THE CELL PHONE PROBLEM

CELL PHONES

TECHNOLOGY | EXPOSURES | HEALTH EFFECTS

ENVIRONMENT & HUMAN HEALTH, INC.

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Introduction

This report explores what we know about cell phone use, exposures, and effects on human health.

What are the potential health issues associated with cellular telephone use?

Whether it's the increased use of cell phones by children, or the overall increase in cell phone use by adults, human exposure to electromagnetic radiation is happening in ways never dreamed of before. Very young children are using them, teenagers live on them—and some even sleep with them on their pillows, as cell phones are often used as alarm clocks.

What do these exposures consist of and what do they mean for human health? Whether cell phone use affects the human nervous system and reproduction, causes DNA damage and behavioral changes, or creates addictive behavior, cell phones are now ubiquitous in our lives.

Cell phone technology has changed quickly over time and continues to develop, which means that human exposures also change over time. This report explores what we know about cell phone use, exposures, and human health.

The Cell Phone Problem

Electromagnetic Radiation

- All cell phones emit a type of radiation called an electromagnetic field (EMF), composed of waves of electric and magnetic energy moving together through space. Different types of electromagnetic energy are categorized by their wavelengths and frequencies and comprise the electromagnetic "spectrum" (see next page).

- Different radiation frequencies are used by different technologies. Radio waves and microwaves emitted by transmitting antennas are a form of electromagnetic energy collectively referred to as radio-frequency (RF) energy or radiation.

- The RF part of the electromagnetic spectrum consists of frequencies in the range of about 3 kilohertz (3 kHz) to 300 gigahertz (300 GHz). RF energy is used in telecommunications services, including radio and television broadcasting, mobile communication, GPS devices, radio communications for police and fire departments, and satellite communications. Non-communication sources of RF energy include microwave ovens, radar, and industrial uses.

- The complete electromagnetic spectrum consists of both ionizing and non-ionizing radiation. Non-ionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy to remove an electron from an atom or a molecule. Sources of non-ionizing radiation include microwaves, radio waves, cordless phones, wireless networks (wifi), power lines and MRIs.

- Ionizing radiation has high-frequency waves with enough energy to eject electrons from molecules. It can damage the structure of cells in the body (including DNA) and has well-documented effects on human health. Ionizing radiation is emitted by radon, uranium, and

RF energy is used in telecommunications services, including radio and television broadcasting, mobile communication, GPS devices, radio communications for police and fire departments, and satellite communications.

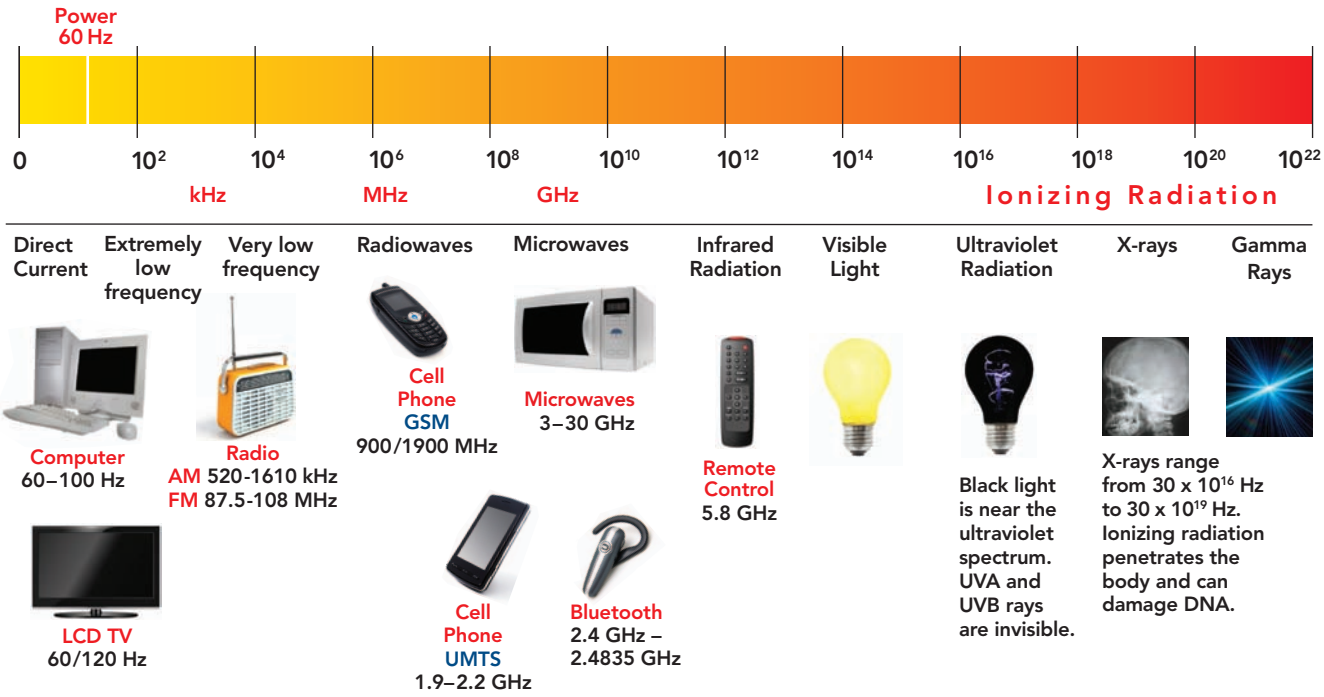
Abbreviations

EMF	electromagnetic field
EMR	electromagnetic radiation
RF	radiofrequency
MW	microwave
ELF	extremely low frequency (typically 1 to 300 Hz)

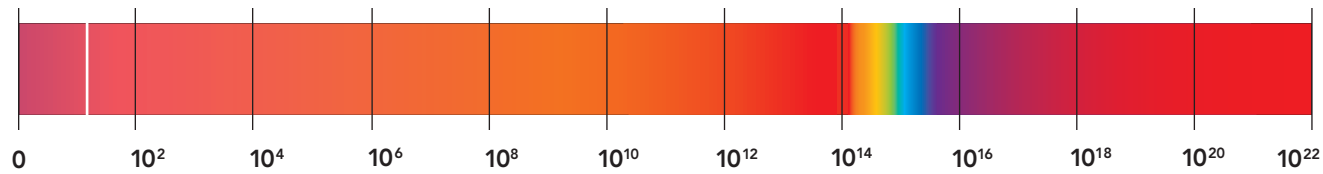
Source: *NIEHS, http://www.niehs.nih.gov/health/docs/emf-02.pdf*

Electromagnetic Spectrum

Frequency (Hz)



Frequency (Hz)



Wavelength in meters

other naturally occurring radioactive elements and is used for X-rays, nuclear medicine, and CT ("cat") scans.

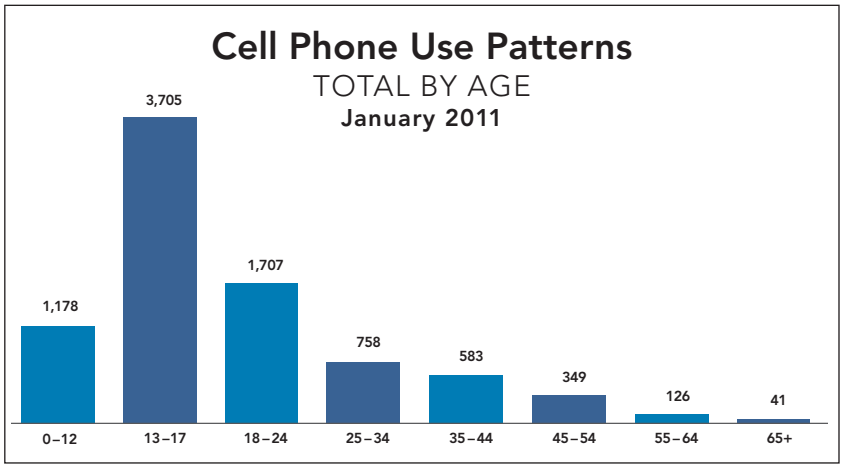
- Decades of research demonstrate that even low doses of ionizing radiation can increase the risk of cancer. The thyroid gland and bone marrow are particularly sensitive to ionizing radiation, especially in children. Leukemia, which arises in the bone marrow, is the most sensitive radiation-induced cancer and may appear as early as a few years after radiation exposure. Other cancers that can result from exposure to ionizing radiation, sometimes decades after exposure, include cancers of the lung, skin, thyroid, brain, breast, and stomach. While cell phones are not associated with ionizing radiation, their long-term risks are unknown.

By the end of 2010, 96 percent of the U.S. population—or slightly more than 300 million people—owned cell phones.

Cell Phone Use Patterns

- Few individuals could afford the cost of a $4,000 cell phone when the first commercial cell phone service was activated in the United States in 1983. But by the end of 2010, 96 percent of the U.S. population—or slightly more than 300 million people—owned cell phones. An entire generation has now grown up using cell phones, and increasingly they're buying family plans for their spouses and children.

- Consumers are using cell phones instead of landlines, evidenced by the fact that nearly 30 percent of households were wireless-only by the end of 2010.[1] By 2007, text messaging had overtaken talking as the primary use of cell phones. Today, young teens text more, talk



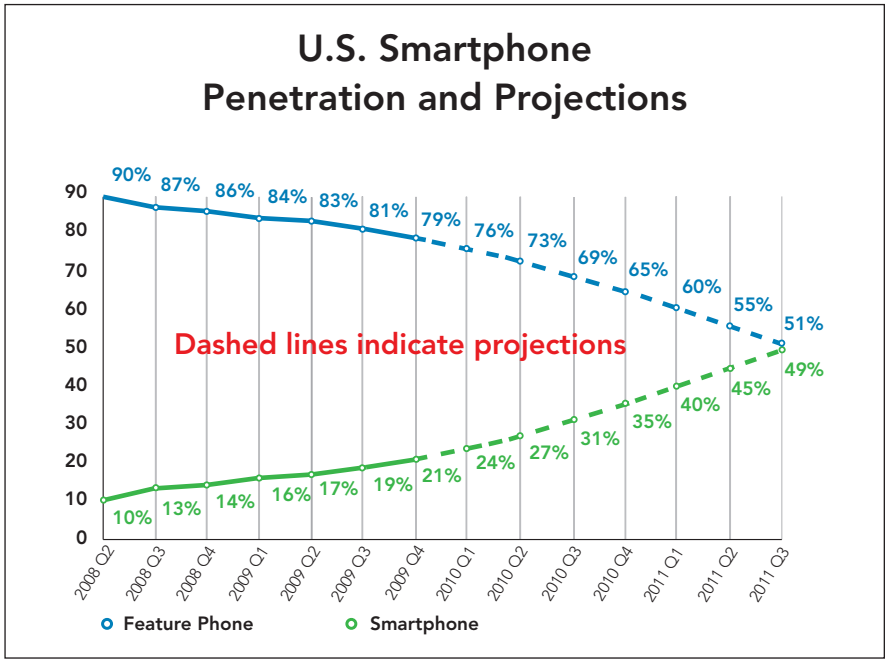
Source: *The Nielsen Company. http://www.onlinemarketing-trends.com/2011/03/us-teens-mobile-texting-numbers.html*

A smartphone is defined as a cell phone that is capable of doing more than just phone. Users can email, search the web, edit documents, keep a calendar, check the weather, play games, and perform many other functions.

less, and watch more videos on their phones than other age groups. Each month, they send and receive an average of 3,705 texts and watch, on average, more than seven hours of mobile video. Teens talk the least on their phones (except for those older than 65), an average of 515 minutes per month compared to more than 750 minutes among users between the ages of 18 and 24.

- *Smartphones* are the most popular phones on the market. A smartphone is defined as a cell phone that is capable of doing more than just phone. Users can email, search the web, edit documents, keep a calendar, check the weather, play games, and perform many other functions.

- About one-third of those aged 12 to 17 currently own a smartphone, twice as many as in 2010. By 2012, more than 60 percent of teens will likely own smartphones.[2] Higher rates of smartphone ownership will change how the majority of people use their phones.



Source: The Nielsen Company. http://gigaom.com/2010/03/26/1-in-2-americans-will-have-a-smartphone-by-christmas-2011

- Smartphone users are using their phones for much more than talking. The percentage of people who use their phone only for calls has dropped from 14 percent of new feature phone owners to three percent of smartphone owners.[3] Originally, a feature phone was simpler than a smartphone, but recent changes and upgrades to the feature phone have now blurred the differences between them. Users report that:
  - 66 percent use speakerphone occasionally
  - 86 percent use the internet
  - 80 percent check email on their devices
- Smartphone owners are more likely to download applications onto their handsets. Games are the most popular type of applications, or "apps," for smartphones, followed by weather and social networking apps. The average mobile gamer plays eight hours a month. A recent Nielsen survey found that people with iPhones play nearly 15 hours each month, while those with Android devices play around nine hours per month.[4]

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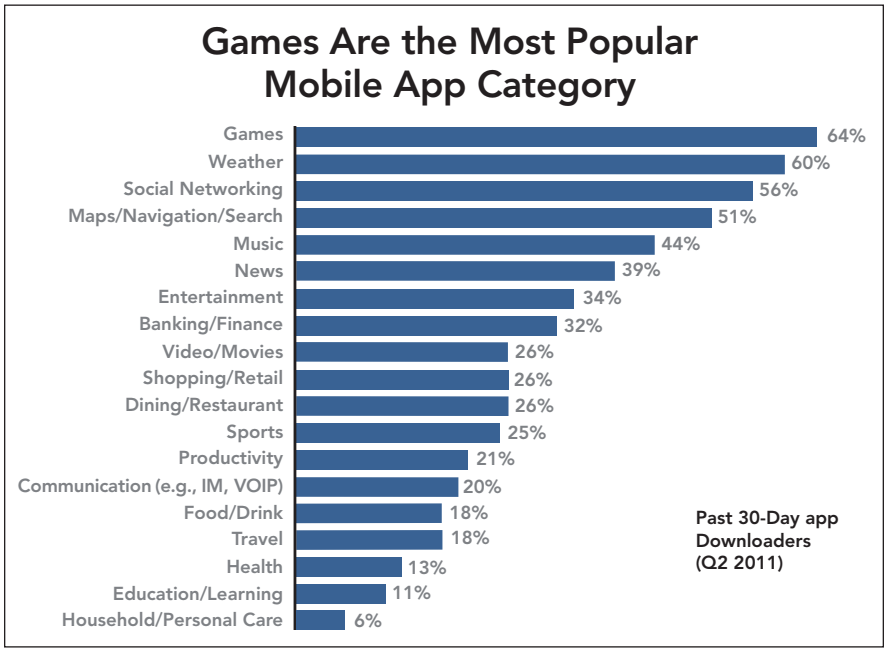


Source: The Nielsen Company. http://www.phonearena.com/image.php?m=Articles.Images&f=name&id=42761&name=n1.jpg&caption=%22Games%22+was+the+number+one+category

Radiofrequency (RF) Exposure from Cell Phones, Headsets, and Cordless Phones

Most countries consider the radiofrequency (RF) spectrum to be the exclusive property of the state.... Cell phone networks worldwide use the Ultra High Frequency (UHF) portion of the RF spectrum for transmission and reception.

