

Cellular Telephone Use and Cancer Risk

Key Points

- Cellular telephones emit radiofrequency (RF) energy, which is another name for radio waves (see Questions 1 and 2).
- Exposure to high levels of RF energy can heat body tissue, but RF energy exposures from cellular telephones are too low to cause significant tissue heating (see Question 2).
- Concerns have been raised that RF energy from cellular telephones may pose a cancer risk to users (see Questions 1 and 2).
- Researchers are studying tumors of the brain and central nervous system and other sites of the head and neck because cellular telephones are held next to the head when used (see Question 5).
- Studies have not shown any consistent link between cellular telephone use and cancer, but scientists feel that additional research is needed before firm conclusions can be drawn (see Questions 6 and 7).

1. Why is there concern that cellular telephones may cause cancer?

There are three main reasons why people are concerned that cellular telephones (also known as “wireless” or “mobile” telephones) may cause certain types of cancer:

- Cellular telephones emit radiofrequency (RF) energy (radio waves), which is a form of radiation that is under investigation for its effects on the human body (1).
- Cellular telephone technology emerged in Europe in the 1980s but did not come into widespread use in the United States until the 1990s. The technology is rapidly changing, so there are few long-term studies of the effects of RF energy from cellular telephones on the human body (1).
- The number of cellular telephone users has increased rapidly. As of December 2008, there were more than 270 million subscribers to cellular telephone service in the United States, according to the Cellular Telecommunications and Internet



Association. This is an increase from 110 million users in 2000 and 208 million users in 2005.

For these reasons, it is important to learn whether RF energy from cellular telephones affects human health.

2. What is RF energy and how can it affect the body?

RF energy is a form of electromagnetic radiation.

Electromagnetic radiation can be divided into two types: Ionizing (high-frequency) and non-ionizing (low-frequency) (2). RF energy is a form of non-ionizing electromagnetic radiation. Ionizing radiation, such as that produced by x-ray machines, can pose a cancer risk at high levels of exposure. However, it is not known whether the non-ionizing radiation emitted by cellular telephones is associated with cancer risk (2).

Studies suggest that the amount of RF energy produced by cellular telephones is too low to produce significant tissue heating or an increase in body temperature. However, more research is needed to determine what effects, if any, low-level non-ionizing RF energy has on the body and whether it poses a health danger (2).

3. How is a cellular telephone user exposed to RF energy?

A cellular telephone's main source of RF energy is produced through its antenna. The antenna of a hand-held cellular telephone is in the handset, which is typically held against the side of the head when the telephone is in use. The closer the antenna is to the head, the greater a person's expected exposure to RF energy. The amount of RF energy absorbed by a person decreases significantly with increasing distance between the antenna and the user. The intensity of RF energy emitted by a cellular telephone depends on the level of the signal sent to or from the nearest base station (1).

When a call is placed from a cellular telephone, a signal is sent from the antenna of the phone to the nearest base station antenna. The base station routes the call through a switching center, where the call can be transferred to another cellular telephone, another base station, or the local land-line telephone system. The farther a cellular telephone is from the base station antenna, the higher the power level needed to maintain the connection. This distance determines, in part, the amount of RF energy exposure to the user.

4. What determines how much RF energy a cellular telephone user experiences?

A cellular telephone user's level of exposure to RF energy depends on several factors, including:

- The number and duration of calls.
- The amount of cellular telephone traffic at a given time.

- The distance from the nearest cellular base station.
- The quality of the cellular transmission.
- The size of the handset.
- How far the antenna is extended.
- Whether or not a hands-free device is used.

5. What parts of the body may be affected during cellular telephone use?

There is concern that RF energy produced by cellular phones may affect the brain and nervous system tissue in the head because hand-held cellular telephones are usually held close to the head. Researchers have focused on whether RF energy can cause malignant (cancerous) brain tumors such as gliomas (cancers of the brain that begin in glial cells, which surround and support the nerve cells), as well as benign (noncancerous) tumors, such as acoustic neuromas (tumors that arise in the cells of the nerve that supplies the ear) and meningiomas (tumors that occur in the meninges, which are the membranes that cover and protect the brain and spinal cord) (1). The salivary glands also may be exposed to RF energy from cellular telephones held close to the head.

6. What studies have been done, and what do they show?

Numerous studies have investigated the relationship between cellular telephone use and the risk of developing malignant and benign brain tumors, but results from long-term studies are still limited.

Several studies have investigated the risk of developing three types of brain tumors: Glioma, meningioma, and acoustic neuroma. Results from the majority of these studies have found no association between hand-held cellular telephone use and the risk of brain cancer (3–8); however, some, but not all, long-term studies have suggested slightly increased risks for certain types of brain tumors (9, 10). Further evaluation of long-term exposures (more than 10 years) is needed.

