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Cell Phones and Cancer Risk

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 “mobile” or “wireless” 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, from their antennas. Tissues nearest to the antenna can absorb this energy.
- The number of cell phone users has increased rapidly. As of December 2014, there were more than 327.5 million cell phone subscribers 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 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. However, improvements in cell phone technology have resulted in devices that have lower power outputs than earlier models.

The NCI fact sheet *Electromagnetic Fields and Cancer* includes information on wireless local area networks (commonly known as Wi-Fi), cell phone base stations, and cordless telephones.

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). Electromagnetic radiation is defined according to its wavelength and frequency, which is the number of cycles of a wave that pass a reference point per second. Electromagnetic frequencies are described in units called hertz (Hz).

The energy of electromagnetic radiation is determined by its frequency; ionizing radiation is high frequency, and therefore high energy, whereas non-ionizing radiation is low frequency, and therefore low energy. The NCI fact sheet *Electromagnetic Fields and Cancer* lists sources of radiofrequency energy. More information about ionizing radiation can be found on the [Radiation](#) page.

The frequency of radiofrequency electromagnetic radiation ranges from 30 kilohertz (30 kHz, or 30,000 Hz) to 300 gigahertz (300 GHz, or 300 billion Hz). Electromagnetic fields in the radiofrequency range are used for telecommunications applications, including cell phones, televisions, and radio transmissions.

The human body absorbs energy from devices that emit radiofrequency electromagnetic radiation. The dose of the absorbed energy is estimated using a measure called the specific absorption rate (SAR), which is expressed in watts per kilogram of body weight.

Exposure to ionizing radiation, such as from x-rays, 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, cell phones, and other sources, there is currently no consistent evidence that non-ionizing radiation increases cancer risk (1).

The only consistently recognized 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 to the area of the body where a cell phone or other device is held (ear, head, etc.). However, it is not sufficient to measurably increase body temperature, and there are no other clearly established effects on the body from radiofrequency energy.

It has been suggested that radiofrequency energy might affect glucose metabolism, but two small studies that examined brain glucose metabolism after use of a cell phone showed inconsistent results. Whereas 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 (2), the other study (3) found reduced glucose metabolism on the side of the brain where the phone was used.

Another study investigated whether exposure to the radiofrequency energy from cell phones affects the flow of blood in the brain and found no evidence of such an effect (4).

The authors of these studies noted that the results are preliminary and that possible health outcomes from changes in glucose metabolism are still unknown. Such inconsistent findings are not uncommon in experimental studies of the biological effects of radiofrequency electromagnetic radiation (5). Some contributing factors include assumptions used to estimate doses, failure to consider temperature effects, and lack of blinding of investigators to exposure status.

How is radiofrequency energy exposure measured in epidemiologic studies?

Epidemiologic studies use information from several sources, including questionnaires and data from cell phone service providers. Direct measurements are not yet possible outside of a laboratory setting. Estimates 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 possible cancer-causing effects of radiofrequency energy?

Radiofrequency energy, unlike ionizing radiation, does not cause DNA damage that can lead to cancer. Its only consistently observed biological effect in humans is tissue heating. In animal studies, it has not been found to cause cancer or to enhance the cancer-causing effects of known chemical carcinogens (6–8). The National Institute of Environmental Health Sciences (NIEHS), which is part of the National Institutes of Health (NIH), is carrying out a large-scale study in rodents of exposure to radiofrequency energy (the type used in cell phones). This investigation is being conducted in highly specialized labs that can specify and control sources of radiation and measure their effects. Preliminary results from this study were released in May 2016.

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) (9).

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 who do not have cancer at study entry 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. These studies have not shown clear evidence of a relationship between cell phone use and cancer. However, researchers have reported some statistically significant associations for certain subgroups of people.

Three large epidemiologic studies have examined the possible association between cell phone use and cancer: Interphone, a case-control study; the Danish Study, a cohort study; and the Million Women Study, another cohort study.

• Interphone

How the study was done: This is the largest health-related 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.

What the study showed: 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 analysis showed a statistically significant, although 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 slightly reduced risk of brain cancer compared with people who did not use cell phones regularly (5,10,11). Another recent analysis from this study 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 (12).

• **Danish Study**

How the study was done: This cohort study, conducted in Denmark, 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 (13–15).

• **Million Women 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 (16), this association disappeared after additional follow-up of the cohort (17).

In addition to these three large studies, other, smaller epidemiologic studies have looked for associations between cell phone use and cancer. These include:

- Two NCI-sponsored case-control studies, each conducted in multiple U.S. academic medical centers or hospitals between 1994 and 1998, that used data from questionnaires (18) or computer-assisted personal interviews (19). Neither study showed a relationship between cell phone use and the risk of glioma, meningioma, or acoustic neuroma.
- 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 (20). This study found no association for either gliomas or meningiomas when comparing 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 (21).
- 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 (22).