- Most countries consider the radiofrequency (RF) spectrum to be the exclusive property of the state. In the 1980s, the RF spectrum was only used for radio and television broadcasting. Today, RF spectrum users include mobile phones, wireless computers, and many other wireless devices. The RF spectrum is divided into different frequency bands, each of which has specific applications.

- Cell phone networks worldwide use the Ultra High Frequency (UHF) portion of the RF spectrum for transmission and reception. The first commercial standard for mobile connection in the United States was in the 800-megahertz (MHz) frequency band. A megahertz is a unit of frequency equal to one million cycles per second. Megahertz is used to measure wave frequencies, as well as the speed of microprocessors.

- Radio waves, which are used for both radio and TV broadcasts, are typically measured in megahertz. FM radio stations, for example, broadcast their signals between 88 and 108 MHz. When you tune to 93.7 on a radio, the station is broadcasting at a frequency of 93.7 MHz.

- Although the first cell phones connected at 800 MHz, more powerful generations of cell phones have evolved over the past 40 years, with each decade bringing a higher operating frequency than the one before.

Communications Standards

- The two primary mobile communication technologies used today are the Global System for Mobile Communications (GSM) and the Universal Mobile Telecommunications System (UMTS).

Communications Technologies

YEAR INTRODUCED	MOBILE PHONE	TYPE	FREQUENCY
1980s	1G	Analog phones	450 & 900 MHz
1990s	2G	Digital (GSM)	900 & 1900 MHz
2000	3G	UMTS	1900–2200 MHz
2011	4G	UMTS	2000–8000 MHz (frequencies not yet allocated)

The GSM network is divided into various cells that interact with a corresponding tower to serve mobile phones in that area. The GSM standard initially used the 900 MHz band. Service providers such as AT&T and Comcast compete for licenses in ever higher frequency bands.

GSM phones that transmit around 900 MHz (or 900 million cycles per second) are being replaced by UMTS phones that transmit around 2.1 gigahertz (GHz) = 2.1 billion cycles per second.

Frequency/Wavelength

1 hertz	=	1 Hz	=	one oscillation per second
1 kilohertz	=	1 kHz	=	one thousand Hz
1 Megahertz	=	1 MHz	=	one million Hz
1 Gigahertz	=	1 GHz	=	one billion Hz

- Experimental studies on the potential health effects of RF radiation attempt to replicate a specific frequency. Studies published in the early 1990s were based on frequency exposures of analog phones popular in the 1980s. GSM phones that transmit around 900 MHz (or 900 million cycles per second) are being replaced by UMTS phones that transmit around 2.1 gigahertz (GHz) = 2.1 billion cycles per second. Health and behavioral studies conducted on 3G (third-generation) UMTS frequencies are likely to be outdated as 4G and 5G devices become widely available.

A person who is text messaging, accessing the internet, or using a "hands-free" device will have lower exposure to RF energy than someone holding the phone against his or her head.

- Universal Mobile Telecommunications Service (UMTS) is 3G broadband that transmits packets of information, including voice, video, and text. UMTS is a global standard that will eventually provide consistent services and coverage anywhere within range of the land-based or satellite transmitters. Little research on the effects of UMTS microwaves on human health is available.[5]

- Ultra wideband (UWB or digital pulse wireless) technology, approved by the Federal Communications Commission (FCC) in 2002, allows the transmission of large amounts of digital data over a wide spectrum of frequency bands with very low power for a short distance.

- Most cell phones used in 2011–2012 operate at frequencies between 450 and 2700 MHz, with peak powers in the range of 0.1 to 2 watts (a watt is a unit of power). The radiofrequency exposure to a user decreases rapidly with increasing distance from the phone.

- A person who is text messaging, accessing the internet, or using a "hands-free" device will have lower exposure to RF energy than someone holding the phone against his or her head. Someone who stores the phone in a briefcase or purse will have far lower exposure than one who carries the device in a pocket. This is the case even in standby mode because of the device's constant searching for service or new messages.

Specific Absorption Rate (SAR)

- Exposure to RF energy is determined by the Specific Absorption Rate (SAR), a measure of the rate at which energy is absorbed by the body when exposed to radiofrequency. It is defined as the power absorbed per mass of tissue, measured in watts per kilogram (W/kg).

- The SAR is commonly used to measure power absorbed during MRI scans and from mobile phones. The FCC's allowable SAR

limit for the head is 1.6 W/kg (measured where the absorption rate is highest, which in the case of a mobile phone is often close to the phone's antenna). For exposure of other parts of the body from cell phones, partial-body SAR limits have been established to control absorption of RF energy (see Laws, Regulations, and Policies on page 44).

- The FCC requires manufacturers to ensure that cell phones are below SAR levels and asserts that all phones legally sold in the United States are therefore "safe." No specific labeling of the SAR is required on the phone or packaging material, but the FCC ID number from the phone (sometimes behind the battery pack) can be entered into a database on the FCC's website to find the specific SAR value.

Bluetooth is a brand name for a wireless networking technology that uses shortwave radiofrequency to connect cell phones, portable computers, and other wireless devices.

- The SAR varies by phone model. For example, the iPhone has SAR levels ranging from 0.79 W/kg to 1.38 W/kg, depending on the model (the iPhone 4 is the highest). The SAR for a specific model also varies according to the frequency. The Apple iPad, on average, has an SAR level of 1.04 W/kg, but varies from frequency to frequency, ranging from 0.74 to 1.19 W/kg. The display unit of a phone or hand-held device also emits radiation. Larger screens typically release more radiation.

RF Exposure from Headsets and Cordless Phones

- *Bluetooth* is a brand name for a wireless networking technology that uses shortwave radiofrequency to connect cell phones, portable computers, and other wireless devices. Bluetooth technology allows two electronic devices to talk to each other wirelessly.

- Bluetooth, invented in Sweden in 1994, was named for Harald Blåtand (known as Harald Bluetooth), a tenth-century Danish Viking king who united and controlled large parts of Scandinavia that today are Denmark and Norway. The name was chosen to highlight the

Although wired headsets may reduce exposure to the head, the body can still be exposed when the phone is kept in a pocket.

potential of the technology to unify the telecommunications and computing industries. Bluetooth originally was an internal code name that was never expected to survive as the name used in the commercial arena.[6]

- Bluetooth and wired headsets are classified as "low-power, non-licensed radiofrequency devices" by the FCC. Bluetooth devices emit lower levels of RF radiation than cell phones and may reduce the amount of RF radiation exposure to the head.[7]

- Bluetooth devices may increase exposure to different parts of the body, however, including the testes or ovaries when a phone is kept in a pocket while in stand-by mode.[8] Although wired headsets may reduce exposure to the head, the body can still be exposed when the phone is kept in a pocket. In fact, there will be two exposures: one at a lower frequency to the ear and another to the body from the pocket or wherever the cell phone is kept.

- The three different categories of range for Bluetooth—Class 1, Class 2, and Class 3—determine the level of operation. Devices with the highest range of operation are categorized as Class 1, which has the highest power usage and the highest range, up to 328 feet. Class 1 devices are expensive and are generally used by industry.

- Most Bluetooth devices for mobile phones are in Class 2, which has a range of about 32.8 feet. This means you can transfer information to another Class 2 or Class 1 device from about 33 feet away from the device.

- Finally, Class 3 has the lowest range, about three feet. It is the least expensive and is used for such devices as headsets.

- In recognition of this power difference, the Swiss Federal Office of Public Health advises users of the stronger Class 1 transmitters to switch off the internet connection when making phone calls to reduce additional exposure of the head to radiation.[9]

- Wireless hands-free devices may also reduce exposure to the head, but may increase exposure to RF energy in the ear.[10]

- Digital Enhanced Cordless Telephone (DECT) is a digital communication standard that is used mainly for cordless phone systems. DECT allows the use of multiple cordless handsets with one base station. Unlike cell phone emissions, DECT cordless phone emissions are always of the same strength during a call, despite the distance from the base station or the quality of the connection.

Unlike cell phone emissions, DECT cordless phone emissions are always of the same strength during a call, despite the distance from the base station or the quality of the connection.

- Digital Enhanced Cordless Telephone (DECT) cordless phones sold in the United States today emit pulses of microwave radiation similar to cell phones, in the frequency range of 1880–1930 MHz. Studies show that DECT phones are the source of the highest levels of RF emissions in many homes and a source of overall personal exposure to RF-EMF.[11]

- Not until the mid-1990s did cordless DECT technology became economically feasible for use in the home, and few studies have looked at exposure and health risks. A German study, for example, found no association between cordless phone use and brain tumors, while a Swedish study found elevated risks of brain tumors with long-term use of cordless phones.[12]

Radiofrequency Exposure: Children and Teenagers

Nineteen percent of children age two to five are more likely to operate a smartphone than swim, tie their shoelaces, or make their own breakfast.

- Today's teenagers are the first generation to grow up using a wireless device and to have been exposed to RF radiation as young children. Childhood RF radiation exposure is a concern for several reasons:
  - A child's brain absorbs significantly more radiation than an adult's brain.
  - Children's anatomical differences may allow greater exposure of their brain regions from cell phone RF because of differences in electrical conductivity in their bone marrow.[13]

Young Children

- Despite concerns about the long-term health effects of RF radiation exposure, the popularity of cell phone use among young children is skyrocketing, even among very young children. Nineteen percent of children aged two to five are more likely to operate a smartphone than swim, tie their shoelaces, or make their own breakfasts. Almost as many children aged two to three (17 percent) can play with smartphone applications as children aged four to five (21 percent). One-quarter of all U.S. children aged two to five know how to make a mobile phone call.[14]

- Numerous phones are designed specifically for young children, some with applications for preschool children. Pocket Zoo streams live video of animals at zoos around the world, "flash cards" coach children to read and spell, a "Wheels on the Bus" app sings in multiple languages, and iGo Potty reminds toddlers when to use the bathroom.

- The design of educational applications has led to smartphone adoption in many schools. Outside the classroom, cell phone companies target children by offering free cell phones for kids when added to a family plan.

- Phones like AT&T's *Firefly* are designed for the smaller hands of kids 8 to 12, and Disney phones are specifically made for young children. Sprint's family plan offers phone models for young children and different phones for teens. For very young children, Verizon offers the *Migo,* a phone with a simplified keypad that allows you to program in four numbers. Hello Kitty Bluetooth wireless earphone and Bluetooth devices are newer products for kids.

Tweens and Teens

- Seven out of 10 children in the United States aged 10 to 14 have cell phones. These devices are now the dominant source of radio-frequency exposure in preteens and teens.

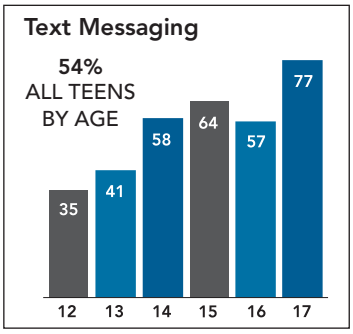
- One in three teens sends more than 3,000 texts per month. Those aged 13 to 17 have the highest levels of text messaging—an average of 3,364 mobile texts per month—more than double the rate of the next most active texting demographic sample, aged 18 to 24. They talk less than older populations—an average of 515 minutes per month, compared to 750 minutes among those aged 18 to 24.[15] Frequent texting means cell phones are often kept in a pocket all day and under a pillow or on a teenager's bed at night.

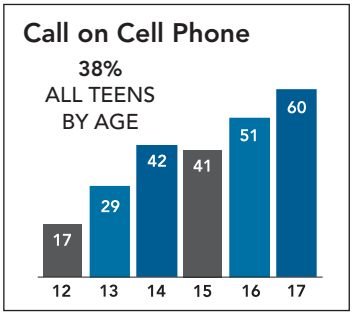
- According to the Pew Internet and American Life Project *(see charts)*, texting behavior is the biggest determinant of whether a teen sleeps with a phone. Teens who use their cell phones to text are more likely to sleep with their phones than cell-owning teens who don't text. According to Pew, teens are not the only age group who sleep next to their phones at night. Nearly all young adults aged 18 to 29—90 percent—sleep with their cell phone on or right next to their bed.

