National Cancer Institute at the National Institutes of Health

Fact Sheet

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Cell Phones and Cancer Risk

Key Points

- Cell phones emit radiofrequency energy, a form of non-ionizing electromagnetic radiation, which can be absorbed by tissues closest to where the phone is held.
- The amount of radiofrequency energy a cell phone user is exposed to depends on the technology of the phone, the distance between the phone's antenna and the user, the extent and type of use, and the user's distance from cell phone towers.
- Studies thus far have not shown a consistent link between cell phone use and cancers of the brain, nerves, or other tissues of the head or neck. More research is needed because cell phone technology and how people use cell phones have been changing rapidly.

1. **Why is there concern that cell phones may cause cancer or other health problems?**

   There are three main reasons why people are concerned that cell phones (also known as "wireless" or "mobile" telephones) might have the potential to cause certain types of cancer or other health problems:

   - Cell phones emit radiofrequency energy (radio waves), a form of non-ionizing radiation. Tissues nearest to where the phone is held can absorb this energy.
   - The number of cell phone users has increased rapidly. As of 2010, there were more than 303 million subscribers to cell phone service in the United States, according to the Cellular Telecommunications and Internet Association. This is a nearly threefold increase from the 110 million users in 2000. Globally, the number of cell phone subscriptions is estimated by the International Telecommunications Union to be 5 billion.
   - Over time, the number of cell phone calls per day, the length of each call, and the amount of time people use cell phones have increased. Cell phone technology has also undergone

substantial changes.

2. **What is radiofrequency energy and how does it affect the body?**

   Radiofrequency energy is a form of electromagnetic radiation. Electromagnetic radiation can be categorized into two types: ionizing (e.g., x-rays, radon, and cosmic rays) and non-ionizing (e.g., radiofrequency and extremely low-frequency or power frequency).

   Exposure to ionizing radiation, such as from radiation therapy, is known to increase the risk of cancer. However, although many studies have examined the potential health effects of non-ionizing radiation from radar, microwave ovens, and other sources, there is currently no consistent evidence that non-ionizing radiation increases cancer risk (1).

   The only known biological effect of radiofrequency energy is heating. The ability of microwave ovens to heat food is one example of this effect of radiofrequency energy. Radiofrequency exposure from cell phone use does cause heating; however, it is not sufficient to measurably increase body temperature.

   A recent study showed that when people used a cell phone for 50 minutes, brain tissues on the same side of the head as the phone's antenna metabolized more glucose than did tissues on the opposite side of the brain (2). The researchers noted that the results are preliminary, and possible health outcomes from this increase in glucose metabolism are still unknown.

3. **How is radiofrequency energy exposure measured in epidemiologic studies?**

   Levels of radiofrequency exposure are indirectly estimated using information from interviews or questionnaires. These measures include the following:

   - How "regularly" study participants use cell phones (the minimum 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

4. **What has research shown about the possible cancer-causing effects of radiofrequency energy?**

   Although there have been some concerns that radiofrequency energy from cell phones held closely to the head may affect the brain and other tissues, to date there is no evidence from studies of cells,

animals, or humans that radiofrequency energy can cause cancer.

It is generally accepted that damage to DNA is necessary for cancer to develop. However, radiofrequency energy, unlike ionizing radiation, does not cause DNA damage in cells, and it has not been found to cause cancer in animals or to enhance the cancer-causing effects of known chemical carcinogens in animals (3–5).

Researchers have carried out several types of epidemiologic studies to investigate the possibility of a relationship between cell phone use and the risk of malignant (cancerous) brain tumors, such as gliomas, as well as benign (noncancerous) tumors, such as acoustic neuromas (tumors in the cells of the nerve responsible for hearing), most meningiomas (tumors in the meninges, membranes that cover and protect the brain and spinal cord), and parotid gland tumors (tumors in the salivary glands) (6).

In one type of study, called a case-control study, cell phone use is compared between people with these types of tumors and people without them. In another type of study, called a cohort study, a large group of people is followed over time and the rate of these tumors in people who did and didn't use cell phones is compared. Cancer incidence data can also be analyzed over time to see if the rates of cancer changed in large populations during the time that cell phone use increased dramatically. The results of these studies have generally not provided clear evidence of a relationship between cell phone use and cancer, but there have been some statistically significant findings in certain subgroups of people.

Findings from specific research studies are summarized below:

- The Interphone Study, conducted by a consortium of researchers from 13 countries, is the largest health-related case-control study of use of cell phones and head and neck tumors. Most published analyses from this study have shown no statistically significant increases in brain or central nervous system cancers related to higher amounts of cell phone use. One recent analysis showed a statistically significant, albeit modest, increase in the risk of glioma among the small proportion of study participants who spent the most total time on cell phone calls. However, the researchers considered this finding inconclusive because they felt that the amount of use reported by some respondents was unlikely and because the participants who reported lower levels of use appeared to have a reduced risk of brain cancer (7–9). Another recent study from the group found no relationship between brain tumor locations and regions of the brain that were exposed to the highest level of radiofrequency energy from cell phones (10).
- A cohort study in Denmark linked billing information from more than 358,000 cell phone subscribers with brain tumor incidence data from the Danish Cancer Registry. The analyses found no association 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 (11–13).

