phone Towers

Concerns about cell phones and electro-magnetic fields (EMF) are shared by many people, but a closer look can provide some reassurance. There is no good scientific evidence that cell phones or cell phone towers have harmed people. If the potential for harm was there, we have the tools to discover and confirm it.



Richard Margolese MD (/oss/articles-by-author/Richard Margolese MD) | 13 Nov 2019

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Page 8

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**T**he large increase in lung cancer following World War II, was quickly recognized as a public health problem. The surge in smoking following WWI & II, when soldiers were given free cigarettes, caused a clear mini-epidemic. The science was clear from the beginning, and science is clear about the lack of danger from EMF. Similarly, the dangers of pesticides and asbestos were discovered and dealt with. Using these same public health tools there has been no meaningful evidence that cell phone radiation is harmful.

Electromagnetic radiation occurs across a spectrum. Think of a piano keyboard with low-frequency notes, or energy rays, on the left and high-frequency, more dangerous rays, on the right. We are constantly surrounded by many different levels of radiation from this spectrum.

The low energy bands are essentially harmless to us. This includes radio broadcasts, cell phones, the Wi-Fi in your house, and even TV remote controls. These are all weaker than the radiation from an ordinary household light bulb, which is itself radiation.

As we move up the energy spectrum we come to TV and UHF broadcasts, still safe.

The next step is a band of energy which humans have evolved to detect with some sensitive cells in our retinas. This is the visual spectrum from red to violet. It is only when you reach the ultraviolet level that there is enough energy to dislodge electrons and damage cells. That is what “ionizing radiation” means. This damage can lead to cellular mutations which can cause cancer. UV light can damage skin, but it takes higher energies to penetrate deeper. These higher energies come from X-rays, gamma rays, etc.

The EMFs below this level are just too weak to have an effect and there are no credible studies linking cancer (or any other illnesses) to this type of radiation. Just because we can see the towers does not mean they are any more of a threat to us than radio or television broadcasts washing over us constantly, or GPS signals, or TV screens. Even your household electric wiring leaks EMFs into the surroundings.

The energy in radiation rays from a cellphone is 1 million times weaker than a light bulb.

We can be reassured by one simple proof. Our societies have been awash in these radiation fields for over 100 years, but there is no increase in cancer rates as a result. It was easy to see the increase in lung cancer when smoking became popular and we would be able to detect increases in other cancers if they were occurring. Furthermore, the problems with smoking, asbestos, suntan, and pesticides, all prove the point: threats to health were identified, confirmed with scientific investigations, and public health measures were adopted. Cellphone towers just do not have the energy to harm us.

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For more information on EMF sources see:

<https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>  
(<https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>).

For information on health effects, see:

<https://www.theguardian.com/science/blog/2016/feb/17/electromagnetic-radiation-doesnt-make-you-ill-or-give-you-cancer-heres-why>  
(<https://www.theguardian.com/science/blog/2016/feb/17/electromagnetic-radiation-doesnt-make-you-ill-or-give-you-cancer-heres-why>).

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*Dr. Richard Margolese is a Professor of Surgical Oncology at McGill University and finds it important to demystify science for the public.*

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# Radiation: Health risks of mobile phones and base stations

20 September 2013 | Q&A

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## What are the health risks associated with mobile phones and their base stations?

This is a question which WHO takes very seriously. Given the immense number of people who use mobile phones, even a small increase in the incidence of adverse effects on health could have major public health implications.

Because exposure to the radiofrequency (RF) fields emitted by mobile phones is generally more than a 1000 times higher than from base stations, and the greater likelihood of any adverse effect being due to handsets, research has almost exclusively been conducted on possible effects of mobile phone exposure.

Research has concentrated on the following areas:

- cancer
- other health effects
- electromagnetic interference
- traffic accidents.

**Cancer**

Based on mixed epidemiological evidence on humans regarding an association between exposure to RF radiation from wireless phones and head cancers (glioma and acoustic neuroma), RF fields have been classified by the International Agency for Research on Cancer as possibly carcinogenic to humans (Group 2B). Studies to date provide no indication that environmental exposure to RF fields, such as from base stations, increases the risk of cancer or any other disease.

#### **Other health effects**

Scientists have reported other health effects of using mobile phones including changes in brain activity, reaction times, and sleep patterns. These effects are minor and have no apparent health significance. More studies are underway to try to confirm these findings.

