CELL PHONES

TECHNOLOGY | EXPOSURES | HEALTH EFFECTS

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Table of Contents

List of Tables

List of Figures

Introduction

EHHI's report investigates what we know about cell phone use and human exposures, and introduces an original research study that explores cell phone effects on behavior.

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 dreamt 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, reproduction, DNA damage, behavioral changes, or creates addictive behavior and causes car accidents, 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. EHHI's report investigates what we know about cell phone use and human exposures, and introduces an original research study that explores cell phone effects on behavior.

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 chart).

- 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 comprises 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.

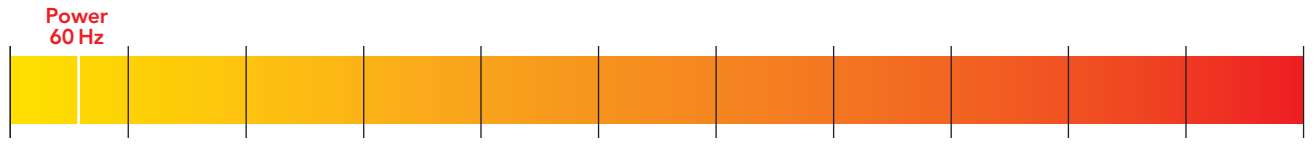
Abbreviations

EMF	electromagnetic field
EMR	electromagnetic radiation
RF	radio frequency
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)



Direct Current

Computer
60–100 Hz

LCD TV
60/120 Hz

Extremely low frequency

Very low frequency

Radio
AM 520-1610 kHz
FM 87.5-108 MHz

Radiowaves

Cell Phone GSM
900/1900 MHz

Cell Phone UMTS
1.9–2.2 GHz

Microwaves

Microwaves
3–30 GHz

Bluetooth
2.4 GHz – 2.4835 GHz

Infrared Radiation

Remote Control
5.8 GHz

Visible Light

Ultraviolet Radiation

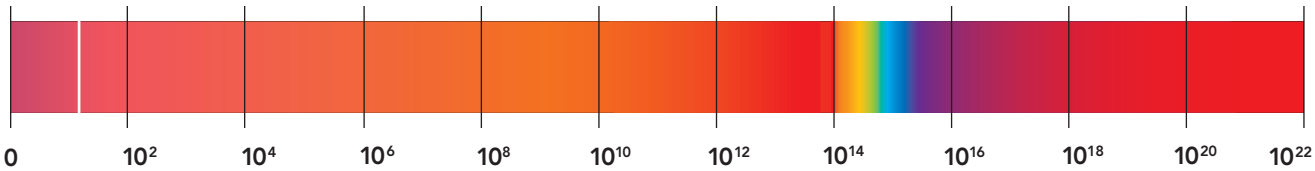
Black light is near the ultraviolet spectrum. UVA and UVB rays are invisible.

X-rays

Gamma Rays

X-rays range from 30 x 10^{16} Hz to 30 x 10^{19} Hz. Ionizing radiation penetrates the body and can damage DNA.

Frequency (Hz)



Wavelength in meters

Radio	Microwave	Infrared	Visible	Ultra-violet	X-ray	Gamma Rays
10^3	10^{-2}	10^{-5}	.5 x 10^{-6}	10^{-8}	10^{-10}	10^{-12}

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

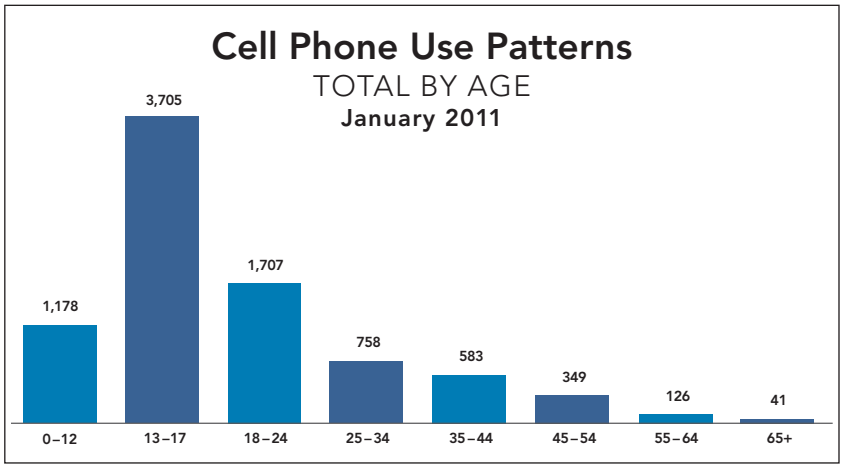
- Decades of research demonstrate that even low doses of ionizing radiation can increase the risk of cancer. The thyroid gland and bone marrow are particularly sensitive to ionizing radiation, especially in children. Leukemia, which arises in the bone marrow, is the most sensitive radiation-induced cancer 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 Nielson Company. http://www.onlinemarketing-trends.com/2011/03/us-teens-mobile-texting-numbers.html