- Early case-control studies in the United States, Europe, and Japan were unable to demonstrate a relationship between cell phone use and glioma or meningioma (14).
- Some case-control studies in Sweden found 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 (15). However, another large, case-control study in Sweden did not find an increased risk of brain cancer among people between the ages of 20 and 69 (16). In addition, the international CEFALO study, which compared children who were diagnosed with brain cancer between ages 7 and 19 with similar children who were not, found no relationship between their cell phone use and risk for brain cancer (17).
- NCI's Surveillance, Epidemiology, and End Results (SEER) Program, which tracks cancer incidence in the United States over time, found no increase in the incidence of brain or other central nervous system cancers between 1987 and 2007, despite the dramatic increase in cell phone use in this country during that time (18, 19). Similarly, incidence data from Denmark, Finland, Norway, and Sweden for the period 1974–2008 revealed no increase in age-adjusted incidence of brain tumors (20, 21). A 2012 study by NCI researchers, which compared observed glioma incidence rates in SEER with projected rates based on risks observed in the Interphone study (8), found that the projected rates were consistent with observed U.S. rates. The researchers also compared the SEER rates with projected rates based on a Swedish study published in 2011 (15). They determined that the projected rates were at least 40 percent higher than, and incompatible with, the actual U.S. rates.
- Studies of workers exposed to radiofrequency energy have shown no evidence of increased risk of brain tumors among U.S. Navy electronics technicians, aviation technicians, or fire control technicians, those working in an electromagnetic pulse test program, plastic-ware workers, cellular phone manufacturing workers, or Navy personnel with a high probability of exposure to radar (6).

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

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

- **Recall bias**, which may happen when a study collects data about prior habits and exposures using questionnaires administered after disease has been diagnosed in some of the study participants. It is possible that study participants who have brain tumors may remember their cell phone use differently than individuals without brain tumors. Many epidemiologic studies of cell phone use and brain cancer risk lack verifiable data about the total amount of cell phone use over time. In addition, people who develop a brain tumor may have a tendency to recall using their cell phone mostly on the same side of their head where the tumor was found,

regardless of whether they actually used their phone on that side of their head a lot or only a little.

- **Inaccurate reporting**, which may happen when people say that something has happened more or less often than it actually did. 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, for example, 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. Furthermore, for people who have died, next-of-kin are often less familiar with the cell phone use patterns of their deceased family member and may not accurately describe their patterns of use to an interviewer.
- **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. Also, controls who did not or rarely used cell phones were less likely to participate in the Interphone study than controls who used cell phones regularly. For example, the Interphone study reported participation rates of 78 percent for meningioma patients (range 56–92 percent for the individual studies), 64 percent for the glioma patients (range 36–92 percent), and 53 percent for control subjects (range 42–74 percent) (9). One series of Swedish studies reported participation rates of 85 percent in people with brain cancer and 84 percent in control subjects (16).
- **Changing technology and methods of use**. Older studies evaluated radiofrequency energy exposure from analog cell phones. However, most cell phones today use digital technology, which operates at a different frequency and a lower power level than analog phones. Digital cell phones have been in use for more than a decade in the United States, and cellular technology continues to change (6). Texting, for example, has become a popular way of using a cell phone to communicate that does not require bringing the phone close to the head. Furthermore, the use of hands-free technology, such as wired and wireless headsets, is increasing and may decrease radiofrequency energy exposure to the head and brain.

6. **What do expert organizations conclude?**

The International Agency for Research on Cancer (IARC), a component of the World Health Organization, has recently classified radiofrequency fields as "possibly carcinogenic to humans," based on limited evidence from human studies, limited evidence from studies of radiofrequency energy and cancer in rodents, and weak mechanistic evidence (from studies of genotoxicity, effects on immune system function, gene and protein expression, cell signaling, oxidative stress, and apoptosis, along with studies of the possible effects of radiofrequency energy on the blood-brain barrier).

The American Cancer Society (ACS) states that the IARC classification means that there could be

some risk associated with cancer, but the evidence is not strong enough to be considered causal and needs to be investigated further. Individuals who are concerned about radiofrequency exposure can limit their exposure, including using an ear piece and limiting cell phone use, particularly among children.

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 U.S. Food and Drug Administration (FDA), which is responsible for regulating the safety of machines and devices that emit radiation (including cell phones), notes that studies reporting biological changes associated with radiofrequency energy have failed to be replicated and that the majority of human epidemiologic studies have failed to show a relationship between exposure to radiofrequency energy from cell phones and health problems.

The U.S. Centers for Disease Control and Prevention (CDC) states that, although some studies have raised concerns about the possible risks of cell phone use, scientific research as a whole does not support a statistically significant association between cell phone use and health effects.