#### **Electromagnetic interference**

When mobile phones are used very close to some medical devices (including pacemakers, implantable defibrillators, and certain hearing aids) there is the possibility of causing interference with their operation. The risk is much reduced for 3G phones and newer equipment. There is also the potential of interference between mobile phones signals and aircraft electronics. Some countries have licensed mobile phone use on aircraft during flight using systems that control the phone output power.

#### **Traffic accidents**

Research has shown an increased risk of traffic accidents, some 3-4 times greater chance of an accident, when mobile phones (either handheld or with a "hands-free" kit) are used while driving due to distraction.

## **Conclusions**

While an increased risk of brain tumours from the use of mobile phones is not established, the increasing use of mobile phones and the lack of data for mobile phone use over time periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. In particular, with the recent popularity of

mobile phone use among younger people, and therefore a potentially longer lifetime of exposure, WHO has promoted further research on this group and is currently assessing the health impact of RF fields on all studied endpoints.

## **WHO TEAM**

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## Peer Reviewed Published Research on Cell Tower Radiation, Base Station Radiation and Health Effects

Watch a CBS investigation into California firefighters fighting to halt cell towers on their firestations below.

ConsumerWatch: 5G Cellphone Towers Signal Renewed Concern



## “Electromagnetic Fields: A Hazard to Your Health?” on Cell Tower Radiation



“In recent years, concern has increased about exposure to radio frequency electromagnetic radiation emitted from cell phones and phone station antennae. An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing:

- Headaches
- Memory problems
- Dizziness
- Depression
- Sleep problems

Short-term exposure to these fields in experimental studies have not always shown negative effects, but this does not rule out cumulative damage from these fields, so larger studies over longer periods are needed to help understand who is at risk. In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment.”

-American Academy of Pediatrics

## COMPILATION OF RESEARCH STUDIES ON CELL TOWER RADIATION AND HEALTH

European Parliament requested a research report “Health Impact of 5G” which was released in July 2021 and concluded that commonly used RFR frequencies (450 to 6000 MHz) are probably carcinogenic for humans and clearly affect male fertility with possible adverse effects on the development of embryos, fetuses and newborns.

A review entitled “Evidence for a health risk by RF on humans living around mobile phone base stations: From radiofrequency sickness to cancer reviewed the existing scientific literature and found radiofrequency sickness, cancer and changes in biochemical parameters (Balmori 2022).

Surveys of people living near cell tower antennas in France, Spain, Iraq, India, Germany, Egypt, Poland have found significantly higher reports of health problems including sleep issues, fatigue and headaches (See Santini et al. 2003, López 2021, Alazawi 2011, Pachauau and Pachauua 2016, Eger et al. 2004, Abdel-Rassoul et al. 2007, Bortkiewicz et al., 2004).



EN

Two published case reports document illness that developed after 5G antennas were installed. In “The Microwave Syndrome after Installation of 5G Emphasizes the Need for Protection from Radiofrequency Radiation” (Hardell and Nilsson 2023), a man and woman developed microwave syndrome symptoms (e.g., neurological symptoms, tinnitus, fatigue, insomnia, emotional distress, skin disorders, and blood pressure variability) after a 5G base station was installed on the roof above their apartment.

Similarly, in “Development of the Microwave Syndrome in Two Men Shortly after Installation of 5G on the Roof above their Office” two men developed symptoms after 5G antennas were activated on the roof of their workplace. The symptoms disappeared in both men within a couple of weeks (case 1) or immediately (case 2) after leaving the office.

Anthony B. Miller, L. Lloyd Morgan, Iris Udasin, Devra Lee Davis, Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102), *Environmental Research*, Volume 167, 2018, Pages 673-683, ISSN 0013-9351

- Radiofrequency radiation is emitted by cell towers. This review paper concludes that “Based on the evidence reviewed it is our opinion that IARC’s current categorization of RFR as a possible human carcinogen (Group 2B) should be upgraded to Carcinogenic to Humans (Group 1).”

Zothansiama, et al. “Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations.” *Electromagnetic Biology and Medicine* 36.3 (2017): 295-305.

- This study evaluated effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters). The study found higher radiofrequency radiation exposures and statistically significant differences in the blood of people living closer to the cellular antennas. The group living closer to the antennas had for example, statistically significant higher frequency of micronuclei and a rise in lipid peroxidation in their blood. These changes are considered biomarkers predictive of cancer.