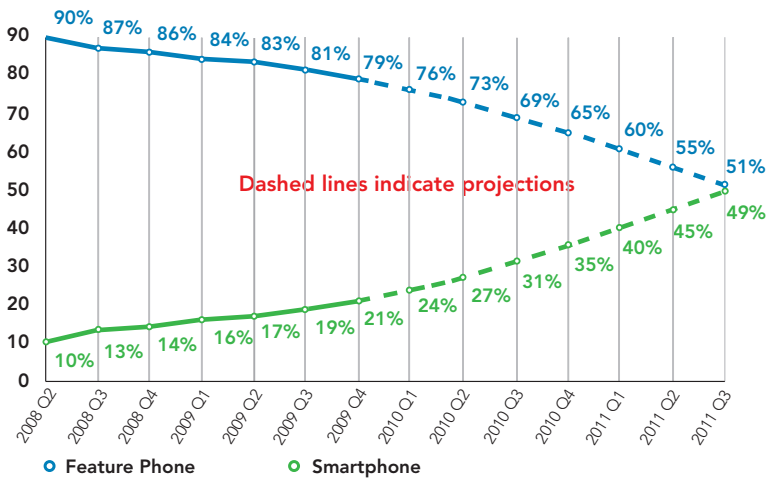
A smartphone is defined as a cell phone that is capable of doing more than just phone. Users can email, search the web, edit documents, keep a calendar, check the weather, play games, and perform many other functions.

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 functioning as more than just a 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 12–17 year olds 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.

U.S. Smartphone Penetration and Projections



Source: The Nielson 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 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 their differences. Users report that:
  - 66 percent use speakerphone occasionally
  - 86 percent use the internet
  - 80 percent check email on their device
- 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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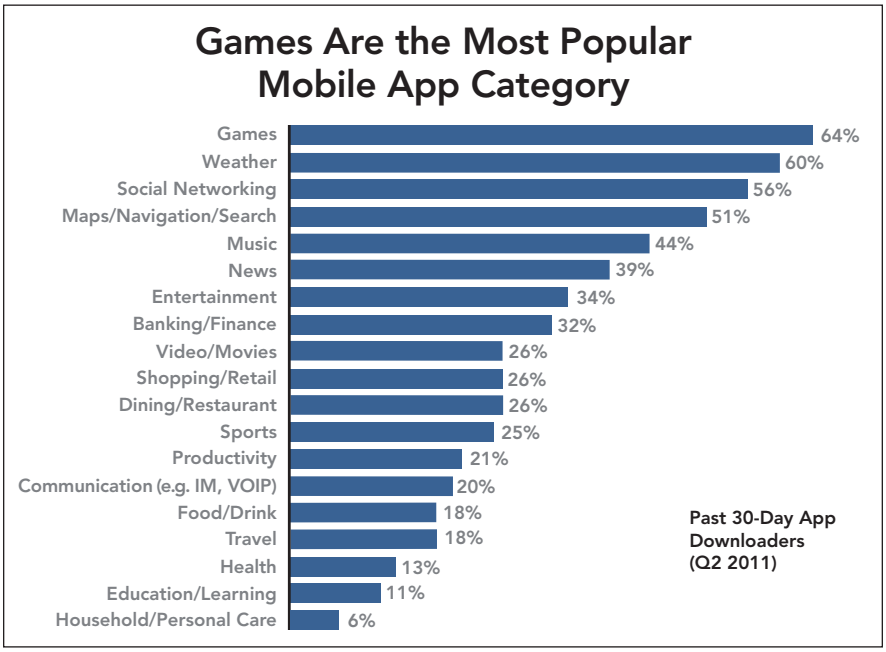


Source: The Nielson Company. http://www.phonearena.com/image.php?m=Articles.Images&f=name&id=42761&name=n1.jpg&caption=%22Games%22+was+the+number+one+category

Radio Frequency (RF) Exposure from Cell Phones, Headsets, and Cordless Phones

Most countries consider the radio frequency (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 radio frequency (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) or 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 far 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 (known as UWB or as digital pulse wireless) technology, approved by the 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 radio frequency 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 far 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 stand-by 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 radio frequency. It is defined as the power absorbed per mass of tissue and has units of 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 are established to control absorption of RF energy (see Regulatory Standards Section, page x).

- 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.

- 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. The larger the screen, the more radiation is emitted.

Bluetooth is a brand name for a wireless networking technology that uses short-wave radio frequency to connect cell phones, portable computers, and other wireless devices.

RF Exposure from Headsets and Cordless Phones

- *Bluetooth* is a brand name for a wireless networking technology that uses short-wave radio frequency 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.

- Bluetooth and wired headsets are classified as "low-power, non-licensed radio frequency 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.[6]

- 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.[7] 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 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.[8]

- 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.