- Slightly fewer—70 percent—of those aged 30 to 49 sleep with their cell phones nearby, as do half of all of cell phone users aged 50 to 64. Although these statistics are impressive, the magnitude of radiation exposure received by the owner remains unclear, as it varies by make of phone and distance from the body.

Teens who use their cell phones to text are more likely to sleep with their phones than cell-owning teens who don't text.

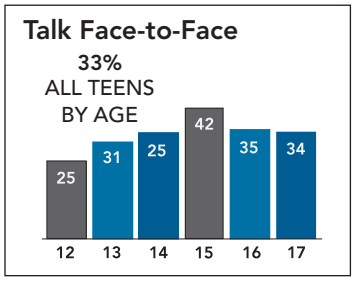
Most teens text friends daily
The percentage of teens who contact their friends daily by different methods, by age ▼

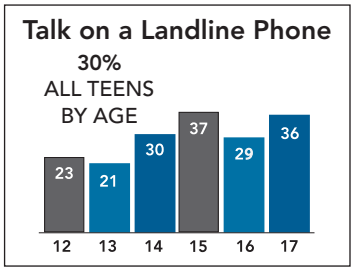


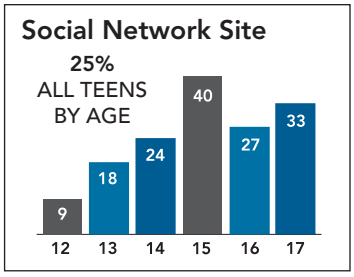


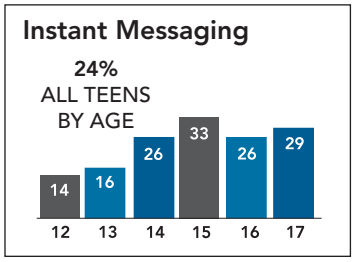
Source: Pew Research Center's Internet and American Life Project

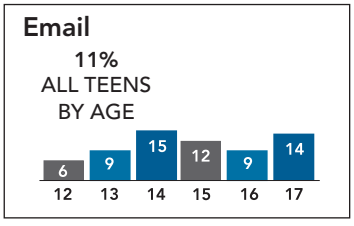
The percentage of teens who contact their friends daily by different methods, by age ▼











- Teenagers now tend to talk on mobile phones more than landlines, a trend that will likely continue. Both teens and young adults in school and college are also using mobile devices at school. Teachers and administrators use smartphone applications to take attendance, poll a classroom, and send out information about homework, exams, school events, and more.

Who sleeps with their cell phone?

The percentage of adults in each group who sleep with a cell phone

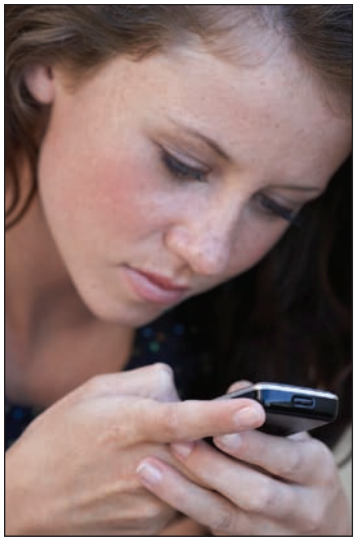
Total	**65%**
Men	67%
Women	64%
Age	
18–29	90%+
30–49	70%+
50–64	50%+
65+	34%+
Race/Ethnicity	
White, Non-Hispanic	62%+
Black, Non-Hispanic	78%
Hispanic, English-speaking	75%
Household Income	
Less than $30,000	73%+
$30,000–$49,999	70%
$50,000–$74,999	61%
$75,000+	64%
Education Level	
Less than High School	67%
High School Diploma	63%
Some College	66%
College+	67%
Parent Status	
Parent	72%+
Not a Parent	62%
Community Type	
Urban	70%+
Suburban	65%
Rural	61%

Source: Pew Research Center's Internet and American Life Project, April 29–May 30, 2010 Tracking Survey. N=2,252 adults 18 and older; n=1,1917 based on cell phone users

Cell Phones in Schools

- Today's children will clearly have a much greater exposure to radiation from cell phones throughout their lives than today's adults.[16]
- Many U.S. classrooms contain wireless routers, which are a source of RF exposure, even for those who do not use handheld devices.
- For online college students, cell phone applications provide access to class materials and discussion boards.
- Concerns about the health risks to children from cell phone RF energy has resulted in efforts in France and throughout Europe to ban cell phone use in schools. Specifically, France prohibits the use of mobile phones in kindergartens, primary schools, and colleges as precautionary measures to reduce potential health risks.
- Following France's ban, the Council of Europe Committee of Ministers recommended that member states should "ban all mobile phones, DECT phones or WiFi or Wireless Local Area Network (WLAN) systems from classrooms and schools." The draft resolution still requires the council's full Parliamentary Assembly for approval.[17]
- The Toronto District School Board recently rescinded a four-year-old rule banning cell phone use, citing support for "21st century learning." In Edmonton schools, cell phones are allowed, but only for use during breaks, and in Halifax most schools have policies in place to keep personal electronic devices out of the classroom.[18]

As cell phones have increased in popularity, parents have increasingly lobbied school boards to allow cell phones, based on the argument that phones will make students and schools safer.



Smartphones have been credited with sparking an educational revolution, and the majority of parents support this.

- In the United States, many school districts restrict cell phones in schools, primarily because they can be disruptive to the educational environment. Some school districts have banned cell phone in schools due to concerns that the phones exacerbate drug and gang problems.

- As cell phones have increased in popularity, parents have increasingly lobbied school boards to allow cell phones, based on the argument that phones will make students and schools safer. A cell phone ban in the New York City schools, the nation's largest school system, sparked a lawsuit by concerned parents. Currently, the New York Department of Education has the following policy:

  > *Students are NOT permitted to bring electronic devices—iPods, cell phones, kindles, blackberries, etc. to school. All electronic devices, cellular phones/blackberries must be turned off and left in the main office or they will be confiscated when seen and/or heard. Cellular phones will be returned to parents/guardians ONLY.* [19]

- The recent increase in the number of educational smartphone applications has resulted in some classrooms making smartphones an integral part of their lesson plans.

- Smartphones have been credited with sparking an educational revolution, and the majority of parents support this. Most U.S. parents (67 percent) would purchase a mobile device for their child to use for schoolwork if the school allowed it, and 61 percent support the idea of students using mobile devices to access online textbooks, according to a 2011 national briefing.[20]

- Younger students across the country use mobile device programs like TeacherMate, introduced in 2008, bundled with games customized to match K-2 reading. Math curricula (available on iPads and iPod Touches) are now being offered to poor rural communities around the world.[21]

Health Risks

As the science has matured, researchers and government officials have become increasingly concerned about exposures that affect pregnant women—and their fetuses.

- Russian and Eastern European scientists issued the earliest reports that low-level exposure to RF radiation could cause a wide range of health effects, including behavioral changes, effects on the immunological system, reproductive effects, changes in hormone levels, headaches, irritability, fatigue, and cardiovascular effects.

- Since the first reports appeared in the literature, scientists have recognized the near-ubiquitous use and exposure to cell phones and other radiofrequency technologies in the last decade, and have launched and completed many studies. As the science has matured, researchers and government officials have become increasingly concerned about exposures that affect pregnant women—and their fetuses. Their concern is also for children whose brains and organs do not fully mature until age 21.

- Non-ionizing radiation, with long wavelength and low frequency, does not break chemical bonds, but has sufficient energy to move electrons and heat body tissue, leading to biological effects at certain doses. Except for optical radiation, there is little data on the quantitative relationships between exposures to different types of non-ionizing radiation and effects on human health.

- In 1996, the World Health Organization (WHO) established the International EMF Project to review the scientific literature concerning biological effects of EMFs, and will conduct a formal risk assessment of all studied health outcomes from exposure to RF fields by 2012.

- The majority of studies examining biological and health effects of cell phone radiation have focused on the potential of cell technologies to cause cancer, nervous system disorders, and adverse reproductive effects. This literature is reviewed on the following pages.

Several studies have found an increase in the risk of developing some types of tumors after long-term exposure, but experimental studies are not available to explain the link, causing some to remain skeptical about the association.

Cancer

- Since RF-EMFs are emitted from cell phones in close proximity to the head, the potential for brain tumors has been a concern. Most studies have focused on potential associations between cell phone use and only a few types of brain tumors.

- Several studies have found an increase in the risk of developing some types of tumors after long-term exposure, but experimental studies are not available to explain the link, causing some to remain skeptical about the association. Overall, 33 peer-reviewed epidemiologic studies on cell phones and cancer have been conducted. Twenty-five of these studies have focused on brain tumors.[22] Some have found a risk of cancer with long-term use of cell phones,[23] while others have not.[24]

- Data derived from studies spanning decades may be dated by the time they are published, due to rapidly changing technology and cell phone use patterns. A National Cancer Institute (NCI) case-control study of brain tumors and use of cell phones by adults which began in 1994 — 11 years after the first commercial cell phone was activated in the United States — found no indication of higher brain tumor risk among people who had used cell phones compared with those who had not used them. However, patterns of cell phone use and the types of phones used in the United States have changed since the early to mid-1990s, and few users in the study reported using cell phones for five years or more.[25]

Types of Brain Tumors

Glioma	Cancer that begins in brain cells
Meningioma	Tumor originating in the brain and spinal cord; not always malignant.
Acoustic Neuroma	Non-cancerous tumors that arise in nerve cells that supply the ear
Salivary Gland Tumors	Cancerous and non-cancerous

- Strong studies about the relationships between cell phone use and cancer have been published by Hardell et al. and WHO's International Agency for Research on Cancer (IARC). Both Hardell et al.

and IARC's Interphone studies are the subject of criticism about methodological deficiencies, inadequate exposure assessment, and problems with recall and response.

- **IARC's Interphone study**, the largest cell phone health study conducted, found "suggestions of an increased risk of glioma at the highest exposure levels" but notes "biases and error prevent a causal interpretation."[26] The Mobile Manufacturers forum notes that it provides assurance of the safety of cell phones, and the Food and Drug Administration (FDA) notes that these biases and errors limit the strength of conclusions that can be drawn from it. Others argue that the study may underestimate the real risk of cell phones today, noting that the average present-day user in the U.S. could fall into this "highest level of exposure" risk use category after about 13 years.[27]

- The Swedish researcher **Dr. Lennart Hardell et al.** have conducted six independently funded studies on cell phones and tumors, using the Swedish Cancer Registry, and has found a consistent pattern of increased risk for glioma and acoustic neuroma after 10 years of mobile phone use. Noting that the evidence for risks from prolonged cell phone and cordless phone use is "quite strong," Hardell et al. concluded, "For people who have used these devices for 10 years or longer, and when they are used mainly on one side of the head, the risk of malignant brain tumor is doubled for adults and is even higher for persons with first use before the age of 20 years."[28]

- Critics of Hardell's studies claim "recall bias" prevent objective data, and have prevented Hardell's work from supporting a theory of cancer causation in humans in legal decisions. The Daubert standard rule of evidence requires scientific evidence to be "reliable and relevant" in order to be admitted to federal court. Others argue that Hardell may have underestimated the risk from mobile phone use and that his research is less biased than that of the Interphone study.[29]

For people who have used these devices for 10 years or longer, and when they are used mainly on one side of the head, the risk of malignant brain tumor is doubled for adults and is even higher for persons with first use before the age of 20 years.

Review studies note that insufficient time has passed to evaluate long-term risks associated with slow-growing brain tumors, but some studies already show possible evidence of an increased risk of brain tumors from the use of cell phones.

Table 1. Comparison of the Hardell and Interphone Studies

AUTHOR	FINDING	CONCERNS	FUNDING
Lennart Hardell et al.	Increased risk for glioma and acoustic neuroma after 10 years of mobile phone use.	Recall bias; no dose-response relationship	Independently funded
IARC's Interphone	Suggestions of an increased risk of glioma at the highest exposure levels.	Biases and error prevent a causal interpretation.	Funded in part by industry with agreement to guarantee scientific independence.