Rodrigues NCP, Dode AC, Andrade MKdN, O'Dwyer G, Monteiro DLM, Reis INC, Rodrigues RP, Frossard VC, Lino VTS. The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil. *International Journal of Environmental Research and Public Health*. 2021; 18(3):1229. <https://doi.org/10.3390/ijerph18031229>

- For all cancers and for the specific types investigated (breast, cervix, lung, and esophagus cancers), the higher the exposure to RBS (radio base stations- cell antenna installations) radiofrequency, the higher the median of mortality rate. In capitals where radio base station radiofrequency exposure was higher than 000/antennas-year, the median of the breast cancer mortality rate was 27.33/100,000, while for all cancers, it was 111.68/100,000 (Table 1).
- “Conclusions: The balance of our results indicates that the exposure to radiofrequency electromagnetic fields from an RBS increases the rate of mortality by all cancers and specifically by breast, cervix, lung, and esophageal cancers. These conclusions are based on the fact that the findings of this study indicate that, the higher the RBS radiofrequency exposure, the higher the cancer mortality rate, especially for cervix cancer (adjust RR = 2.18). The spatial analysis showed that the highest RBS radiofrequency exposure was observed in a city located in the southern region of Brazil, which also showed the highest mortality rate for all types of cancer and specifically for lung and breast cancers.”

Meo, S. A., Almahmoud, M., Alsultan, Q., Alotaibi, N., Alnajashi, I., & Hajjar, W. M. (2018). Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health. *American Journal of Men's Health*.

- High exposure to RF-EMF produced by mobile phone base station towers was associated with delayed fine and gross motor skills, spatial working memory,

and attention in school adolescents compared to students who were exposed to low RF-EMF.



Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. Yakymenko (2011) *Exp Oncology*, 33(2):62-70.

- Even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby.

Association of Exposure to Radio-Frequency Electromagnetic Field Radiation (RF-EMFR) Generated by Mobile Phone Base Stations (MPBS) with Glycated Hemoglobin (HbA1c) and Risk of Type 2 Diabetes Mellitus, Sultan Ayoub Meo et al, *International Journal of Environmental Research and Public Health*, 2015

- Elementary school students who were exposed to high RF-EMFR generated by MPBS had a significantly higher risk of type 2 diabetes mellitus relative to their counterparts who were exposed to lower RF-EMFR.

Isabel López, Nazario Félix, Marco Rivera, Adrián Alonso, Ceferino Maestú. *What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid.* Environmental Research. Volume 194, March 2021, 110734. <https://doi.org/10.1016/j.envres.2021.110734>.

- Residents of a Madrid Spain neighborhood surrounded by nine telephone antennas took a survey. 105 measurements of electromagnetic radiation were taken both outside and inside the houses. People who were exposed to higher radiation values presented with more severe headaches, dizziness and nightmares and slept fewer hours.

Neurobehavioral effects among inhabitants around mobile phone base stations Abdel-Rassoul et al, *Neurotoxicology*, 2007

- This study found that living nearby mobile phone base stations (cell antennas) increased the risk for neuropsychiatric problems such as headaches,  EN problems, dizziness, tremors, depression, sleep problems and some changes in the performance of neurobehavioral functions.

Meo SA, Almahmoud M, Alsultan Q, Alotaibi N, Alnajashi I, Hajjar WM, Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health. *Am J Mens Health*. 2018 Dec 7:1557988318816914. doi: 10.1177/1557988318816914.

- This study investigated the impact of exposure to radiofrequency electromagnetic field (RF-EMF) radiation generated by mobile phone base station towers (MPBSTs) on cognitive functions. Two hundred and seventeen volunteer male students aged between 13 and 16 registered from two different intermediate schools: 124 students were from School 1 and 93 students were from School 2. The MPBSTs were located within 200 m from the schoolbuildings. In School 1, RF-EMF was  $2.010 \mu\text{W/cm}^2$  with a frequency of 925 MHz and in School 2, RF-EMF was  $10.021 \mu\text{W/cm}^2$  with a frequency of 925 MHz. Students were exposed to EMFR for 6 hr a day, 5 days a week for a total period of 2 years. The Narda Safety Test Solution device SRM-3006 was used to measure RF-EMF in both schools, and cognitive functions tasks were measured by the Cambridge Neuropsychological Test Automated Battery (CANTAB). Significant impairment in Motor Screening Task (MOT;  $p = .03$ ) and Spatial Working Memory (SWM) task ( $p = .04$ ) was identified among the group of students who were exposed to high RF-EMF produced by MPBSTs. High exposure to RF-EMF produced by MPBSTs was associated with delayed fine and gross motor skills, spatial working memory, and attention in school adolescents compared to students who were exposed to low RF-EMF.