A series of multinational case-control studies (comparing individuals who have a disease or condition [case subjects] with a similar group of people who do not have the disease or condition [control subjects]), collectively known as the INTERPHONE study, are being coordinated by the International Agency for Research on Cancer (11). The primary objective of these studies is to assess whether RF energy exposure from cellular telephones is associated with an increased risk of malignant or benign brain tumors and other head and neck tumors. Participating countries include Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden, and the United Kingdom (12). Several reports describing data from individual countries have been published independently by researchers involved in the INTERPHONE study; however, these reports represent only a portion of the entire INTERPHONE dataset. The combined INTERPHONE analysis is under way and will provide more comprehensive and stable risk estimates than analyses from the individual countries.

Two reports published in November 2004 by researchers from individual countries that are participating in the INTERPHONE study described results of assessments of cellular telephone use and the risk of acoustic neuroma. One report described a Danish case-control study that showed no increased risk of acoustic neuroma in long-term (10 years or more) cellular telephone users compared with short-term users, and there was no increase in the incidence of tumors on the side of the head where the phone was usually held (13). The other report described a Swedish study that examined similar populations and found a slightly elevated risk of acoustic neuroma in long-term cellular telephone users but not in short-term users (14).

A pooled analysis of data from Denmark, Finland, Norway, Sweden, and the United Kingdom did not find relationships between the risk of acoustic neuroma and the duration of cellular telephone use, cumulative hours of use, or number of calls; however, the risk of a tumor on the same side of the head as the reported phone use was higher among persons who had used a cellular telephone for 10 years or more. Some other studies have reported similar findings (15). However, there is concern that people with a tumor on one side of their heads might be more likely to report phone use on that side (9).

Other reports from the Danish and Swedish researchers who are collaborating in the INTERPHONE study investigated whether a relationship exists between cellular telephone use and the risk of meningioma or glioma. These studies compared individuals with meningioma or glioma with a control group of disease-free individuals and found no link between these conditions and cellular telephone use (16, 17).

In addition, pooled analyses of data from four Nordic countries and the United Kingdom did not show overall associations between the risk of glioma or meningioma and the cumulative hours of cellular telephone use or the number of calls (18, 19). There was a slightly increased risk of glioma occurring on the same side of the head as the reported phone use among persons who used a cellular telephone for at least 10 years (18).

In an attempt to avoid the issue of biases associated with case-control studies, investigators defined a cohort of 420,095 persons in Denmark with cellular telephone subscriptions and linked this roster with the Danish Cancer Registry to identify brain tumors occurring in this population (7, 8). Cellular telephone use was not associated with glioma, meningioma, or acoustic neuroma, even among persons who had been subscribers for 10 or more years. This type of prospective study has the advantage of not having to rely on people's ability to remember past cellular telephone use.

Incidence data from the Surveillance, Epidemiology and End Results (SEER) program of the National Cancer Institute showed no increase between 1987 and 2005 in the age-adjusted incidence of brain or other nervous system cancers despite the dramatic increase in use of cellular telephones (20).

There are very few studies of the possible relationship between cellular telephone use and tumors other than those of the brain and central nervous system (21–24).

7. Why are the results of the studies inconsistent?

There are several reasons for the discrepancies between studies:

- Information about cellular telephone use, including the frequency of use and the duration of calls, has largely been assessed through questionnaires. The completeness and accuracy of the data collected during such interviews is dependent on the memory of the responding individuals. In case-control studies, individuals with brain tumors may remember cellular telephone use differently from healthy individuals, which can result in a problem known as *recall bias*.
- Cellular telephone use is relatively new in the United States (mostly since the 1990s), and cellular technology continues to change (1). Although older studies evaluated RF energy exposure from analog telephones, most cellular telephones today use digital technology, which operates at a different frequency and power level than analog phones.
- The interval between exposure to a carcinogen and the clinical onset of a tumor may be many years or decades. Scientists have been unable to monitor large cohorts of cellular telephone users for the length of time it might take for brain tumors to develop (1).
- Other limitations of current epidemiologic studies on cellular telephone use and brain cancer include a lack of verifiable data regarding cumulative RF energy exposure over time (the total amount of RF energy individuals have encountered) and potential errors in the exposure information reported by study participants after individuals are diagnosed with cancer, a problem known as *reporting bias* (25, 26). In addition, participation rates are frequently different between case subjects and control subjects in brain tumor studies, a problem known as *participation bias*. Some studies have indicated greater participation by individuals diagnosed with brain tumors compared with controls, and participation rates may be related to cellular telephone use.
- The use of “hands-free” wireless technology, such as Bluetooth®, is increasing and may contribute to variation in cellular telephone exposures.