- Data from ionizing radiation studies indicate a brain tumor latency time of between 20 and 55 years. Acoustic neuromas associated with childhood radiation exposure used to treat "enlarged" tonsils and adenoids appeared up to 55 years after the original exposure, with a mean of 38 years.[30]

- Review studies note that insufficient time has passed to evaluate long-term risks associated with slow-growing brain tumors, but some studies already show possible evidence of an increased risk of brain tumors from the use of cell phones. Almost all research on mobile phone radiation studying an exposure duration of 10 years or longer point towards the existence of an increased tumor risk in the head.[31]

- The most recent U.S. brain cancer incidence rates indicate that rates have declined slightly or remained the same, except in those aged 20 to 29. Females in this group experienced a statistically significant increase in frontal lobe cancers, but not in parts of the brain that would be more highly exposed to RF radiation from cell phones.[32]

- In 2011, WHO's International Agency for Research on Cancer (IARC) classified electromagnetic fields as possibly carcinogenic to humans, citing an increased risk of glioma associated with wireless phone use.[33] The evidence linking wireless phone use to glioma

Table 2. RF Radiation from Cell Phones and Cancer: Conclusions of Peer-Reviewed Review Studies

AUTHOR	FINDINGS	AFFILIATION
Ahlbom A et al. (2009)[34]	"…the studies published to date do not demonstrate an increased risk within approximately 10 years of use for any tumor of the brain or any other head tumor.… For slow-growing tumors…the absence of association reported thus far is less conclusive because **the observation period has been too short."**	International Commission for Non-Ionizing Radiation Protection
Khurana VG et al. (2009)[35]	"..there is **adequate epidemiologic evidence to suggest a link** between prolonged cell phone usage and the development of an ipsilateral brain tumor."	Australian National University
Han YY et al. (2009)[36]	"Some studies of longer term cell phone use have found an **increased risk of ipsilateral AN [acoustic neuroma]."**	Center for Environmental Oncology–University of Pittsburgh Cancer Institute
Kohli et al. (2009)[37]	"The evaluation of current evidence provided by various studies to suggest the possible carcinogenic potential of radiofrequency radiation is **inconclusive."**	Department of Internal Medicine, Government Medical College and Hospital, India
Myung et al.[38]	"…there is **possible evidence** linking mobile phone use to an increased risk of tumors from a meta-analysis of low-biased case-control studies."	National Cancer Control Research Institute, National Cancer Center, Korea
Croft et al (2009)[39]	"There are reports of small associations between MP-use ipsilateral to the tumour for **greater than 10 years,** for both acoustic neuroma and glioma, but the present paper argues that these are especially prone to confounding by recall bias."	Australian Centre for Radiofrequency Bioeffects Research
Abdus-Salam et al. (2008)[40]	"…published research works over several decades including some with over ten years of follow up have not demonstrated any significant increase in cancer among mobile phone users. However, the need for caution is emphasized as it **may take up to four decades** for carcinogenesis to become fully apparent."	Department of Radiotherapy, College of Medicine, University of Ibadan, Ibadan, Nigeria.
Kundi (2008)[41]	"The overall evidence speaks in favor of an increased risk, but its magnitude cannot be assessed at present because of **insufficient information on long-term use."**	Institute of Environmental Health, Medical University of Vienna, Vienna, Austria

and acoustic neuroma is considered "limited" and inadequate to draw conclusions for other types of cancers. "Limited evidence of carcinogenicity" is defined by IARC as, "a positive association… between exposure to the agent and cancer for which a causal interpretation is considered by the Working Group to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence."[42]

In 2011, IARC classified radiofrequency electromagnetic fields (RF-EMFs) as possibly carcinogenic to humans, citing an increased risk of glioma associated with wireless phone use.

Table 3. IARC Cancer Groups

IARC's Groups	Number	Examples
Group 1: **Carcinogenic to humans**	107	Asbestos, arsenic, benzene, radon, solar radiation, vinyl chloride, tobacco smoke
Group 2A: **Probably carcinogenic to humans**	59	Nitrate or nitrite, UV radiation, trichloroethylene
Group 2B: **Possibly carcinogenic to humans**	266	Carbon tetrachloride, gasoline, diesel fuel (marine), lead, naphthalene, styrene, RF-EMFs
Group 3: **Unclassifiable as to carcinogenicity in humans**	508	Fluorescent lighting, Hepatitis D virus, personal use of hair coloring products, malathion, melamine
Group 4: **Probably not carcinogenic to humans**	1	Caprolactam (used in making plastics and nylon)

Source: *WHO, IARC. Agents Classified by the IARC Monographs, Volumes 1–100*

- The primary goal of IARC is to identify causes of cancer and it has established the most widely used system for classifying carcinogens. IARC has evaluated the cancer-causing potential of more than 900 likely candidates, placing them into one of the groups in Table 3.

- NCI's *2011 Annual Report to the Nation on the Status of Cancer* notes that the association between long-term (>10 years) cell phone use and brain cancer is *unclear,* "primarily because of the relatively recent adoption of widespread use of cellular phones, as well as issues of bias and study design."[43]

- The NCI further acknowledges that "acoustic neuromas are of particular interest with regard to cellular phone use because of the proximity of these tumors to the phone" and that the "relatively large number of acoustic neuromas identified in the first four years of data collection suggests that etiologic studies will be possible in the future."[44]

Nervous System

- The effects of exposure to RF-EMFs from cell phones on the human nervous system have been the subject of a large number of studies in recent years. Minor effects on brain activity have been found. but have not been related to adverse health effects. No consistent significant effects on cognitive performance and memory have been observed.[45]

- Experiments by Narayanan et al. found that memory retention and retrieval were significantly affected in mobile phone RF-EMR-exposed rats.[46] Several other studies have also measured cognitive effects in animals (Table 4).

- Examples of effects in humans include impaired cognitive performance after exposure to a pulsed electromagnetic field[47] and slower response times to spatial working memory tasks when exposed to RF from a standard GSM cellular phone placed next to the head of male subjects.[48]

- Most studies have focused on changes in cognitive performance after short-term RF-EMF exposure, and most have involved young and middle-aged male and female subjects. Since children represent a sensitive subgroup, as their brains are not yet completely mature, they may react differently to RF-EMF exposure.[49]

- A 2011 review of the literature on the effects of RF-EMF exposure on cognitive performance measured in humans found inconsistent study results due to differences in methodology, sample size, composition of study groups, experimental design and exposure setup, as well as the exposure conditions. The authors note, "The lack of a validated tool, which reliably assesses changes in cognitive performance caused by RF-EMF exposure, may contribute to the current inconsistencies in outcomes."[50]

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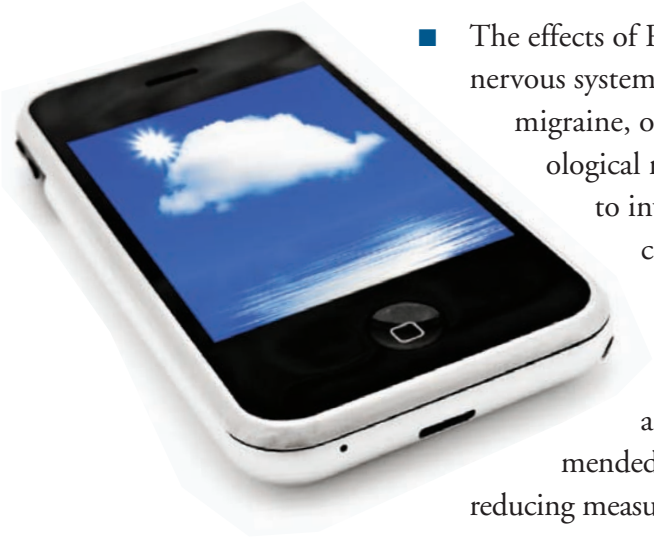


- The effects of RF-EMF exposure from cell phones on central nervous system (CNS) disorders, such as Alzheimer's disease, migraine, or vertigo, has been the focus of recent epidemiological research in Denmark, which is the first country to investigate a possible association between the use of cell phones and the risk of CNS disorders.

- The study found a weak, but statistically significant, association between cell phone use and migraine and vertigo. The Danish study recommended more research in this area, along with RF exposure-reducing measures, until more data have been obtained.[51]

Table 4. RF Radiation from Cell Phones and Effects on Cognition, Learning, or Memory Findings

Author	Year	Species	Frequency	SAR	Exposure Duration	Effect
Narayan SN et al.[52]	2010	Rat	900 MHz – 1.8 GHz	NS	50 missed calls (45 sec.); within 1 hr per day for 4 weeks	Altered passive avoidance behavior and hippocampal morphology
Fragopoulou AF et al.[53]	2010	Mouse	900 MHz	0.41 W/kg – 0.98 W/kg	1 hr 55 min. for the first 3 days; 3 hr 45 min. on the fourth day's probe trial	Deficits in consolidation and/or retrival of learned spatial information
Daniels WM et al.[54]	2009	Rat	840 MHz	NS	Continuous for 3 hrs/day from day 2 to day 14 after birth	Decreased locomotor activity, increased grooming and a tendency toward increased basal corticosterone levels
Nittby H et al.[55]	2008	Rat	900 MHz	0.0006 W/kg – 0.06 W/kg	2 hrs/week for 55 weeks	Reduced memory functions after GSM exposure (P = 0.02)
Eliyahu I et al.[56]	2006	Human	890.2 MHz	NS	Continuous for 2 hours	Exposure to left side of brain slowed left-hand response time
Maier R et al.[57]		Human	902 MHz	NS	Continuous for 50 min	Pulsed EMF exposure impaired cognitive performance

Reproduction

- Several research studies have examined the effects of RF-EMF on the male reproductive system. The focus of research has included effects on semen quality and potential changes associated with RF-EMF exposures and electromagnetic radiation.

- The potential effects of RF-EMF from cell phones on fertility were investigated in a 2005 epidemiological study, which found correlations between cell phone use and changes in semen quality.[58] An experimental study that same year involving exposure of male mice to RF-EMR noted a significant genotoxic effect on epididymal sperm.[59]

- Other studies have correlated the duration of exposure to cell phones with defects in sperm count, motility, viability, and normal morphology, but most of the studies have been small and the evidence remains equivocal.[60]

- Agarwal et al. found that cell phone use decreased semen quality in 361 men by reducing sperm count, motility, viability, and normal morphology, and that the decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality. The same research group placed men's semen samples 2.5 centimeters (about an inch) away from a cell phone, in talk mode, for one hour. This is an average distance between the testes and the pants' pocket.

- Semen exposed to RF electromagnetic waves emitted from cell phones had higher levels of damaging free radicals, lower sperm motility (the ability of sperm to move and swim), lower sperm viability (the percentage of live sperm), and possibly greater oxidative stress.[61]

The potential effects of RF-EMF from cell phones on sperm were investigated in a 2005 epidemiological study, which found correlations between cell phone use and changes in semen quality.

Table 5. Select Cell Phone Radiation Studies Demonstrating Potential Effects on Fertility

Author	Year	Effect Noted
Deluliis et al.[62]	2009	"RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately, DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and well-being of their offspring."
Salama N et al.[63]	2009	"Low intensity pulsed radiofrequency emitted by a conventional mobile phone kept in the standby position could affect the testicular function and structure in the adult rabbit."
Agarwal A et al.[64]	2009	"Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility."
Agarwal A et al.[65]	2008	"Use of cell phones decrease[s] the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality."
Yan JG et al.[66]	2007	"Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats through chi-squared analysis…. [A]bnormal clumping of sperm cells was present in rats exposed to cellular phone emissions and was not present in control group rats. These results suggest that carrying cell phones near reproductive organs could negatively affect male fertility."
Wdowiak A et al.[67]	2007	"In the analysis of the effect of GSM equipment on the semen it was noted that an increase in the percentage of sperm cells of abnormal morphology is associated with the duration of exposure to the waves emitted by the GSM phone. It was also confirmed that a decrease in the percentage of sperm cells in vital progressing motility in the semen is correlated with the frequency of using mobile phones."
Panagopoulos DJ et al.[68]	2007	"Both types of radiation were found to decrease significantly and non thermally the insect's reproductive capacity, but GSM 900 MHz seems to be even more bioactive than DCS 1800 MHz. The difference seems to be dependent mostly on field intensity and less on carrier frequency."
Erogul O et al.[69]	2006	"These data suggest that EMR emitted by cellular phone influences human sperm motility. In addition to these acute adverse effects of EMR on sperm motility, long-term EMR exposure may lead to behavioral or structural changes of the male germ cell. These effects may be observed later in life, and they are to be investigated more seriously."
Aitken et al.[70]	2005	"…while RF-EMR does not have a dramatic impact on male germ cell development, a significant genotoxic effect on epididymal spermatozoa is evident and deserves further investigation."
Fejes I et al.[71]	2005	"Low and high transmitter groups also differed in the proportion of rapid progressive motile sperm (48.7% vs. 40.6%). The prolonged use of cell phones may have negative effects on the sperm motility characteristics."

Other Effects

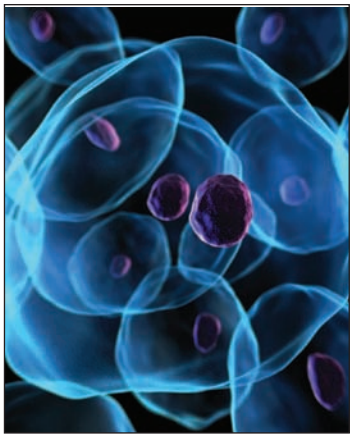
Genotoxic Effects/Cell Damage

- Researchers have studied the potential of RF-EMFs to cause changes in a cell's genetic material (DNA) and/or to damage the genome. "Genotoxic" substances can potentially cause genetic mutations or cellular damage that can contribute to the development of cancerous tumors.

- The European Union's *in vitro* REFLEX study of human cells exposed to cell phone microwave radiation (2000 to 2004) showed that radiation from cell phones has the potential to damage the genome of isolated human cells, but the findings were very controversial. The lead author of the study argues that there is enough evidence that RF radiation can alter the genetic material of exposed cells.[72] Other scientists agree: A recent review of 101 papers on the genotoxic effects of RF-EMF found that 49 reported a genotoxic effect.[73]

- Numerous studies in laboratory animals have demonstrated that mobile phones or simulated RF radiation exposures can damage cells. While some authors have suggested that this could lead to neurological damage, other authors have not.[74] There is no standard testing methodology for the evaluation of possible genotoxic effects of EMFs, which may in part explain why the findings are inconsistent.

- DNA studies have particular importance with respect to children. Researchers who placed a mobile phone at a one-meter (about a yard) distance from human cells found a reduction in DNA repair in cells with double-strand DNA damage. The strongest effects were observed in stem cells. Since stem cells are more active in children, researchers argue that children may be at an increased risk of cancer from cell phone exposures.[75]



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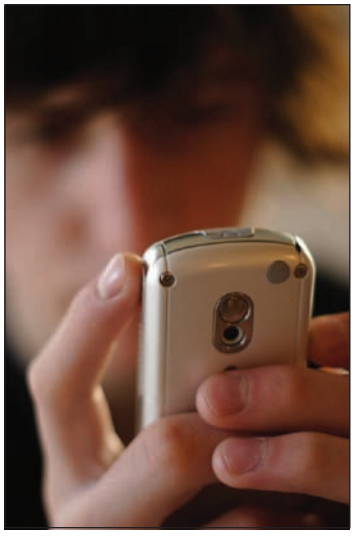


The addictive nature of cell phones has concerned psychologists for years. Recently, psychologists have warned that smartphone users are especially at risk for becoming addicted to their devices.