Biological Effects from Exposure to Electromagnetic Radiation Emitted by Cell Tower Base Stations and Other Antenna Arrays, Levitt & Lai, *Environmental Reviews*, 2010

- This review of 100 studies found approximately 80% showed biological effects near towers. "Both anecdotal reports and some epidemiology studies have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory

changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations.”



Mortality by neoplasia and cellular telephone base stations. Dode et al. (Brazil), Science of the Total Environment, Volume 409, Issue 19, 1 September 2011, Pages 3649–3665

- This 10 year study on cell phone antennas by the Municipal Health Department in Belo Horizonte and several universities in Brazil found a clearly elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell phone transmission towers. Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the cities antennas be removed. Many antennas were dismantled.

Pearce, M., Limiting liability with positioning to minimize negative health effects of cellular phone towers, Environmental Research, Volume 181, 2020,

- “There is a large and growing body of evidence that human exposure to RFR from cellular phone base stations causes negative health effects including both i) neuropsychiatric complaints such as headache, concentration difficulties, memory changes, dizziness, tremors, depressive symptoms, fatigue and sleep disturbance, and ii) increased incidence of cancer and living in proximity to a cell- phone transmitter station.” The author recommends long-term planning “to minimize the risk of liability from unintended human harm due to cellular phone base station siting” including voluntary restrictions on the placement of cellular phone base stations within 500 m of schools and hospitals.”
- 

Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations  
Khurana, Hardell et al., International Journal of Occupational Environmental Health, Vol 16(3):263-267, 2010

- A review of 10 epidemiological studies that assessed for negative health effects of mobile phone base stations (4 studies were from Germany, each from Austria, Egypt, France, Israel, Poland, Spain) found that seven showed altered neurobehavioral effects near cell tower and three showed increased cancer incidence.



The review also found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations.

**Health effects of living near mobile phone base transceiver station (BTS) antennae: a report from Isfahan, Iran.** Shahbazi-Gahrouei et al, Electromagnetic Biology Medicine, 2013.

- This cross-sectional study found the symptoms of nausea, headache, dizziness, irritability, discomfort, nervousness, depression, sleep disturbance, memory loss and lowering of libido were statistically increased in people living closer than 300 m from cell antennas as compared to those living farther away. The study concludes that "antennas should not be sited closer than 300 m to people to minimize exposure."

**How does long term exposure to base stations and mobile phones affect human hormone profiles?** Eskander EF et al, (2011), Clin Biochem

- RFR exposures significantly impacted ACTH, cortisol, thyroid hormones, prolactin for females, and testosterone levels for males.

**Investigation on the health of people living near mobile telephone relay stations: Incidence according to distance and sex** Santini et al, 2002 , Pathol Bio

- People living near mobile phone masts reported more symptoms of headache, sleep disturbance, discomfort, irritability, depression, memory loss and

concentration problems the closer they lived to the installation. Study authors recommend that the minimal distance of people from cellular base stations should not be < 300 m. 

Navarro EA, Segura J, Portoles M, Gomez-Perretta C, The Microwave Syndrome: A preliminary Study. 2003 (Spain) Electromagnetic Biology and Medicine, Volume 22, Issue 2, (2003): 161 – 169

- Statistically significant positive exposure-response associations between RFR intensity and fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

### Two Important Animal Studies on Radiofrequency Radiation

These studies indicate that government limits are non protective. Government limits are based on the assumption that radiofrequency radiation is only harmful at thermal levels. However, the cancers developed in animals in these studies at radiation levels that were non thermal.

Falcioni et al. 2018, “Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz base station environmental emission” Environmental Research Journal

- Researchers with the renowned Ramazzini Institute (RI) in Italy performed a large-scale lifetime study of lab animals exposed to environmental levels (comparable to allowable limits from cell towers) of RFR radiation and found the rats developed increased cancers- schwannoma of the heart in male rats. This study confirms the \$25 million US National Toxicology Program study which used much higher levels of cell phone radiofrequency (RF) radiation, but also reported finding the same unusual cancers as the Ramazzini-schwannoma of the heart in male rats. In addition, the RI study of cell tower

radiation also found increases in malignant brain (glial) tumors in female rats and precancerous conditions including Schwann cells hyperplasia in b  EN and female rats.