- Wired headsets may also reduce exposure to the head, but may increase exposure to RF energy in the ear if the cord is not kept close to the body.[9]

- 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.

- 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 to 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.[10]

- 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.[11]

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.

Radio Frequency 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 electric conductivity in their bone marrow.[12]

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 age two to five are more likely to operate a smartphone than swim, tie their shoelaces, or make their own breakfast. Almost as many two- to three-year-olds (17 percent) can play with smartphone applications as four- to five-year-olds (21 percent). One-quarter of all U.S. children aged two to five know how to make a mobile phone call.[13]

- 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 RF exposure for preteens and teens.

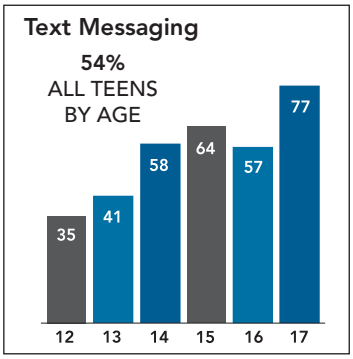
- One in three teens sends more than 3,000 texts per month. Those age 13 to 17 have the highest levels of text messaging—an average of 3,364 mobile texts per month—more than double the rate of the next most active texting demographic sample, 18- to 24-year-olds. They talk less than older populations—an average of 515 minutes per month, compared to 750 minutes among 18- to 24-year olds.[14] 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.

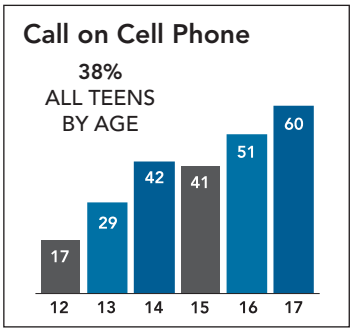
- According to the Pew Internet and American Life Project, the biggest determinant of whether a teen sleeps with a phone is texting behavior. Teens who use their cell phones to text are more likely to sleep with their phones than cell-owning teens who don't text. According to Pew, teens are not the only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

- Slightly fewer—70 percent—of 30- to 49-year-olds sleep with their cell phones nearby, as do half of all of 50- to 64-year-old cell phone users. 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.

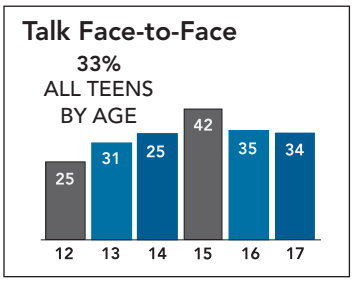
Teens who use their cell phones to text are more likely to sleep with their phones than cell-owning teens who don't text.

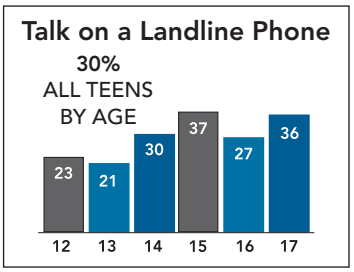
Most teens text friends daily
The percentage of teens who contact their friends daily by different methods, by age ▼

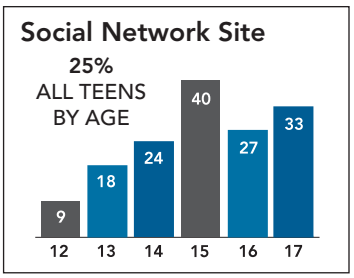


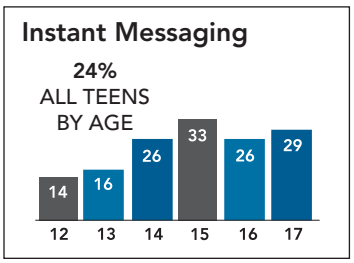


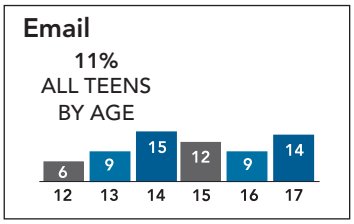
The percentage of teens who contact their friends daily by different methods, by age ▼











- One key point is that 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

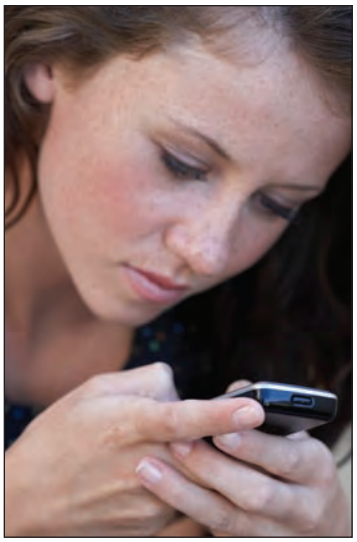
Total	**65%**
Men	67%
Women	64%
Age	
18–29	90%
30–49	70%
50–64	50%
30+	34%
Race/Ethnicity	
White, Non-Hispanic	62%+
Black, Non-Hispanic	78%
Hispanic, English-speaking	75%
Household Income	
Less than $30,000	73%+
$30,000–$49,999	70%
$50,000–$74,999	61%
$75,000+	64%
Education Level	
Less than High School	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.[1]
- 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 a recent report by a Council of Europe Committee that concluded that immediate action was required to protect children from RF-EMFs, the committee 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.[16]
- 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.[17]

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. [18]

- 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.[19]

- 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.[20]

Health Risks

- 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. The 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.