The Federal Communications Commission (FCC) concludes that there is no scientific evidence that proves that wireless phone use can lead to cancer or to other health problems, including headaches, dizziness, or memory loss.

7. **What studies are under way that will help further our understanding of the health effects of cell phone use?**

A large prospective cohort study of cell phone use and its possible long-term health effects was launched in Europe in March 2010. This study, known as COSMOS , will enroll approximately 250,000 cell phone users ages 18 or older and will follow them for 20 to 30 years.

Participants in COSMOS will complete a questionnaire about their health, lifestyle, and current and past cell phone use. This information will be supplemented with information from health records and cell phone records.

The challenge of such ambitious studies is to maintain the completeness of their cohorts over many decades. Researchers will need to determine whether participants who leave are somehow different from those who remain throughout the follow-up period.

Another case-control study, called Mobi-Kids , is under way to examine health effects among children.

Although recall bias is minimized in case-control studies that link to cell phone records, such studies face other problems. For example, it is impossible to know who is using the listed cell phone or whether that individual also places calls using other cell phones. To a lesser extent, it is

not clear whether multiple users of a single phone will be represented on a single bill.

The NIEHS, which is part of the National Institutes of Health, is carrying out a study of risks related to exposure to radiofrequency energy (the type used in cell phones) in highly specialized labs that can specify and control sources of radiation and measure their effects on rodents.

8. **Do children have a higher risk of developing cancer due to cell phone use than adults?**

In theory, children have the potential to be at greater risk than adults for developing brain cancer from cell phones. 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 therefore have a greater proportional exposure to the field of radiofrequency radiation that is emitted by cell phones. And children have the potential of accumulating more years of cell phone exposure than adults do.

So far, the data from clinical studies in children do not support this theory. The first published analysis came from a large case-control study called CEFALO, which was conducted in Denmark, Sweden, Norway, and Switzerland. The study included children who were diagnosed with brain tumors between 2004 and 2008, when their ages ranged from 7 to 19. Researchers did not find an association between cell phone use and brain tumor risk in this group of children. However, they noted that their results did not rule out the possibility of a slight increase in brain cancer risk among children who use cell phones, and that data gathered through prospective studies and objective measurements, rather than participant surveys and recollections, will be key in clarifying whether there is an increased risk (18).

Researchers from the Centre for Research in Environmental Epidemiology in Spain are conducting another international study—Mobi-Kids —to evaluate the risk associated with new communications technologies (including cell phones) and other environmental factors in young people ages 10 to 24.

9. **What can cell phone users do to reduce their exposure to radiofrequency energy?**

The FDA and FCC have suggested some steps that concerned cell phone users can take to reduce their exposure to radiofrequency energy (1, 22):

- Reserve the use of cell phones for shorter conversations or for times when a landline phone is not available.
- Use a hands-free device, which places more distance between the phone and the head of the user.

Hands-free kits reduce the amount of radiofrequency energy exposure to the head because the antenna, which is the source of energy, is not placed against the head.

10. **Where can I find more information about radiofrequency energy from my cell phone?**

    The FCC provides information about the specific absorption rate (SAR) of cell phones produced and marketed within the last 1 to 2 years. The SAR corresponds with the relative amount of radiofrequency energy absorbed by the head of a cell phone user (23). 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.

11. **What are other sources of radiofrequency energy?**

    The most common exposures to radiofrequency energy are from telecommunications devices and equipment (1). In the United States, cell phones currently operate in a frequency range of about 1,800 to 2,200 megahertz (MHz) (6). In this range, the electromagnetic radiation produced is in the form of non-ionizing radiofrequency energy.

    Cordless phones (phones that have a base unit connected to the telephone wiring in a house) often operate at radio frequencies similar to those of cell phones; however, since cordless phones have a limited range and require a nearby base, their signals are generally much less powerful than those of cell phones.

    Among other radiofrequency energy sources, AM/FM radios and VHF/UHF televisions operate at lower radio frequencies than cell phones, whereas sources such as radar, satellite stations, magnetic resonance imaging (MRI) devices, industrial equipment, and microwave ovens operate at somewhat higher radio frequencies (1).

12. **How common is brain cancer? Has the incidence of brain cancer changed over time?**

    Brain cancer incidence and mortality (death) rates have changed little in the past decade. In the United States, 22,910 new diagnoses and 13,700 deaths from brain cancer are estimated for 2012.

    The 5-year relative survival for brain cancers diagnosed from 2002 through 2008 was 35 percent (24). This is the percentage of people diagnosed with brain cancer who will still be alive 5 years after diagnosis compared with the survival of a person of the same age and sex who does not have cancer.

    The risk of developing brain cancer increases with age. From 2005 through 2009, there were fewer than 5 brain cancer cases for every 100,000 people in the United States under age 65, compared with approximately 19 cases for every 100,000 people in the United States who were ages 65 or older (24).

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