- “Our findings of cancerous tumors in rats exposed to environmental levels of RF are consistent with and reinforce the results of the US NTP studies on cell phone radiation, as both reported increases in the same types of tumors of the brain and heart in Sprague-Dawley rats. Together, these studies provide sufficient evidence to call for the International Agency for Research on Cancer (IARC) to re-evaluate and re-classify their conclusions regarding the carcinogenic potential of RFR in humans,” said Fiorella Belpoggi PhD, study author and RI Director of Research.
- The Ramazzini study exposed 2448 Sprague-Dawley rats from prenatal life until their natural death to “environmental” cell tower radiation for 19 hours per day (1.8 GHz GSM radiofrequency radiation (RFR) of 5, 25 and 50 V/m). RI exposures mimicked base station emissions like those from cell tower antennas, and exposure levels were far less than those used in the NTP studies of cell phone radiation.
- [Watch Press Conference](#)

Wyde, Michael, et al. “National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposure). Statement on conclusions of the peer review meeting by NIEHS, released after external peer review meeting and the DNA damage presentation.

- This 25 million dollar study is the most complex study completed by the NTP and the world’s largest rodent study on radiofrequency radiation exposure to date which found long term exposure at non thermal levels associated with brain cancer and schwannomas of the heart in male rats. In addition damage to heart was found in all exposure levels. The full report is expected to be released in Fall 2018.

## More Important Studies on Cell Tower Radiation

- Radiofrequency radiation (RF) is increasingly being recognized as a new form of environmental pollution. This article reviews relevant electromagnetic frequencies, exposure standards and current scientific literature on the health implications of 2G, 3G, 4G and 5G.
- Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radiofrequencies, it will be years or decades before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated.

Noa Betzalel, Paul Ben Ishai, Yuri Feldman, [The human skin as a sub-THz receiver – Does 5G pose a danger to it or not?](#), Environmental Research, Volume 163, 2018, Pages 208-216, ISSN 0013-9351,

- Researchers have developed a unique simulation tool of human skin, taking into account the skin [multi-layer structure](#) together with the helical segment of the sweat duct embedded in it. They found that the presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in [extremely high frequency](#) band that will be used in 5G. “One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.”

[Mobile phone infrastructure regulation in Europe: Scientific challenges and human rights protection](#) Claudia Roda, Susan Perry, Environmental Science & Policy, Volume 37, March 2014, Pages 204-214.

- This article was published in Environmental Science & Policy by human rights experts. It argues that cell tower placement is a human rights issue for children.
- “We argue that (1) because protection of children is a high threshold norm in Human Right law and (2) the binding language of the Convention on the

Rights of the Child obliges States Parties to provide a higher standard of protection for children than adults, any widespread or systematic form of environmental pollution that poses a long-term threat to a child's rights to life, development or health may constitute an international human rights violation.

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- In particular we have explained how the dearth of legislation to regulate the installation of base stations (cell towers) in close proximity to children's facilities and schools clearly constitutes a human rights concern according to the language of the Convention on the Rights of the Child, a treaty that has been ratified by all European States.

#### SAFETY ZONE DETERMINATION FOR WIRELESS CELLULAR TOWER Nyakyi et al, Tanzania (2013)

- This research looked at the radiation that cell towers emit and states a safety zone is needed around the towers to ensure safe sleeping areas. The authors state that "respective authorities should ensure that people reside far from the tower by 120m or more depending on the power transmitted to avoid severe health effect."

A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. Ghandi et al, 2014 (India):

- This cross-sectional case control study on genetic damage in individuals living near cell towers found genetic damage parameters of DNA were significantly elevated. The authors state, "The genetic damage evident in the participants of this study needs to be addressed against future disease-risk, which in addition to neurodegenerative disorders, may lead to cancer."

Human disease resulting from exposure to electromagnetic fields, Carpenter, D. O. Reviews on Environmental Health, Volume 28, Issue 4, Pages 159172.

- This review summarizes the evidence stating that excessive exposure to magnetic fields from power lines and other sources of electric current increases the risk of development of some cancers and neurodegenerative

diseases, and that excessive exposure to RF radiation increases risk of cancer, male infertility, and neurobehavioral abnormalities.



Signifikanter Rückgang klinischer Symptome nach Senderabbau – eine Interventionsstudie. (English-Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal – An Intervention Study) Tetsuharu Shinjyo and Akemi Shinjyo, 2014 Umwelt-Medizin-Gesellschaft, 27(4), S. 294-301.