- The CEFALO study, an international case-control study of children diagnosed with brain cancer between ages 7 and 19, which found no relationship between their cell phone use and risk for brain cancer (23).

Investigators have also conducted analyses of incidence trends to determine whether the incidence of brain or other cancers has changed during the time that cell phone use increased dramatically. These include:

- An analysis of data from NCI's Surveillance, Epidemiology, and End Results (SEER) Program evaluated trends in cancer incidence in the United States. This analysis found no increase in the incidence of brain or other central nervous system cancers between 1992 and 2006, despite the dramatic increase in cell phone use in this country during that time (24).
- An analysis of incidence data from Denmark, Finland, Norway, and Sweden for the period 1974–2008 similarly revealed no increase in age-adjusted incidence of brain tumors (25).
- A series of studies testing different scenarios (called simulations by the study authors) were carried out using incidence data from the Nordic countries to determine the likelihood of detecting various levels of risk as reported in studies of cell phone use and brain tumors between 1979 and 2008. The results were compatible with no increased risks from cell phones, as reported by most epidemiologic studies. The findings did suggest that the increase reported among the subset of heaviest regular users in the Interphone study could not be ruled out but was unlikely. The highly increased risks reported in the Swedish pooled analysis were strongly inconsistent with the observed glioma rates in the Nordic countries (26).
- A 2012 study by NCI researchers (27) compared observed glioma incidence rates in U.S. SEER data with rates simulated from the small risks reported in the Interphone study (11) and the greatly increased risk of brain cancer among cell phone users reported in the Swedish pooled analysis (21). The observed U.S. rates showed no increase, but a small increased risk among the subset of heaviest users in the Interphone study could not be ruled out. The observed incidence trends were inconsistent with the high risks reported in the Swedish pooled study. These findings suggest that the increased risks observed in the Swedish study are not reflected in U.S. incidence trends.

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 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. It is possible that study participants who have brain tumors may remember their cell phone use differently from 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 cell phone use

mostly on the same side of the head where their tumor was found, regardless of whether they actually used their phone on that side of the head a lot or only a little.

- **Inaccurate reporting**, which can 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 glioma patients (range 36–92 percent), and 53 percent for control subjects (range 42–74 percent) (11).
- **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 (9). 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.

What do expert organizations conclude 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 energy and cancer in rodents, and inconsistent evidence from mechanistic studies (5).

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 rather than an underlying causal effect. In addition, the Working Group stated that the investigation of risk of cancer of the brain associated with cell phone use poses complex methodologic challenges in the conduct of the research and in the analysis and interpretation of findings.

The American Cancer Society (ACS) states that the IARC classification means that there could be some cancer risk associated with radiofrequency energy, but the evidence is not strong enough to be considered causal and needs to be investigated further. Individuals who are concerned about radiofrequency energy 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) 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 no scientific evidence definitively answers whether cell phone use causes cancer.

The Federal Communications Commission (FCC) concludes that no scientific evidence establishes a causal 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 (1). The Committee also stated that epidemiologic studies do not indicate increased risk for other malignant diseases, including childhood cancer (1).

What studies are under way that will help further our understanding of the possible 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, has enrolled approximately 290,000 cell phone users aged 18 years or older to date 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 this ambitious study is to continue following the participants for a range of health effects over many decades. Researchers will need to determine whether participants who leave the study are somehow different from those who remain throughout the follow-up period.

Although recall bias is minimized in studies such as COSMOS that link participants to their 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 phone company account.

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

There are theoretical considerations as to why the possible risk 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 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.

Thus far, the data from studies in children with cancer 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 either by time since initiation of use, amount of use, or by the location of the tumor (23).

Several studies that will provide more information are under way. Researchers from the Centre for Research in Environmental Epidemiology in Spain are conducting another international case-control study—Mobi-Kids—that will include 2000 young people (aged 10–24 years) with newly diagnosed brain tumors and 4000 healthy young people. The goal of the study is to learn more about risk factors for childhood brain tumors. Results are expected in 2016.

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

The FDA has suggested some steps that concerned cell phone users can take to reduce their exposure to radiofrequency energy (28):

- Reserve the use of cell phones for shorter conversations or for times when a landline phone is not available.
- Use a device with hands-free technology, such as wired headsets, which place 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. Exposures decline dramatically when cell phones are used hands-free.

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 (29). 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.

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, 23,770 new diagnoses and 16,050 deaths from brain and other central nervous system cancers are estimated for 2016.

The 5-year relative survival for brain cancers diagnosed from 2005 through 2011 was 35 percent (30). 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 2008 through 2012, 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 (30).

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