- In 2011, WHO'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.[21]

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

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.

- 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 below.

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 nerve cells
Meningioma	Cancer that begins in nerve cells
Acoustic Neuroma	Non-cancerous tumors that arise in nerve cells that supply the ear
Salivary Gland Tumors	Cancerous and non-cancerous

- The best long-term data—more than 10 years—of cell phone use comes from Hardell et al. and IARC's Interphone study. 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 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.[26]
  - The Swedish researcher **Dr. Lennart Hardell et al.** has 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."[27]
- 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 the Interphone study.[28]

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.

Table 1. Comparison of the Hardell and Interphone Studies

AUTHOR	TYPE	FINDING	CONCERNS	FUNDING
Lennart Hardell et al.	6 studies using the Swedish Cancer Registry	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	14,000 adults interviewed; involved 13 countries	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.

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.

- 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.[37]

- 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.[38]

- The most recent U.S. brain cancer incidence rates indicate that rates have declined slightly or remained the same, except in the 20- to 29-year-old age group. 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.[39]

- In 2011, IARC classified RF EMFs as possibly carcinogenic to humans, citing an increased risk of glioma associated with wireless phone use. The evidence linking wireless phone use to glioma and

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

AUTHOR	FINDINGS	AFFILIATION
Ahlbom A et al. (2009)[29]	"…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)[30]	"..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)[31]	"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)[32]	"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.[33]	"…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)[34]	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)[35]	"…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)[36]	"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

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."[40]

In 2011, IARC classified 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."[41]

- 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."[42]

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.[43]

- Experiments by Narayanan et al. found that memory retention and retrieval were significantly affected in mobile phone RF-EMR-exposed rats.[44] Several other studies have also measured cognitive effects in animals (Table 1).

- Examples of effects in humans include impaired cognitive performance after exposure to a pulsed electromagnetic field[45] 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.[46]

- 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.[47]

- 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."[48]

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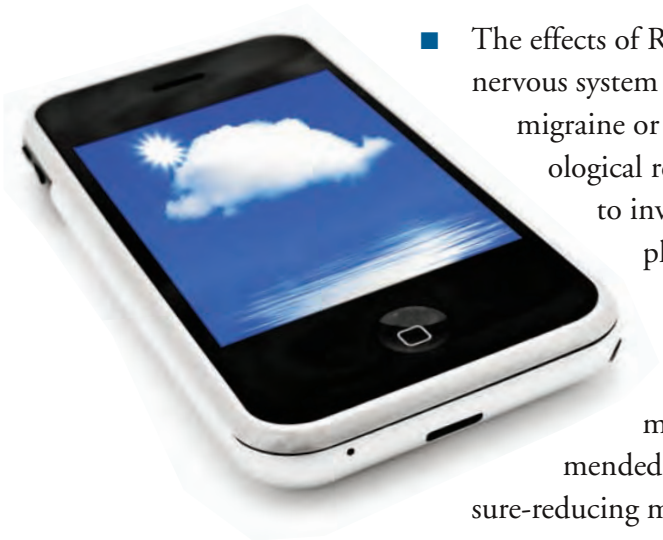


- The effects of RF-EMF exposure from cell phones on central nervous system (CNS) disorders, such as Alzheimer's disease, migraine or vertigo, has been the focus of recent epidemiological research in Denmark, which is the first country to investigate a possible association between use of cell phones and 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.[49]

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.	2010	Rat	900 MHz – 1.8 GHz	NS	50 times 45 s/h once per day for 4 weeks	Altered passive avoidance behavior and hippocampal morphology
Fragopoulou AF et al.	2010	Mouse	900 MHz	0.41 W/kg – 0.98 W/kg	1 h 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.	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.	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.	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.		Human	902 MHz	NS	Continuous for 50 min	Pulsed EMF exposure impaired cognitive performance

Source:

Reproduction

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

- 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 damage to semen quality.[50] An experimental study that same year involving exposure of male mice to RF-EMR noted a significant genotoxic effect on epididymal sperm.[51]

- 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.[52]

- Agarwal et al. found the use of cell phones 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. This same research group placed semen samples from men 2.5 centimeters away from a cell phone in talk mode for one hour. This is the normal 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.[53]

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 damage to semen quality.