- For several decades, Swedish neuroscientists have studied the effects of RF-EMFs on nerve cells. They attached cell phones to the sides of young rats' cages to create intermittent exposures similar to human usages, and discovered neuron damage in the brains of young rats 50 days after weekly two-hour exposure.[76]

Ocular Effects

- Thermal effects from microwave radiation have been reported to cause cataracts and effects on the retina, cornea and other ocular systems, but non-thermal effects are less well understood.[77] Studies of non-thermal effects of RF-EMFs from mobile phones are relatively recent. Researchers have recommended further study of effects on the eye lens and lens epithelial cells.[78]

- Electromagnetic fields from microwave radiation have been shown to have a negative impact on the eye lens. One study warns, "High-frequency microwave electromagnetic radiation from mobile phones and other modern devices has the potential to damage eye tissues, but its effect on the lens epithelium is unknown at present."[79]

Psychological Effects

- The addictive nature of cell phones has concerned psychologists for years. Recently, psychologists have warned that smartphone users are especially at risk for becoming addicted to their devices. In a recent study, subjects checked their phones 34 times a day. People may check their phones out of habit or compulsion, but habitually checking can be a way to avoid interacting with people.[80]

- Some people can experience withdrawal symptoms typically associated with substance abuse, such as anxiety, insomnia, and depression, when they are without their smartphones. Most of the studies conducted on the potential psychological effects of cell phones have focused on young adults and adolescents.

- According to a recent Columbia University study, "communication, responsibility, and relationships all seem to be negatively influenced by the use of text messaging" in both early and late adolescent groups.[81] Frequent mobile phone use has been associated with stress, sleep disturbances, and symptoms of depression among young adult men and women.[82] Yen et al. cite "withdrawal symptoms without cellular phone use" as a common psychological reaction in adolescents to the removal of cell phone access.[83]

Some people can experience withdrawal symptoms typically associated with substance abuse, such as anxiety, insomnia and depression, when they are without their smartphones.

Electromagnetic Hypersensitivity

- Some individuals experience adverse medical symptoms from exposure to electromagnetic fields. People with electromagnetic hypersensitivity (EHS) report symptoms from even low levels of exposure to non-ionizing electromagnetic radiation.

- Concerns that cell phones may be associated with EHS are largely a result of complaints from cell phone users about headaches, nausea, dizziness, blurred vision, and other symptoms. Few studies have been conducted on electromagnetic hypersensitivity from exposure to mobile phones.[84]

Studies Specific to Children

- Children may be potentially susceptible to RF effects because of their developing nervous systems, increased levels of cell division, undeveloped immune systems, thinner skulls, and more conductive brain tissue. Children experience greater RF penetration relative to head size, and longer lifetime exposure in comparison with adults.[85]

- Epidemiological studies demonstrating health effects of RF radiation from cell phones on children are extremely limited. The few studies that have specifically focused on cell phones and children have focused on cancer, behavior, and neonatal heart rate.

Dr. Hardell reported that people who started mobile phone use before the age of 20 had a more than five-fold increase in glioma. Those who started using mobile phones young were also five times more likely to develop acoustic neuromas.

Cancer, Hardell study

At the first international conference on mobile phones and health in 2008, Lennart Hardell, M.D., Ph.D., reported that people who started mobile phone use before the age of 20 had a more than five-fold increase in glioma. Those who started using mobile phones when they were young were also five times more likely to develop acoustic neuromas.[86]

Cancer, CEFALO study

The CEFALO is an international, multicenter, case-control study of the association between mobile phone use and brain tumor risk in children aged 7 to 19.

- Published in July 2011, the CEFALO study was conducted in Denmark, Sweden, Norway, and Switzerland. It included children and adolescents aged 7–19 years who were diagnosed with a brain tumor between 2004 and 2008.
- The study found that children and adolescent patients with brain tumors were not statistically significantly more likely to have been regular cell phone users than control subjects. The authors note that the possibility that cell phones might confer a small increase in risk cannot be ruled out and emphasize "the importance of future studies with objective exposure assessment or the use of prospectively collected exposure data."[87]
- The report has some shortcomings; most notably, it can take 10 years or more to develop cancer following exposure, but only seven years have passed since the beginning of the study.
- Second, phone use patterns have changed significantly since the study was conducted. In the study, one call per week counted as "regular" use, skewing the results.
- An analysis of a subset of the data corresponding only to heavy cell phone users, however, found different results. In the author's words: "[There] was a highly significant association between the

time since first subscription and brain tumor risk. Children who used cell phones for at least 2.8 years were more than twice as likely to have a brain tumor than those who never regularly used cell phones."[88]

Environment and Human Health, Inc.'s forthcoming animal research study shows a relationship between cell phone use in pregnancy and behavioral issues in the offspring.

- ## Behavior

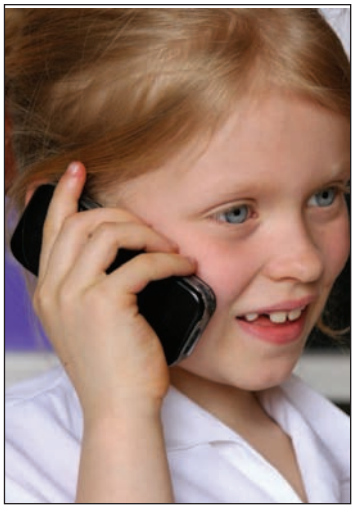
Professor Leeka Kheifets, M.A., Ph.D., of the Department of Epidemiology at the University of California, Los Angeles, and her colleagues conducted several studies on children's exposure to mobile phones early in life and the association with behavioral problems.

- One study, involving 13,000 children who reached age seven by 2006, concluded that exposure to mobile phones prenatally and postnatally was associated with behavioral difficulties.[89]
- More recently, a dataset consisting of nearly 29,000 children who reached age seven by 2008 replicated the previous study, demonstrating that mobile phone use was associated with behavioral problems in children.[90]
- **Environment and Human Health, Inc.'s forthcoming animal research study shows a relationship between cell phone use in pregnancy and behavioral issues in the offspring.**

- ## Heart Rate

Pregnant women exposed to EMF emitted by mobile phones on telephone-dialing mode for 10 minutes a day during pregnancy and after birth had babies with statistically significant increases in fetal and neonatal heart rate. The study involved 90 women with uncomplicated pregnancies. The authors suggest that this may result from a physiological response to the pulsed magnetic fields, and recommend avoidance of cellular phone use during early weeks of gestation, and also recommend further studies.[91]

- Several other epidemiological studies on children are ongoing, but results of these studies are not yet available.



One study, involving 13,000 children who reached age seven by 2006, concluded that exposure to mobile phones prenatally and postnatally was associated with behavioral difficulties.

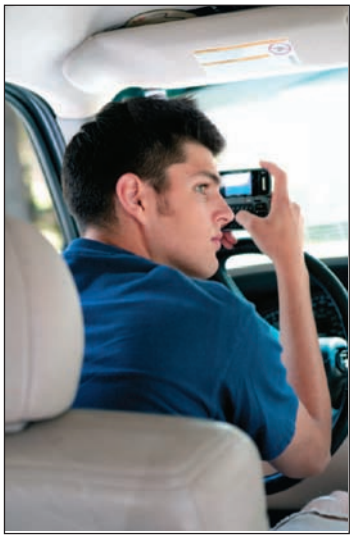
Table 6. Epidemiological Studies on Children and Potential Health Effects from Mobile Phone Use

Study	Date	Health Effect	Finding	Location
Hardell et al.	2008	Brain tumors	Those who used cell phones before age 20 had >5-fold increase in glioma risk.	Sweden
CEFALO Study	2004–2008	Brain tumors	"Regular users of mobile phones were not statistically significantly more likely to have been diagnosed with brain tumors compared with nonusers."	Denmark, Norway, Sweden, and Switzerland
Danish National Birth Cohort/ UCLA	1998–2008	Behavioral	Behavior problems	Denmark
Rezk et al., Egyptian hospitals	2003–2004	Heart rate	Increased fetal and neonatal heart rate	Egypt
MOCHE	2006–2010	Environmental exposures during pregnancy and childhood	Pending	Korea
MOBI-KIDS Study	Began 2010	Brain tumors	Pending	Australia Austria, Canada, France, Germany, Greece, Israel, Italy, New Zealand, Spain, Taiwan, and the Netherlands
MoRPhEUS	2005–2010	Cognitive ability, blood pressure, or hearing	Shorter response times on learning tasks; less accurate working memory	Australia

Source: *McLaughlin Centre for Population Health Risk Assessment. http://www.rfcom.ca/young/index.shtml*

Cell Phones and Car Accidents

- Driving while talking, texting, or using the internet distracts drivers and increases the risk of accidents. Teens are the population group at greatest risk from cell phone use while driving.
- Nearly 9 in 10 teenage drivers admit to engaging in distracted-driving behaviors, such as texting or talking on a cell phone. Motor vehicle crashes are the leading cause of death for U.S. teens, who are involved in three times as many fatal crashes as all other drivers.
- In 2009, 20 percent of all injury crashes were caused by distracted driving. About one in five of those deaths involved reports of a cell phone. Physically dialing a phone while driving can increase the risk of a crash as much as six times — and texting increases this risk by 23 times.



Nearly 9 in 10 teenage drivers admit to engaging in distracted-driving behaviors, such as texting or talking on a cell phone.

Teens and Distracted Driving

Have you ever experienced or done any of the following?

	All teens 12–17	Older teens 16–17	Cell users ages 16–17	Texters ages 16–17
Been in a car when the driver was texting	48	64	70	73
Been in a car when the driver used a cell phone in a way that put themselves or others in danger?	40	48	51	52
Talked on a cell phone while driving	n/a	43	52	54
Texted while driving	n/a	26	32	34

Source: Pew Research Center's Internet and American Life Project, Teens and Mobile Phones Survey conducted from June 26–September 24, 2009. N=800 teens age 12–17 and the margin of error is ±4% for all teens. For older teens ages 16–17, N=283. For cell users ages 16–17, N=242. For texters ages 16–17, N=222. Margins of error for these subgroups range between ±6% and 7%.

Data from Pew Research Center's Internet and American Life Project show that as of 2009 about 48 percent of teens had been in a car when the driver was texting. These statistics are likely to be low, since the rate of texting by teens has increased since 2009.

- **Driving**

  A 2010 study found that drivers, on average, talk 7 percent of the time while driving and drivers under 30 talk about 16 percent of the time while driving. Assuming these use rates, restricting cell phones while driving could have prevented an estimated 22 percent (1.3 million) of the crashes in 2008.[92]

- **Texting**

  - Data from Pew Research Center's Internet and American Life Project show that as of 2009 about 48 percent of teens had been in a car when the driver was texting. These statistics are likely to be low, since texting by teens has increased since 2009.

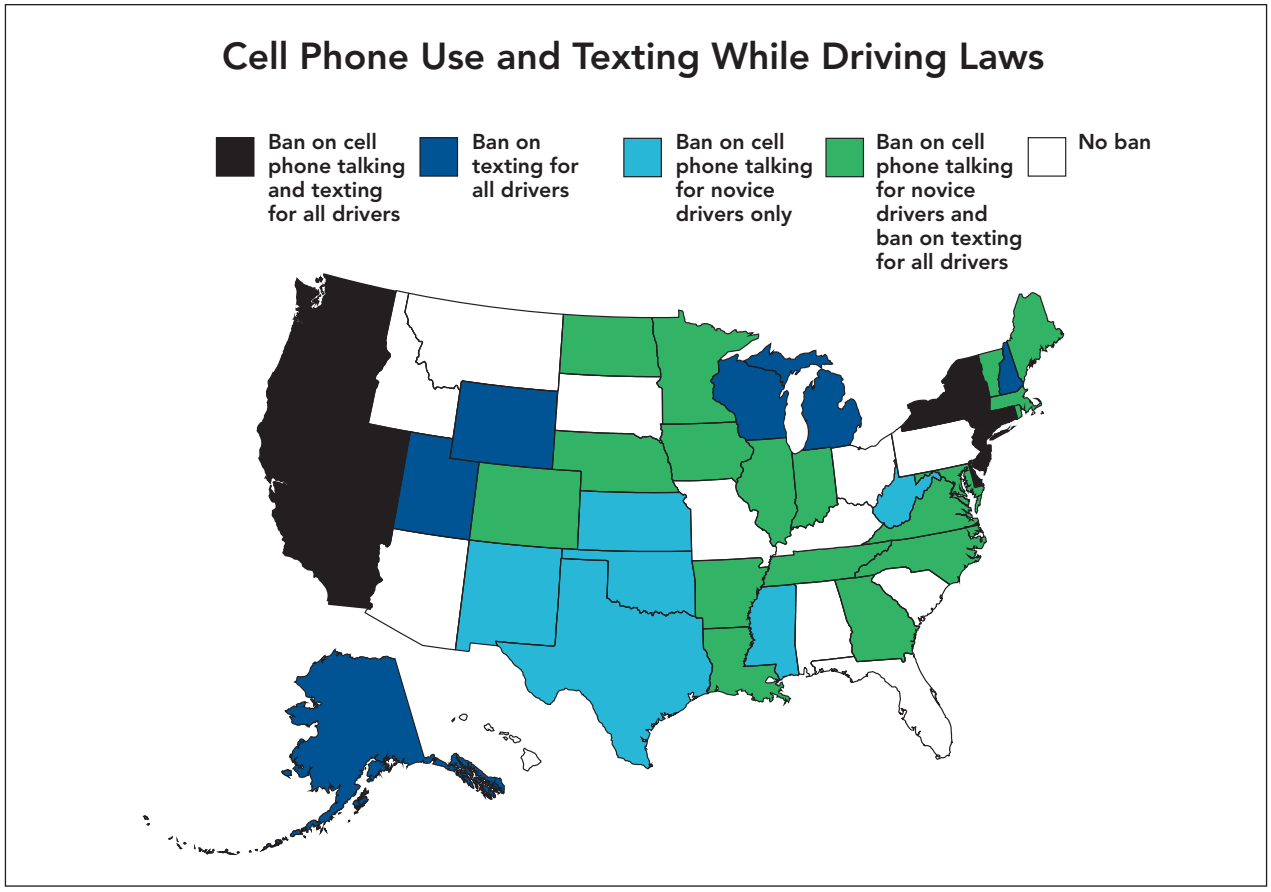
  - An analysis of U.S. Fatality Analysis Reporting System (FARS) records (1999 to 2008) estimated that texting resulted in more than 16,000 additional road fatalities from 2001 to 2007.[93]

- **Internet**

  With an estimated 40 percent of Americans now using smartphones, use of the internet while driving is an added risk factor for drivers. A 2011 study from State Farm Insurance found that 19 percent of drivers admit to using the internet while driving.[94]

- The Pew Research Center found that about 40 percent of teens had been in a car when the driver used a cell phone in a way that put themselves or others in danger.[95] Distracted driving has likely grown since 2009 with rising rates of cell phone use among teens. Cell phone use and/or texting while driving is against the law in numerous states, as shown in the chart on the following page.