- Japanese study Showed Statistically Significant Adverse Health Effects from electromagnetic radiation from mobile phone base stations. Residents of a condominium building that had cell tower antennas on the rooftop were examined before and after cell tower antennas were removed. In 1998, 800MHz cell antennas were installed, then later in 2008 a second set of antennas (2GHz) were installed. Medical exams and interviews were conducted before and after the antennas were removed in 2009 on 107 residents of the building who had no prior knowledge about possible. These results lead researchers to question the construction of mobile phone base stations on top of buildings such as condominiums or houses.

Effect of GSTM1 and GSTT1 Polymorphisms on Genetic Damage in Humans Populations Exposed to Radiation From Mobile Towers. Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R., Arch Environ Contam Toxicol. 2015 Aug 5. [Epub ahead of print]

- In our study, 116 persons exposed to radiation from mobile towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes by multiplex polymerase chain reaction method. DNA damage in peripheral blood lymphocytes was determined using alkaline comet assay in terms of tail moment (TM) value and micronucleus assay in buccal cells (BMN). Our results indicated that TM value and BMN frequency were higher in an exposed population compared with a control group and the difference is significant. In our study, we found that different health symptoms, such as depression, memory status, insomnia, and hair loss, were significantly associated with exposure to EMR. Damaging effects of nonionizing radiation result from the generation of reactive oxygen species (ROS) and subsequent

radical formation and from direct damage to cellular macromolecules including DNA.



Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations, Hutter HP et al, (May 2006), Occup Environ Med. 2006 May;63(5):307-13

- Found a significant relationship between some cognitive symptoms and measured power density in 365 subjects; highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels.

Oberfeld, A.E. Navarro, M. Portoles, C. Maestu, C. Gomez-Perretta, The microwave syndrome: further aspects of a Spanish study,

- A health survey was carried out in La Nora, Murcia, Spain, in the vicinity of two GSM 900/1800 MHz cellular phone base stations. The adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Bortkiewicz et al, 2004 (Poland), Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review, Med Pr.2004;55(4):345-51.

- Residents close to mobile phone masts reported: more incidences of circulatory problems, sleep disturbances, irritability, depression, blurred vision and concentration difficulties the nearer they lived to the mast.
- The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station.

Wolf R and Wolf D, Increased Incidence of Cancer Near a Cell-phone Transmitter Station, International Journal of Cancer Prevention, (Israel)  
VOLUME 1, NUMBER 2, APRIL 2004

- A significant higher rate of cancer (300% increase) among all residents living within 300m radius of a mobile phone mast for between three and seven years was detected.
- 900% cancer increase among women alone
- In the area of exposure (area A) eight cases of different kinds of cancer were diagnosed in a period of only one year. This rate of cancers was compared both with the rate of 31 cases per 10,000 per year in the general population and the 2/1222 rate recorded in the nearby clinic (area B). The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Changes of Neurochemically Important Transmitters under the influence of modulated RF fields – A Long Term Study under Real Life Conditions(Germany),  
Bucher and Eger, 2011

- German study showing elevated levels of stress hormones (adrenaline, noradrenaline), and lowered dopamine and PEA levels in urine in area residents during 1st 6 months of cell tower installation. Even after 1.5 years, the levels did not return to normal.

The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer (Umwelt-Medizin-Gesellschaft 17,4 2004) Eger et al, 2004 (Germany)

- 200% increase in the incidence of malignant tumors was found after five years' exposure in people living within 400m radius of a mobile phone mast. The proportion of newly developing cancer cases is significantly higher among patients who live within 400 meters of a cell phone transmitter. Early age of cancer diagnosis.

Microwave electromagnetic fields act by activating voltage-gated calcium channels: why the current international safety standards do not predict biological hazard. Martin L. Pall. Recent Res. Devel. Mol. Cell Biol. 7(2014).

- “It can be seen from the above that 10 different well-documented microwave EMF effects can be easily explained as being a consequence of EMF VGCC activation: oxidative stress, elevated single and double strand breaks in DNA, therapeutic responses to such EMFs, breakdown of the blood-brain barrier, cancer, melatonin loss, sleep dysfunction, male infertility and female infertility.”

Pall ML. 2015. Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. *J. Chem. Neuroanat.* 2015 Aug 20.

- Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation.
- Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose-response relationships.
- Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five

criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.



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