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

Author	Year	Effect Noted
Deluliis et al.	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.	2009	"Low intensity pulsed radio frequency 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.	2008	"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.	2008	"Use of cell phones decrease 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 et al.	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.	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."
Yan IG et al.	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. In addition, abnormal 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."
Panagopoulos DI et al.	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.	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 serious."
Aitken et al.	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.	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

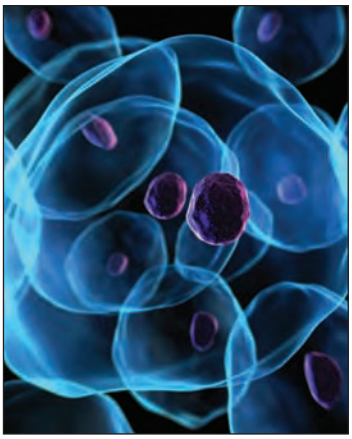
Genotoxic Effects/Cell Damage

- 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.[54] Other scientists agree: A recent review of 101 papers on the genotoxic effects of RF-EMF found that 49 reported a genotoxic effect.[55]

- 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, others studies have not.[56] There is no standard testing methodology for the evaluation of possible genotoxic effects of EMFs, which may in part explain why findings are inconsistent.

- DNA studies have particular importance with regard to children. Researchers who placed a mobile phone at a one-meter (about a yard) distance from human stem 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 increased risk of cancer from exposure to cell phones.[57]



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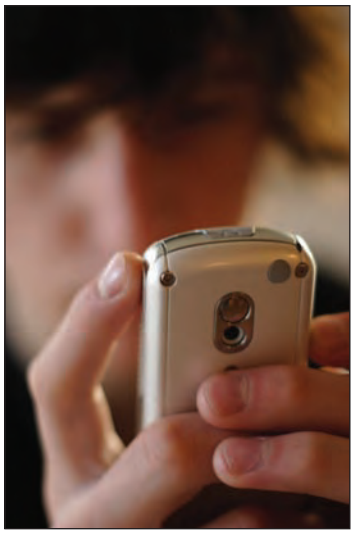


The addictive nature of cell phones has concerned psychologists for years. Recently, psychologists have warned that smartphone users are especially at risk for becoming addicted to their device.

- 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 two-hour exposure.[58]

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.[59] 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.[60]

- Electromagnetic fields from microwave radiation have been shown to have a negative impact on the eye lens. The 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."[61]

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.[62]

- 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.

- Frequent mobile phone use has been associated with stress, sleep disturbances, and symptoms of depression among young adult men and women.[63] Yen et al. cite "withdrawal symptoms without cellular phone use" as the most common symptom of mobile phone use among adolescents.[64] 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.[65]

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.[66]

Studies Specific to Children

- Research scientists agree that children may experience potentially greater susceptibility to RF effects because of their developing nervous systems, increased levels of cell division, undeveloped immune systems, thinner skulls, more conductive brain tissue, greater RF penetration relative to head size, and longer lifetime exposure.[67]

- 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 get 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 young were also five times more likely to get acoustic neuromas.[68]

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 age 7–19.

- Published in July 2011, the CEFALO study was conducted in Denmark, Sweden, Norway, and Switzerland. It included children and adolescents age 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."[69]
- 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."[70]

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.

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 more behavioral difficulties.
- 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. The authors made no suggestions as to why this occurs. See EHHI's new study on fetal exposures and behavior on page 44.

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 as 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.[71]

- 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 more 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	Risk of glioma is more than 5-fold in children	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	Announced 2005	Cognitive ability, blood pressure, or hearing	Pending	Australia

Source:

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 nine 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 nine 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 his or herself 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=222. Margins of error for these subgroups range between ±6% and 7%.

The 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.[72]

- **Texting**

  - The 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.

  - 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.[73]