- According to a 2010 study by the Highway Loss Data Institute — a group funded by the insurance industry — bans on handheld cell phones in New York, Connecticut, California and the District of Columbia had little impact on accident rates.[96]

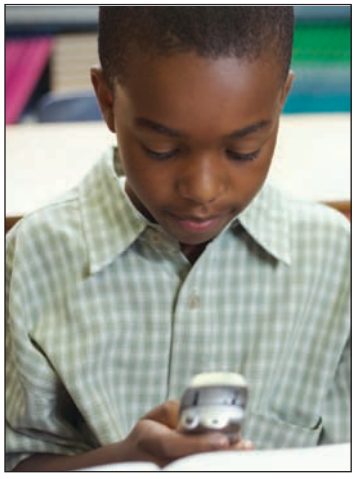


Source: *Cell Phone Use And Texting While Driving Laws,* ***as of January 2012.*** *Data from: http://www.statehighwaysafety.org/html/stateinfo/laws/cellphone_laws.html*

- The U.S. Department of Transportation is evaluating devices that will disable cell phones if they're traveling above a specific speed.

- As of January 2012, as shown on the map above, a total of nine states, the District of Columbia and the Virgin Islands have prohibited all or novice drivers from using handheld cell phones while driving. Several other states have passed laws, but they have not yet gone into effect. Laws banning talking on a handheld cell phone, except in Maryland, allow for "primary enforcement," which means that a police officer may cite a driver for using a handheld cell phone in the absence of any other traffic offense.

U.S. and International Agencies' Opinions on Health Risks



Claims of safety have been made despite a lack of understanding about the extent of RF exposure to children.

- The consensus of some U.S. agencies that monitor, research or regulate human exposure to RF radiation from mobile phones is that the scientific evidence linking mobile phones with health problems is inconclusive. The federal agencies involved in monitoring, researching or regulating RF radiation include the Food and Drug Administration (FDA), Environmental Protection

Table 7. U.S. Government Agency Positions: Cell Phones and Children

Agency	Role in Managing RF Exposure	Opinion on Cell Phones
FDA	Lead federal health agency for monitoring health effects of RF-emitting products.	"The scientific evidence does not show a danger to any users of cell phones from RF exposure, including children and teenagers."
EPA	Coordinates RF health-related activities among the various federal agencies with health or regulatory responsibilities in this area.	"...the scientific evidence linking long-term use of cell phones to cancer or other health effects is **not conclusive.** More research is needed to clarify the question of safety."
FCC	Certifies that phones sold in the U.S. comply with FCC guidelines for RF exposure. Relies on FDA and others for health and safety related questions about mobile phones.	"There is no scientific evidence to date that proves that wireless phone usage can lead to cancer or a variety of other health effects, including headaches, dizziness or memory loss."
CDC	No Regulatory Authority	"The recent studies suggest a possible link between these tumors and radiofrequency from cell phones. More research is needed to establish this link conclusively and to quantify these potential health risks."

Source: *Government agency websites, accessed June 2011*

Agency (EPA), Federal Communications Commission (FCC) and the Centers for Disease Control and Prevention (CDC).

- Claims of safety have been made despite a lack of understanding about the extent of RF exposure to children. Exposure assessment is difficult because both phone frequency and usage patterns have changed so dramatically in recent years. In 2008, the National Academy of Sciences identified the characterization of exposure to juveniles, children, pregnant women, and fetuses from personal wireless devices and RF fields from base station antennas as their top research priority.[97]

- The FDA position is that scientific evidence does demonstrate risks from RF exposure to users of mobile phones, including children and teenagers. The FDA notes that "little is known about potential health effects of long-term exposure to radiofrequency radiation" and has nominated the National Toxicology Program (NTP) to conduct a large cell phone radiofrequency radiation experimental study.[98] Results of the NTP study will likely not be available until 2014.

- The CDC states, "We are not aware of any study that has looked specifically at how radiofrequency exposure might affect children. We do know that children who start using cell phones early in life potentially will be exposed to radiofrequency for longer periods during their lifetimes."[99]

- The International Commission on Non-Ionizing Radiation Protection, the International Committee on Electromagnetic Safety, and the World Health Organization (WHO) Electromagnetic Fields Project claim that there is no proven health risk from RF-EMFs emitted from cell phones and that the present safety limits on cell phones are protective of human health. Many other scientists argue that, based on currently available scientific evidence, it is not clear that current standards are protective.[100]

The CDC states, "We are not aware of any study that has looked specifically at how radiofrequency exposure might affect children."

Laws, Regulations, and Policies

The FCC is charged with regulating interstate and international communications by radio, television, wire, and satellite, but is not a health-related or standard-setting agency.

Current Exposure Limits

- Many countries have set regulations that limit personal exposures to radiofrequency energy. Although many U.S. agencies have addressed the issue, there are no federally developed standards in the U.S. for safe RF exposure levels.

- In the U.S., the Federal Communications Commission (FCC), Environmental Protection Agency (EPA), Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Administration (OSHA), have either set standards or assessed exposures.

The FCC

- The FCC is charged with regulating interstate and international communications by radio, television, wire, and satellite, but is not a health-related or standard-setting agency. The FCC must rely on exposure standards developed by non-governmental organizations, including the Institute of Electrical and Electronics Engineers (IEEE) and the National Council on Radiation Protection and Measurements (NCRP).

- The FCC guidelines specify exposure limits in terms of the Specific Absorption Rate (SAR), a measure of the rate at which RF energy is absorbed by the body. *The allowable SAR limit for cell phones is 1.6 watts per kilogram (W/kg), averaged over one gram of tissue, for the head; 0.08 W/kg for whole-body exposure; and 4 W/kg for exposure to the hands, wrists, feet and ankles.*

- The SAR standards were established in 1996 in the United States and have remained unchanged since then. In Europe and abroad, the SAR is set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) at 2 W/kg, averaged over a volume of 10 grams of tissue.

- The FCC's SAR standard actually dates back to a 1986 U.S. Air Force study that estimated safe thermal-level references for a healthy adult male, with disclaimers that the results would differ for a person of a different size, age, or general health condition.[101]

- The 1986 U.S. Air Force study showed adverse behavioral effects in animals after they absorb enough radiofrequency energy to increase their body temperature by one degree Celsius.[102] The Institute of Electrical and Electronics Engineers (IEEE) defends its *thermal-based* standard based on its claim that there is insufficient data to document non-thermal health effects.

- The FCC states on its website that SAR levels are not intended to be used by consumers to compare phones and that all phones sold in the U.S. are in compliance with the SAR and are therefore safe.

- According to the FCC, many people mistakenly assume that using a cell phone with a lower reported SAR value necessarily decreases a user's exposure to RF emissions, or is somehow "safer" than using a cell phone with a higher SAR value. However, a single SAR value does not provide enough information about the amount of RF exposure to reliably compare individual cell phone models."[103] Some governments, including Switzerland, Germany, and the U.K., recommend using a cell phone with a low SAR.

The 1986 U.S. Air Force study showed adverse behavioral effects in animals after they absorb enough radiofrequency energy to increase their body temperature by one degree Celsius.

The FDA

- The FDA does not review the safety of radiation-emitting consumer products such as cell phones and similar wireless devices before they can be sold, although the agency does have the authority to take action if cell phones are shown to emit radiofrequency (RF) energy at a level that is hazardous to the user.

NIOSH and OSHA

- NIOSH conducts health-hazard assessments related to occupational RF exposure. OSHA has no specific standards, but notes

A National Institutes of Health study confirms that changes in the brain occur from exposure to cell phone radiation at non-thermal levels.

that research is continuing into the possible biological effects of exposure to RF and microwave radiation from radios, cell phones, and industrial equipment.

Concerns about the Specific Absorption Rate (SAR)

- The FCC's SAR has been criticized for having been based on data from the 1980s, as well as on conclusions drawn from highly variable data dependent on signal strength and distance from the body.

- The SAR has received international criticism for methodological problems, for ignoring non-thermal effects that may occur at lower levels, and the fact that SAR is insufficient to protect children who are likely to absorb higher levels of radiation from cell phone use.[104]

Non-Thermal Effects

- Non-thermal effects from cell phone exposure have been noted in numerous studies. A 2011 National Institutes of Health study confirms that changes in the brain occur from exposure to cell phone radiation at non-thermal levels. The study included 47 healthy people using a cell phone for a 50-minute call.[105]

- The study showed that metabolism in the region of the brain closest to the cell phone antenna was significantly higher and correlated with the estimated higher electromagnetic field. The study's cell phone model set the Specific Absorption Rate at 0.901 W/kg for the head, well under the FCC's SAR limit of 1.6 W/kg for cell phones. Although the health impacts of this study are unknown, it provides evidence that RF-EMF exposure from cell phone use affects brain function in humans at levels below the SAR.[106]

Methodological Problems

- There are standardized methods for SAR testing so that cell phone manufacturers may use their own testing methods to calculate a phone's SAR. Ten years ago, the U.S. Government Accounting

Office (GAO) concluded that measurement uncertainties and procedural variations could cause a phone's actual maximum SAR level to fall within a range of ±50–60 percent of the test result.

- The SAR can be influenced by many factors, including the way different technicians set up the test, mix the tissue fluid, position the handset, and simulate human tissue; the type of head model used; the type and calibration of the probe used to measure the radiated electric field; and the methods for averaging SAR measurements or calibrating the measuring instruments.[107]

SARs for Children

- The model used to estimate the SAR for a cell phone user's head was derived from the size and dimensions of the head of a large adult male.[108] A comparison of anatomically based models of the human head show that this SAR may underestimate the absorption rate in children by a factor of two or more. Studies show deeper penetration of absorbed energy in a child's head, the result of the thinness of the outer ear and skull of young children.[109, 110]

- Experiments have shown that smaller head models produce statistically higher SAR values than larger models.[111] The National Academy of Sciences (NAS) notes that better characterization of SARs for children of various age groups is necessary and that current models are not adequate for children.[112]

Studies show deeper penetration of absorbed energy in a child's head, the result of the thinness of the outer ear and skull of young children.

Precautionary Warnings for Children

- Despite U.S. agency opinions that insufficient evidence exists to warrant precautionary warnings, there remains concern that the RF exposure from cell phones may pose a risk to children. International conferences and reports continue to discuss this subject.[113]

- The first precautionary recommendation discouraging mobile phone use by children was issued in the U.K. in 2004 by a group of independent scientists.[114] Recently, the European Parliament, France,

Table 8. Foreign Cell Phone Restrictions/Advisories for Children

Government	Advisory
Canada[115]	"… parents who are concerned about possible long-term risks from RF exposure may wish to take extra precautions by limiting their children's use of cell phones."
Council of Europe[116]	"…take all reasonable measures to reduce exposure to electromagnetic fields…particularly the exposure to children and young people who seem to be most at risk from head tumors." A draft resolution recommends that member states should ban all mobile phones and wireless networks in classrooms and schools and run information campaigns aimed at children and young adults about the risks to human health.
Finland[117]	"Parents should restrict the number and duration of calls as well as encourage the use of hands-free units."
France[118]	"Advertising promoting the use of cell phones by children below 14 years is banned; Prohibits the use of mobile phones in kindergartens, primary schools and colleges."
India[119]	Limited use of mobile phones by children; children below 16 should be discouraged from using mobile phones.
Israel[120]	Limits children's use of mobile phones.
U.K.[121]	"Widespread use of mobile phones by children (under the age of 16) should be discouraged for non-essential calls."
Russia[122]	Advises against mobile phones for 18 years and under: "Current safety standards for exposure to microwaves from the mobile phones have been developed for the adults and don't consider the characteristic features of the children's organism."
Switzerland[123]	Children and teens should keep their calls short or send a text message.

Germany, Russia, Sweden, Switzerland, India, Israel, and Finland have issued warnings that children should not use mobile phones.