Although research has not consistently demonstrated a link between cellular telephone use and cancer, scientists still caution that further surveillance is needed before conclusions can be drawn (1, 27).

8. Do children have a higher risk of developing cancer due to cellular telephone use than adults?

There are currently no data on cellular telephone use and risk of cancer in children because no published studies to date have included children. Cellular telephone use is increasing rapidly in children and adolescents, and they are likely to accumulate many years of exposure during their lives (1). In addition, children may be at greater risk

because their nervous systems are still developing at the time of exposure. A large case-control study of childhood brain cancer in several Northern European countries is in progress.

9. What can cellular telephone users do to reduce their exposure to RF energy?

The U.S. Food and Drug Administration has suggested some steps that cellular telephone users can take if they are concerned about potential health risks from cellular telephones:

- Reserve the use of cellular telephones for shorter conversations, or for times when a conventional phone is not available.
- Switch to a type of cellular telephone with a hands-free device that will place more distance between the antenna and the head of the phone user.

Hands-free kits reduce the amount of RF energy exposure to the head because the antenna, which is the source of RF energy, is not placed against the head (2). However, most studies conducted on cellular telephone use and cancer risk have focused on hand-held models not equipped with hands-free systems because they deliver the most RF energy to the user's head.

10. Where can I find more information about RF energy exposure?

The Federal Communications Commission (FCC), which regulates interstate and international communications, provides consumers with information about human exposure to RF energy from cellular telephones and other devices at <http://www.fcc.gov/oet/rfsafety> on the Internet. This Web page includes links to information about the specific absorption rate (SAR) of cellular telephones produced and marketed within the last 1 to 2 years. The SAR corresponds to the relative amount of RF energy absorbed into the head of a cellular telephone user. Consumers can access this information using the phone's FCC ID number, which is usually located on the case of the phone.

11. What are other sources of RF energy?

The most common use of RF energy is for telecommunications (2). In the United States, cellular telephones operate in a frequency range of about 1,800 to 2,200 megahertz (MHz) (1). In this range, the electromagnetic radiation produced is in the form of non-ionizing RF energy. AM/FM radios, VHF/UHF televisions, and cordless telephones (telephones that have a base unit connected to the telephone wiring in a house) operate at lower radio frequencies than cellular telephones. Other sources of RF energy, including radar, satellite stations, magnetic resonance imaging (MRI) devices, industrial equipment, and microwave ovens, operate at somewhat higher radio frequencies (2).

Selected References

1. Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A. Epidemiology of health effects on radiofrequency exposure. *Environmental Health Perspectives* 2004; 112(17): 1741–1754.
2. U.S. Food and Drug Administration (2009). *Radiation-Emitting Products: Cell Phones*. Silver Spring, MD. Retrieved September 8, 2009, from: <http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm>.
3. Inskip PD, Tarone RE, Hatch EE, et al. Cellular-telephone use and brain tumors. *New England Journal of Medicine* 2001; 344(2):79–86.
4. Hepworth SJ, Schoemaker MJ, Muir KR, et al. Mobile phone use and risk of glioma in adults: Case-control study. *British Medical Journal* 2006; 332(7546):883–887.
5. Klæboe L, Blaasaas KG, Tynes T. Use of mobile phones in Norway and risk of intracranial tumours. *European Journal of Cancer Prevention* 2007; 16(2):158–164.
6. Takebayashi T, Varsier N, Kikuchi Y, et al. Mobile phone use, exposure to radiofrequency electromagnetic field, and brain tumour: A case-control study. *British Journal of Cancer* 2008; 98(3):652–659.
7. Johansen C, Boice Jr. JD, McLaughlin JK, Olsen JH. Cellular telephones and cancer: A nationwide cohort study in Denmark. *Journal of the National Cancer Institute* 2001; 93(3):203–207.
8. Schuz J, Jacobsen R, Olsen JH, et al. Cellular telephone use and cancer risk: Update of a nationwide Danish cohort. *Journal of the National Cancer Institute* 2006; 98(23): 1707–1713.
9. Schoemaker MJ, Swerdlow AJ, Ahlbom A, et al. Mobile phone use and risk of acoustic neuroma: Results of the Interphone case-control study in five North European countries. *British Journal of Cancer* 2005; 93(7):842–848.
10. Hours M, Bernard M, Montestrucq L, et al. [Cell phones and risk of brain and acoustic nerve tumours: The French INTERPHONE case-control study.] *Revue d'Epidemiologie et de Sante Publique* 2007; 55(5):321–332.
11. Cardis E, Richardson L, Deltour I, et al. The INTERPHONE study: Design, epidemiological methods, and description of the study population. *European Journal of Epidemiology* 2007; 22(9):647–664.