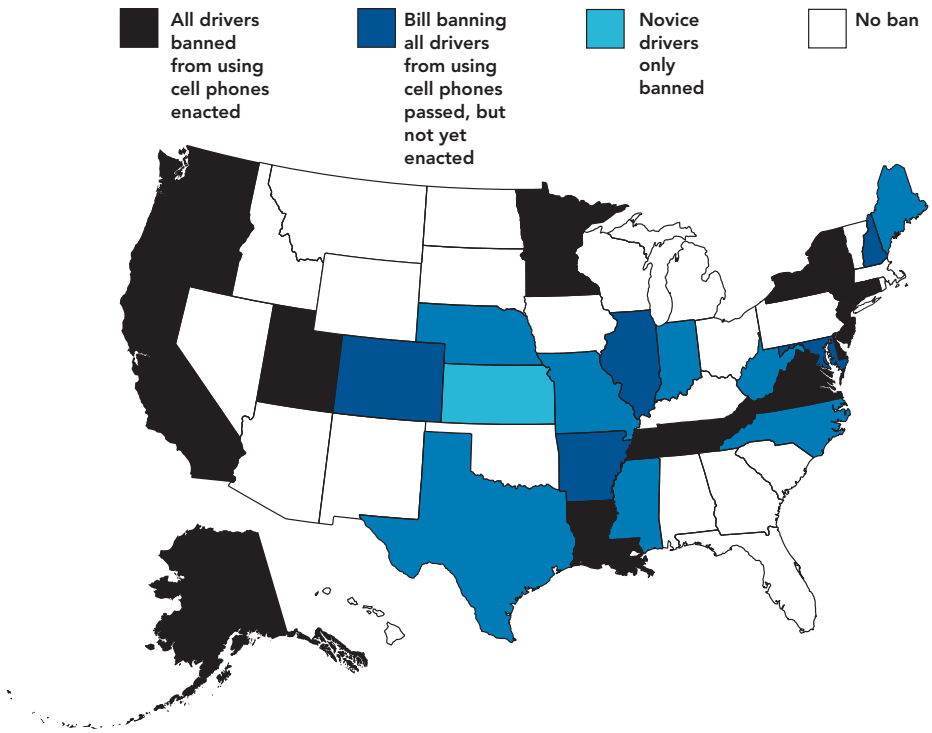
- **Internet**

  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.[74]

- Cell phone use and texting while driving is against laws in several states. As of March 2011, talking on hand-held cell phones while driving is illegal in nine states and the District of Columbia, and text messaging is illegal in 30 states across America.

- According to a 2010 study by the Insurance Institute for Highway Safety, bans on handheld cell phones in New York, Connecticut, California and the District of Columbia had no impact on accident rates.

Cell Phone Use and Texting While Driving Laws

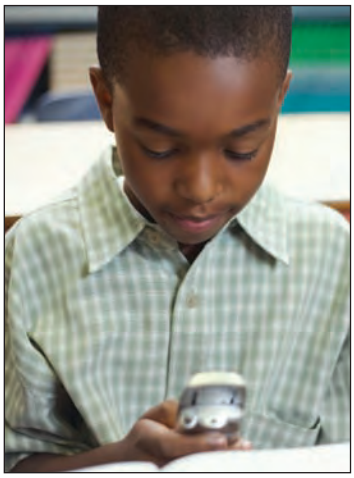


Source: www.newsoxy.com.Cell Phone Use And Texting While Driving Laws. March, 2011. http://www.newsoxy.com/technology/cell-phone-use-and-texting-while-driving-laws-21876.html.

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

- As of September 2011, as shown on the map above, a total of 10 states, the District of Columbia and the Virgin Islands have prohibited drivers from using handheld cell phones while driving. Several other states have passed laws, but they have not yet gone into effect. Some states have banned cell phone use only among novice drivers. All the laws, 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).

- There have been claims of safety 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.

- 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.[74] 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."[80]

- 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.[75]

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

The following is a summary by EHHI of its original research study published in xxx Journal

Fetal Exposure to 800-1900 Mhz Radiofrequency Radiation From Cellular Telephones Affects Neurodevelopment and Behavior

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Introduction

Neurobehavioral disorders are common and increasingly prevalent in children, however their causes are not well understood. To date, 3-7% of school-aged children suffer from attention deficit hyperactivity disorder (ADHD).[1] ADHD is a condition that causes inattentiveness, overactivity, impulsivity, or a combination. For these problems to be diagnosed as ADHD, they must be out of the normal range for a child's age and development.

Children diagnosed with ADHD are at greater risk for low academic achievement, poor school performance, and delinquent behavior inconsistent with their developmental level.[2,3] **The diagnosis of ADHD has increased at an average rate of 3% per year since 1997, making the condition a growing public health concern.**[1] The behavioral problems in ADHD have been associated with neuropathology localized primarily to the prefrontal cortex. Children with ADHD have a reduction in prefrontal cortex volume, a reduction in gray and white matter, and asymmetry.[4,5] These children also have a deficit in working memory associated with inattention and controlled by activity of neurons in the prefrontal cortex.[6]

A recent study showed that poor attention and low working memory capacity may be due to the inability to override the involuntary capture of attention by irrelevant information.[7] This too is controlled by the prefrontal cortex, as the shifting of one's attention voluntarily is driven by "top-down" signals in the prefrontal cortex while the involuntary capture of attention depends on "bottom-up" signals from both subcortical structures and the visual cortex.[7]

The causes of ADHD remain unknown and growing evidence suggests that it is not solely due to genetic factors,[8] but risk factors also include family psychiatric history, socioeconomic status, gender, and smoking during pregnancy.[9,10] A recent epidemiologic study found an association between prenatal cellular telephone exposure and subsequent behavioral problems in the exposed offspring.[11]

This association is important given the increasing number of cellular phone users worldwide, reaching approximately 4 billion as of December 2008.[12] However, evidence of direct causation is lacking.