- Russia has issued the most strongly worded warning, recommending restricting telecommunications devices for those pregnant or under 18. Russia also cites future health risks for children who use mobile phones, noting that current safety standards for exposure to microwaves from mobile phones were developed for adults, not children.[124]

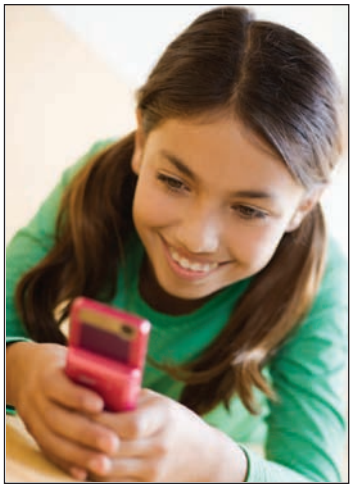
- The first U.S. health care group to advocate precautions for children was the University of Pittsburgh Cancer Institute, which warned in 2008 that children should never use a cell phone except in an emergency.[125]

- Ireland's Department of Health issued a similar warning in 2011.[126] The Bioinitiative Report, drafted by a collaboration of public health experts from universities throughout the world, recommends restrictions on the sale and advertising of cell phones to children.[127]

- The International Commission for Electromagnetic Safety (ICEMS), "strongly advises limited use of cell phones, and other similar devices, by young children and teenagers."[128]

- A 2011 report from the President's Cancer Panel, *Reducing Environmental Cancer Risk,* lists as its top recommendation: "A precautionary, prevention-oriented approach should replace current reactionary approaches to environmental contaminates in which human harm must be proven before action is taken to reduce or eliminate exposures." However, there have been no precautionary warnings regarding the use of cell phones issued by U.S. government agencies to date.

- But even in countries with precautionary warnings, use of cell phones by children is increasing. In the U.K., where the Department of Health warned in 2009 that use of mobile phones by children should be discouraged, more than 50 percent of children aged 5 to 7 and 75 percent of 10-year-olds have their own mobile phones.[129]



The International Commission for Electromagnetic Safety, "strongly advises limited use of cell phones, and other similar devices, by young children and teenagers."

Labeling Requirements

- No specific labeling of the Specific Absorption Rate is required on the phone or packaging material, but the FCC ID number from the phone can be entered into a database on the FCC's website to find each phone's SAR value.

- Several U.S. cities, states, and foreign countries have proposed more transparent labeling of SARs and potential health risks related to RF exposure on cell phones. In 2010, San Francisco passed an ordinance that would have required cell phone retailers to display a cell phone's SAR and make available consumer information materials about cell phone radiation, but the city backed down as a result of a lawsuit filed by the Cellular Telecommunications Industry Association (CTIA), which represents the interests of the wireless communications industry.[130]

- In July 2011, San Francisco's board of supervisors passed a different law that requires retailers to post general warnings about potential radiation risks, along with ways to lower the amount of radiation exposure to individuals.[131] Similar bills have proposed labeling potential health risks of cell phones in Maine, Oregon, and Pennsylvania.[132]

Table 9. Examples of State Efforts to Include Warnings on Cell Phones (2011)

State	2011 Bill	Warning on Device/Packaging	Retailer's Warning	Status/Comments
California	SB 932	Exterior packaging: "This device emits radiofrequency energy. Consult the user's manual for additional information on safe use."	Same as on Device	SB 932 passed the Senate Environmental Quality Committee on May 9, 2011, by a vote of 4 to 2.
Maine	LD 1014	"WARNING: Federal health safety standards have yet to be established for non-thermal effects of cellular telephone radiation, which have been identified as reasons for health safety concerns, such as brain tumors."	"ADVISORY: Cellular telephones should be used with care. ▪ Federal health safety standards have yet to be established for nonthermal effects of cellular telephone radiation. ▪ Nonthermal effects of cellular telephone radiation have been identified as reasons for health safety concerns, such as brain tumors, fertility issues and other consequences of genetic damage. ▪ Avoid contact with head and body. ▪ Avoid proximity to reproductive organs. ▪ Limit use by children. ▪ Pregnant women should avoid use."	May 31, 2011 MAJ: Ought Not to Pass MIN: Ought to Pass as Amended
New Mexico	HM 32	N/A	N/A	The Department of Health and the Department of the Environment submitted a report on effects of cell phone radiation, with recommendations.
Oregon	SB 679	"WARNING: This is a radio-frequency (RF), radiation emitting device that has nonthermal biological effects for which no safety guidelines have yet been established. Controversy exists as to whether these effects are harmful to humans."		Failed to pass; may be reintroduced in 2013
Pennsylvania	HB 1408	"This device emits electromagnetic radiation, exposure to which may cause brain cancer. Users, especially children and pregnant women, should keep this device away from the head and body."	Same as on Device	Referred to CONSUMER AFFAIRS, April 28, 2011 [House]

- Efforts to include SAR levels on cell phone labels have been initiated in France, Germany, the European Parliament, and Taiwan.

Table 10. International Efforts to Label Cell Phones

Government	Label Requirement	Date
France[133]	"For all cell phones sold in the French territory the SAR must be indicated clearly and in French. Possible risks resulting from excessive use must also be mentioned." *(translation)*	2010
Germany[134]	Blue Angel Certification label on mobile phones with a SAR below legal limits.	2007
European Parliament[135]	"Introduce clear labeling indicating the presence of microwaves or electromagnetic fields, the transmitting power or the specific absorption rate (SAR) of the device and any health risks connected with its use."	2011
Taiwan[136]	Cell phones sold in Taiwan are required to carry SAR labels. Permissible SAR levels range between 0.016 and 1.83 watts per kilogram; NCC* posts the amount of radiation exposure from cell phones on its website; NCC "demanded again" that cell phone makers clearly label their products with a health warning.	2010

* National Communications Commission of the Republic of China (Taiwan)

Warnings that cell phones may not be in compliance with the Specific Absorption Rate (SAR) when carried close to the body are noted in user guides, but many consumers never read them.

- Warnings that cell phones may not be in compliance with the SAR when carried close to the body are noted in user guides, but many consumers never read them.

- Cell phone warnings generally refer to the distance between the phone and the user's body. Smartphones carry additional warnings about carrying a phone while connected to a wireless network.

  - **iPhone: 5/8-inch warning**: "iPhone's SAR measurement may exceed the FCC exposure guidelines if positioned less than 15 mm (5/8 inch) from the body."[137]

Some cell phone manufacturers warn consumers—usually in very small print—that phones should only be used with an approved body-worn accessory or holster, which is often supplied by the manufacturer at additional cost.

- **LG Shine: 0.6-inch warning**: "To comply with FCC RF exposure requirements, a minimum separation distance of 0.6 inches (1.5 cm) must be maintained between the user's body and the back of the phone."[138]

- **BlackBerry: .98-inch warning**: "When using any data feature of the BlackBerry device, with or without a USB cable, hold the device at least 0.98 inches (25 mm) from your body. If you use a body-worn accessory not supplied by RIM when you carry the BlackBerry device, verify that the accessory does not contain metal and keep the BlackBerry device at least 0.98 inches (25 mm) from your body when the BlackBerry device is turned on and **connected to a wireless network**."[139]

- **Motorola: 1-inch warning**: "If you do not use a body-worn accessory supplied or approved by Motorola, keep the mobile device and its antenna at least 2.5 centimeters (1 inch) from your body **when transmitting**."[140]

- Some cell phone manufacturers warn consumers—usually in very small print—that phones should only be used with an approved body-worn accessory or holster, which is often supplied by the manufacturer at additional cost. A holster is necessary because otherwise the user may be exposed to radiation levels above FCC guidelines. Contradictory advertising slogans compound consumer confusion about the various distance warnings.

- Despite warning consumers to "keep the BlackBerry device at least 0.98 inches (25 mm) from your body when the Black Berry device is turned on and connected to a wireless network," the Blackberry website runs the following ad that targets young people: *"BlackBerry Pearl – Carry Your Friends in Your Pocket."*[141]

Cell Phone Recycling Problems

- Cell phones are the most omnipresent electronic product on the globe. With relatively short lifecycles because of their perceived obsolescence, discarded cell phones are a significant and growing problem throughout the world.

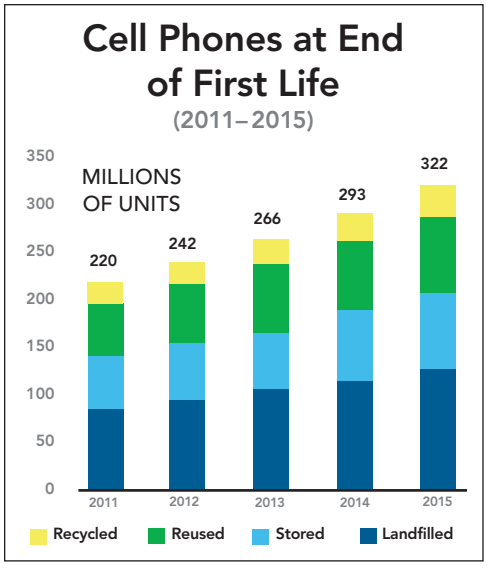
- In the United States, millions of cell phones that contain hazardous lead, mercury, cadmium, arsenic, and flame retardants are thrown out every year.

- One study recently estimated that in 2011 alone, 220 million cell phones will reach the end of their first lives in the United States (see chart). While an estimated 55 million of these will end up stored in people's homes, many more will end up in landfills.[142]

- A few states, including California, Maine, and New York, have disposal bans that cover cell phones—but disposal bans may not be enough. Laws in the U.S. and abroad allow recyclers to export electronic waste to developing countries, where primitive processing of old equipment can expose workers and the environment to toxic materials.

- A United Nations study found that 70 percent of the world's electronic waste is sent to China, where processing and recycling contaminates water and soil, and poisons workers. The report predicts a sharp rise in cell phone waste by 2020—seven times higher than 2007 in China and 18 times higher in India.[143]

Laws in the United States and abroad allow recyclers to export electronic waste to developing countries, where primitive processing of old equipment can expose workers and the environment to toxic materials.



Summary of Findings

Cell Phone Patterns of Use

Use of cellular devices for voice conversations is declining as texting and other forms of non-verbal communication increase.

- **Cellular Device Adoption Rates:** There are nearly 276 million cell phone subscribers in the United States, up from 97 million subscribers in 2000. Rapid growth in the access to cellular technology has been accompanied by steadily increasing frequency and duration of personal cell phone use. The volume and speed of data transmitted have increased rapidly, and demand for data-intensive video applications seems insatiable.

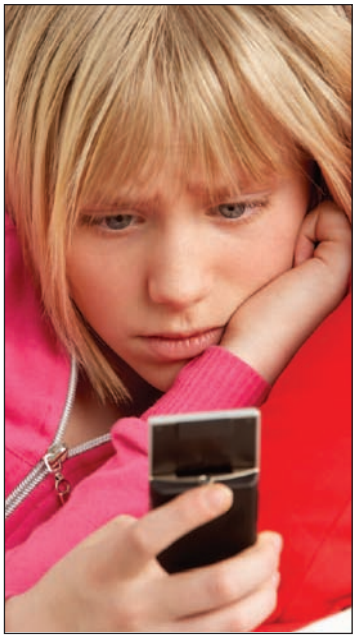
- **Technological Innovation and Marketplace Lifespan:** Most cell phones have a market life of only nine to 24 months, meaning product availability normally ends within this time span. Newer models often are built on earlier hardware platforms, offering additional features or greater speed. Consumers replace phones, on average, every two years, a rate influenced by the duration of their service contracts.

- **Changing Patterns of Use:** Use of cellular devices for voice conversations is declining as texting and other forms of non-verbal communication increase. Texting is now the predominant method of communicating among adolescents, followed by calls, talking face-to-face, use of social network sites, and email. More than 75 percent of teens own cell phones, and one third of them text more than 100 messages per day. Children between the ages of eight and 18 spend an average of 7.5 hours per day on smartphones, computers, televisions, or other electronic devices.

- **New Features Motivate Increased Cell Use:** Patterns of use are strongly affected by the development of new features such as GPS locational services, video chats, internet radio and

television broadcasts, photo editing, video games, social networking applications, and educational programs.

- **Psychological Dependency:** The rise in psychological dependency on cell phones is well documented in the peer-reviewed social scientific literature. The need to "stay in touch" and the ever-strengthening expectation of a near term, if not immediate response, can lead to obsessive and compulsive patterns of use. It can also distract users from work, play, relaxation, safe driving practices, and from more traditional forms of social interaction, such as a face-to-face conversation.



The need to "stay in touch" and the ever-strengthening expectation of a near term, if not immediate response, can lead to obsessive and compulsive patterns of use.

Cell Phone Exposures

- **Electromagnetic Radiation (EMR) Exposure Varies by Phone Model Signal Strength:** Exposure to electromagnetic radiation emitted from cellular devices varies by model of phone, antenna configuration, and signal strength.

  Weak signal strength leads to higher levels of exposure, as the device routinely seeks a stronger signal. The energy emitted by specific models is measured in watts per kilogram (W/kg). The recommended limit in the United States is 1.6 W/kg, which is the amount absorbed by the body, known as the Specific Absorption Rate (SAR).

  Subscribers can visit the Federal Communications Commission website to identify the intensity emitted by any brand and model of phone. Because exposure varies by proximity of the device to human tissues, most models include warnings in packaging materials about the need to hold the device a safe distance from the body. Since the intensity of exposure falls exponentially as the distance from the body increases, users can limit their exposure dramatically by using speakerphones.

Children and fetuses' rapidly developing nervous systems, their more rapid rates of cell division, and longer potential lifetime exposure all heighten their risks for adverse health effects.