12. International Agency for Research on Cancer (2008). *INTERPHONE Study: Latest Results Update--8 October 2008*. Lyon, France. Retrieved September 8, 2009, from: <http://www.iarc.fr/en/research-groups/RAD/Interphone8oct08.pdf>.
13. Christensen HC, Schuz J, Kosteljanetz M, et al. Cellular telephone use and risk of acoustic neuroma. *American Journal of Epidemiology* 2004; 159(3):277–283.
14. Lonn S, Ahlbom A, Hall P, Feychting M. Mobile phone use and the risk of acoustic neuroma. *Epidemiology* 2004; 15(6):653–659.
15. Hardell L, Carlberg M. Mobile phones, cordless phones and the risk for brain tumours. *International Journal of Oncology* 2009; 35:5–17.
16. Christensen HC, Schuz J, Kosteljanetz M, et al. Cellular telephones and risk for brain tumors: A population-based, incident case-control study. *Neurology* 2005; 64(7): 1189–1195.
17. Lonn S, Ahlbom A, Hall P, Feychting M, Swedish Interphone Study Group. Long-term mobile phone use and brain tumor risk. *American Journal of Epidemiology* 2005; 161(6):526–535.
18. Lahkola A, Auvinen A, Raitanen J, et al. Mobile phone use and risk of glioma in five North European countries. *International Journal of Cancer* 2007; 120(8):1769–1775.
19. Lahkola A, Salminen T, Raitanen J, et al. Meningioma and mobile phone use—a collaborative case-control study in five North European countries. *International Journal of Epidemiology* 2008; 37(6):1304–1313.
20. Ries LAG, Melbert D, Krapcho M, et al. *SEER Cancer Statistics Review, 1975–2005*. Bethesda, MD: National Cancer Institute. Retrieved September 4, 2009, from: http://seer.cancer.gov/csr/1975_2005.
21. Stang A, Anastassiou G, Ahrens W, et al. The possible role of radiofrequency radiation in the development of uveal melanoma. *Epidemiology* 2001; 12(1):7–12.
22. Linet MS, Taggart T, Severson RK, et al. Cellular telephones and non-Hodgkin lymphoma. *International Journal of Cancer* 2006; 119(10):2382–2388.
23. Lonn S, Ahlbom A, Christensen HC, et al. Mobile phone use and risk of parotid gland tumor. *American Journal of Epidemiology* 2006; 164(7):637–643.
24. Sadetzki S, Chetrit A, Jarus-Hakak A, et al. Cellular phone use and risk of benign and malignant parotid gland tumors—a nationwide case-control study. *American Journal of Epidemiology* 2008; 167(4):457–467.

25. Lahkola A, Salminen T, Auvinen A. Selection bias due to differential participation in a case-control study of mobile phone use and brain tumors. *Annals of Epidemiology* 2005; 15(5):321–325.
26. Vrijheid M, Deltour I, Krewski D, Sanchez M, Cardis E. The effects of recall errors and of selection bias in epidemiologic studies of mobile phone use and cancer risk. *Journal of Exposure Science and Environmental Epidemiology* 2006; 16(4):371–384.
27. Ahlbom A, Feychting M, Green A, et al. Epidemiologic evidence on mobile phones and tumor risk: A review. *Epidemiology* 2009; 20(5):639–652.

###

Related NCI materials and Web pages:

- National Cancer Institute Fact Sheet 3.46, *Magnetic Field Exposure and Cancer: Questions and Answers*
(<http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields>)
- Cancer Causes and Risk Factors Home Page
(<http://www.cancer.gov/cancertopics/prevention-genetics-causes/causes>)

How can we help?

We offer comprehensive research-based information for patients and their families, health professionals, cancer researchers, advocates, and the public.

- **Call** NCI's Cancer Information Service at 1-800-4-CANCER (1-800-422-6237)
- **Visit** us at <http://www.cancer.gov> or <http://www.cancer.gov/espanol>
- **Chat** using LiveHelp, NCI's instant messaging service, at <http://www.cancer.gov/livehelp>
- **E-mail** us at cancergovstaff@mail.nih.gov
- **Order** publications at <http://www.cancer.gov/publications> or by calling 1-800-4-CANCER
- **Get help** with quitting smoking at 1-877-44U-QUIT (1-877-448-7848)

This fact sheet was reviewed on 9/9/09