Given the recent advances in the technology of cellular phones (i.e., smart phones), they are now used in a capacity beyond that of a basic telephone. For many, cellular telephones are used as a bedside alarm clock and personal organizer. Cellular telephone usage can reach 24 hours per day, leaving users increasingly exposed to the potentially harmful effects of radiofrequency radiation exposure.

In order to determine if *in-utero* cell phone radiation exposure affects behavior we chose to conduct a battery of tests on mice that identify impairments in memory, hyperactivity, anxiety, and fear, which are often associated with ADHD.

Thirty-three female mice were exposed throughout gestation (days 1-17) to radiation from muted and silenced 800-1900 Mhz cellular phones with a SAR of 1.6 W/kg. [The Specific Absorption Rate (SAR) is a measure of tissue radiation exposure. The European Union has set a SAR limit of 2.0 W/kg and in the United States this limit is set at 1.6 W/kg.[13]] The phones were positioned above each cage over the feeding bottle area at a distance of 4.5–22.3 cm from each mouse, depending on the location of the animal within the cage, and placed on an uninterrupted active call for the duration of the trial.

A control group of forty-two female mice was kept concurrently under the same conditions, but using a deactivated phone. Parturition was not different between groups and occurred at 19 days ±1 day. In order to

A recent epidemiologic study found an association between prenatal cellular telephone exposure and subsequent behavioral problems in the exposed offspring.

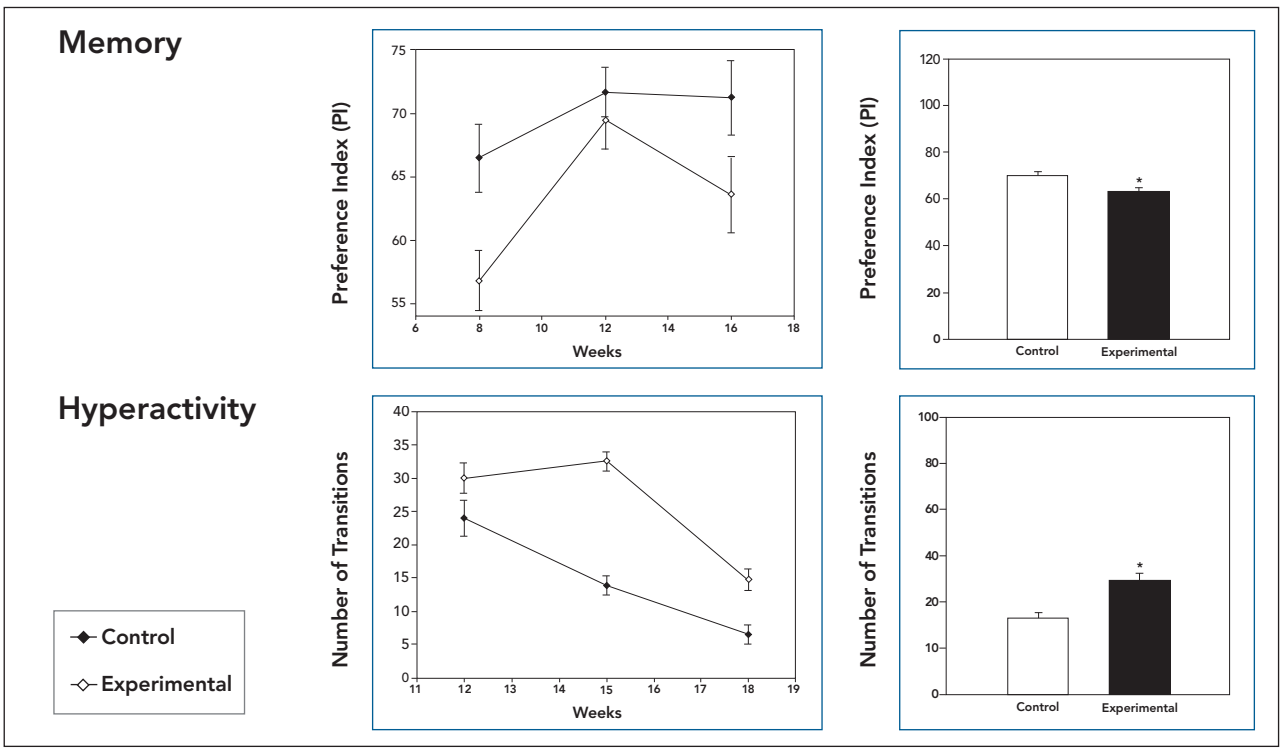
evaluate memory in the exposed and unexposed mice, 161 progeny were given a standard object recognition memory test in three different cohorts at 8, 12, and 16 weeks of age (82 experimental and 79 control mice).

Overall, the mice exposed *in utero* to cell phone radiation were hyperactive, had decreased memory, and decreased anxiety (Figure 1).[12]

To understand the mechanisms underlying the changes in memory and hyperactivity in animals exposed to radiation *in utero,* we examined whether changes in the neuronal circuitry occurred in brain areas responsible for these compromised behaviors.