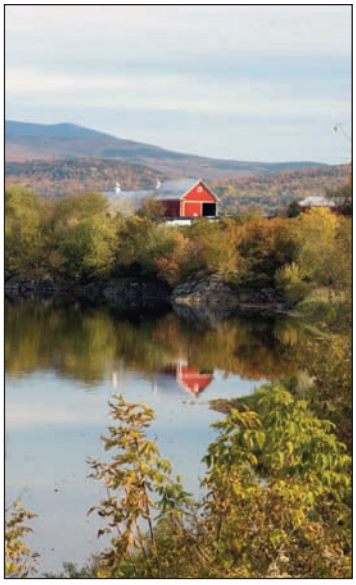
- **Children's Exposure is Greater Than Adults:** The thinner skulls of young children permit cell phone radiation to penetrate more deeply into the brain than is the case with adults. Children and fetuses' rapidly developing nervous systems, their more rapid rates of cell division, and longer potential lifetime exposure all heighten their risks for adverse health effects.

- **Exposure Standard Based Upon 1986 Study:** The FCC's exposure standard (1.6 W/kg) is based upon a 1986 U.S. Air Force study that estimated safe thermal-level references for a healthy adult male. The authors cautioned that the results would differ for a person of a different size, age, or general health condition, yet this limitation has not resulted in any public health advisory. Nor has it led the FCC to conduct additional studies to explore health implications for groups who are more exposed or more susceptible.

- **Heat is Not the Only Worry:** The FCC's current limit for public exposure assumes that the devices only affect health via the heating of tissues. However, molecular, cellular, and organ system changes and damage that are not explained by heat have been reported in numerous peer-reviewed studies. A 2011 National Institutes of Health study confirms that changes in the brain occur from exposure to cell phone radiation at non-thermal levels. This study included 47 healthy people using a cell phone for a 50-minute call.

- **Use and Storage:** How cell phones are held and carried while in standby mode affects the intensity of user exposure to electromagnetic radiation. During calls the devices commonly contact the head, and electromagnetic radiation can enter the skull, exposing human brain tissues. Devices stored in pants pockets while in standby mode expose sensitive reproductive organs to radiofrequency energy. Storage in shirt pockets will increase exposure to breast tissues.

- **People Living in Rural Communities Experience Higher Exposures:** Those who live in rural areas farther away from cellular transmission towers may be receiving higher doses of EMF radiation than people in urban areas. Lower signal strength causes a cell phone to search often for a signal, even in standby mode, and it is this increased frequency of transmission that leads to higher exposures.



Those who live in rural areas farther away from cellular transmission towers may be receiving higher doses of EMF radiation than people in urban areas.

Health Effects

- **Cell Phone Use and Cancer:** In 2011, the World Health Organization's International Agency for Research on Cancer (IARC) classified electromagnetic fields as possibly carcinogenic to humans, based on an increased risk for glioma, a malignant type of brain cancer associated with wireless phone use.

- **Susceptibility of the Developing Nervous System:** The brain is especially susceptible to numerous environmental insults that can produce irreversible damage during critical periods of nervous system development between conception and the age of 21. This vulnerability is well recognized for ionizing radiation, alcohol, tobacco, some pharmaceuticals, cocaine, and stress. The effects of these agents are dependent on dose and timing of exposure. However, even small exposures during periods of neurogenesis have a more profound effect than exposures during adulthood.

- **Effects on the Nervous System:** A number of peer-reviewed studies reported changes in the nervous systems of rats, mice, and humans following exposure to cell phone radiation. These include diminished learning, diminished reaction time, decreased motor function, reduced memory accuracy, and diminished cognition. Also, higher mobile phone use has been associated with faster but less accurate response

Many studies report molecular and cellular effects following cell phone EMF exposures in organs responsible for reproduction, especially in males.

to high-level cognitive tasks. Prenatal and postnatal cell phone exposure have both been associated with behavioral problems, such as hyperactivity in children around the time of entry into primary school at the age of six.

- **Effects on Reproductive Health:** Many studies report molecular and cellular effects following cell phone EMF exposures in organs responsible for reproduction, especially in males. Oxidative stress on human semen, declining sperm counts, reduced sperm motility, and diminished sperm viability all have been reported to be associated with EMF exposures from cellular devices.

- **Difficulty in Understanding Long-Term Effects:** The short lifespan of many cellular products makes patterns of individual exposure to electromagnetic radiation emitted from devices difficult to reconstruct historically, and nearly impossible to predict. Some types of tumors exist for a decade or longer before they are discovered. By the time most long-term studies are published, their findings are irrelevant to predict future public health risk, since networks, device technologies, and exposure patterns change so rapidly.

- **Psychological Health:** Cell phones create a sense of freedom to communicate quickly with those in remote locations. Yet this freedom, if not managed carefully, can create feelings of psychological dependency. Common effects, both reported in the literature and easily recognized, include distraction from social contact among those nearby, the inability to focus on complex and long term tasks, and a heightened sense of anxiety.

- **Genotoxic Effects and DNA Damage:** Cell phones emit non-ionizing electromagnetic radiation that can energize nearby tissues in a manner that can alter the biochemistry of human tissues and change the structure of human DNA. Among 101

papers that examined the genotoxic effects of radiofrequency EMF, nearly half reported damage to genetic material. Other studies found that exposures impair the ability to repair DNA damage.

Neurodevelopmental and Behavioral Effects Following Fetal Exposure

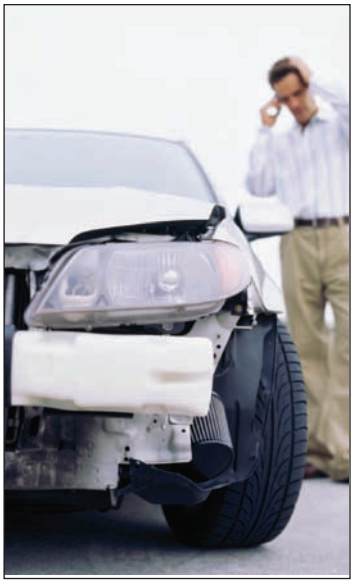
- Aldad, Gan, Gao, and Taylor (2012) report that fetal radio-frequency radiation exposure led to neurobehavioral disorders in mice. Mice exposed *in utero* were hyperactive, had impaired memory, and demonstrated behavioral changes due to an alteration of normal neuronal developmental programming.

Vehicle Accidents, Injury, and Mortality

- Cellular device use while driving poses a serious threat to public health and safety. The National Safety Council attributes 23 percent of all traffic accidents to cell phone use — at least 1.3 million crashes per year. Nearly 1.2 million of these are associated with phone calls, while 100,000 are associated with texting.

- At any one time, approximately 11 percent of all drivers are using their cell phones. Nearly 5,000 fatalities and 500,000 injuries are associated with distracted driving each year. Approximately 20 percent of fatalities are associated with cell phone use, and this percentage is an underestimate due to underreporting of cell use at the time of accidents — some states do not examine the coincidence of accidents and cell use. All of these losses are certainly avoidable.

- By January of 2012, nine states and the District of Columbia had prohibited cell phone use while driving, and many states had banned texting while driving. Widespread disregard for these statutes poses a serious enforcement challenge to local and state



Cell phones have enjoyed freedom from government scrutiny and control that would protect public health and the environment.

police forces. The exceptionally small probability of being caught is well known, so many people behave as if the prohibitions do not exist. Hartford, Connecticut, and Syracuse, New York, were the sites of a Department of Transportation (DOT) experiment involving tough municipal laws, intensive police surveillance, intensive enforcement, and public education about the dangers of cell phone use while driving. In Hartford, cell phone use dropped 57 percent and texting fell 75 percent as a result of the campaign.

- The number of electronic distractions in vehicles is increasing quickly. Televisions, video games, internet access, and MP3 music player connections to sound systems have all been added to traditional electronics, such as CD players, radios, radar detectors, GPS locators, and increasingly complex electronic controls.

- Technologies exist that would block receipt or transfer of signals from cellular devices while a vehicle is in motion. However, none have been required by federal or state governments.

No enforceable standards limiting human exposure to cell phone radiation exist. No precautionary language on packaging is required by the FCC to warn consumers about cell phone radiation emissions, or how people can reduce exposures.

Regulations

- **Lack of Federal Oversight of Health, Safety, and Environmental Effects:** Cell phones have enjoyed freedom from government scrutiny and control that would protect public health and the environment.

  No enforceable standards limiting human exposure to cell phone radiation exist. No precautionary language on packaging is required by the FCC to warn consumers about cell phone radiation emissions, or how people can reduce exposures. By contrast, special precautionary health warnings are required to be printed on the packaging for many pharmaceuticals, alcohol, tobacco products, and pesticides.

- **Chemical Content:** The U.S. federal government does not regulate the content of cell phones, or their method of disposal. Cell phones contain lead, copper, mercury, flame retardants, plastics and batteries that contain nickel and cadmium.

- **Federal Communication Commission Authority:** The FCC relies on medical, public health, or toxicological expertise in other agencies to conduct research on cell phone health hazards.

- **Regulating Producer Responsibility for Waste:** Currently, producers maintain no responsibility for cell phone waste. In 2011, nearly 220 million cell phones will be discarded in the U.S., and fewer than 10 percent of them will be recycled.

  Nearly 70 percent of recycled cell waste is exported to China, where environmental and health regulations are lax, leading to dangerous occupational exposures and contamination of soil, water, fish, and wildlife. This waste is especially hazardous when burned because of the release of dioxins from some plastic polymers. The discarded cell phones also contain diverse metals that will not break down into nontoxic components, and which are also known to be hazardous to human health.

- **Warnings in Other Nations:** Although the U.S. does not require any regulations to restrict advertising or warn against use of cellular devices by pregnant women or children, many other nations do impose restrictions.

Currently, producers maintain no responsibility for cell phone waste. In 2011, nearly 220 million cell phones will be discarded in the U.S., and fewer than 10 percent of them will be recycled.

Recommendations

For The Federal Government

- **Require Pre-Market Cell Phone Emissions Testing:** The federal government should test the emissions of existing and new cellular devices. Emissions and anticipated absorption should be clearly labeled, as should the location of antennas on each device so these areas could be held away from the body.

- **Set Exposure Standards to Protect Human Health:** The federal government should set exposure standards to protect human health. These standards should include an adequate margin of safety for susceptible populations. This would require a new statute that would assign implementation responsibility to the U.S. Environmental Protection Agency (EPA), an organization that already establishes standards for exposure to radioactive materials. EPA is already responsible for monitoring and enforcing limits for emissions of radioactive materials to the environment.

- **Conduct Scientific Studies to Determine Health Risks:** The federal government should be authorized by Congress to offer competitive grants to independent academic researchers to examine the health effects associated with cellular technologies.

- **New Tax on Cell Phones to Fund Studies:** Funding for the health, safety and environmental studies should be provided for by a designated cell phone sales tax.

- **Prohibit Advertising to Children:** The cell phone industry should be prohibited from marketing their products, applications, and software to children.

- **Producer Lifecycle Responsibility:** Producers of cell phone technologies should be required by the federal government to identify the chemical content of their products. Manufacturers should also be required to establish recycling programs to minimize the release of these chemicals to the environment from landfills or incinerators. Distributors of cell phone products should be required to accept old models, and manufacturers should provide assurance that confidential data on older phones will be destroyed.

- **Vehicle Accident and Cell Phone Use Reporting:** The federal government should require states to collect data on the use of cell phones within vehicles at the time of accidents. These data are not collected by all states, so the role of cell phones as a cause of vehicle accidents is currently underestimated.

- **Cumulative Exposure to RF Radiation:** The federal government should evaluate cumulative exposure to radiofrequency radiation in pregnant women and children. Devices that contribute to total exposure include cell phones, cordless DECT phones, wireless handsets, wireless headsets, wireless routers, Bluetooth devices, wireless alarm systems, etc.

- **Prohibit Use of Cellular Devices in Moving Vehicles:** The federal government should foster new technologies that prevent the use of cellular devices in moving vehicles.

- **Need for Low-Cost RF Measurement Device:** The federal government should adopt design standards for low-cost portable RF measurement devices that would permit members of the public to monitor the presence and intensity of RF emissions within their personal environments. Devices should be certified by the U.S. Department of Energy to ensure that monitors operate with precision and consistency.

Recommendations For Individuals

- **Do Not Drive and Use Your Cell Phone:** Driving while using cellular devices greatly increases the likelihood of having an accident.
- **Use Speakerphones:** Try to reduce the amount of time spent with the cellular device held against your ear and head. Use a speakerphone, if possible, or a wired headset to reduce your exposure to RF radiation.
- **Avoid Sleeping With Cellular Devices:** Sleeping next to cell phones causes unnecessary exposure to electromagnetic fields. The cell phone should be kept several feet from the bed.
- **Carry Your Cell Phone Safely:** While in standby mode, cell phones normally send and receive signals. Carrying a cell phone in your pants or shirt pocket will emit electromagnetic radiation to nearby tissues. Try to carry your cell phone away from your body.
- **Learn the Emission Rating for Your Phones:** Learn about the emissions and antenna location for your phone. When purchasing cellular devices, consider the relative emission levels of different brands and models, and be especially cautious if you are providing children with access to the device, or if you are a woman of childbearing age.
- **Avoid Psychological Dependency:** Avoid cell dependency by checking and responding to messages at pre-planned times.
- **Reduce Your Exposure to Other Wireless Radiation Sources:** Learn about EMF emissions from other wireless devices in your life, including computers, laptops, routers, DECT phones, etc. Try to minimize your cumulative exposure to these devices. Consider locating wireless devices away from bedrooms and turn off wireless devices when not in use.

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