Specifically, we asked whether changes in the synaptic transmission in CNS neurons are responsible for impaired memory and hyperactivity in radiation-exposed animals. The prefrontal cortex (PFC) is responsible for executive functions by screening distractions and maintaining attention in goal-oriented behaviors.

Figure 1.

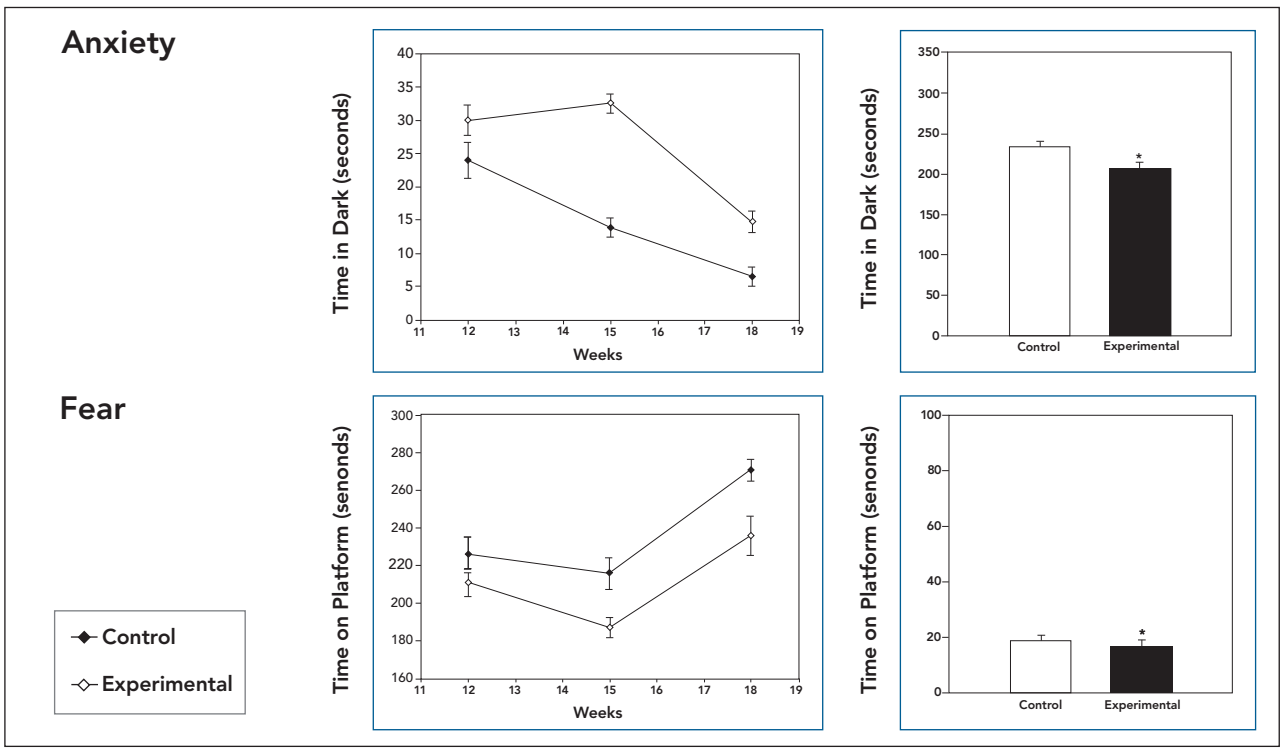


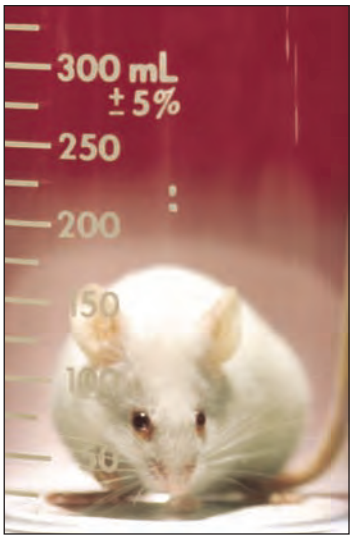
Impairment of the PFC leads to dysregulated behavior/emotion such as ADHD.[13] The pyramidal neurons, the primary cell type in this structure, regulate attention and behavior through a complex and interconnected network. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) were performed in pyramidal neurons of the PFC in control and cell phone-exposed mice. mEPSCs were generated by random vesicle release of glutamate from presynaptic neurons in the absence of stimulation.

Altogether, these results indicate that synaptic efficacy of glutamatergic transmission decreases at both pre- and postsynaptic sites in layer V pyramidal neurons. Thus, we demonstrate impairment in glutamatergic transmission (release from nerve terminals and glutamate receptor response) onto pyramidal neurons in the PFC after *in-utero* exposure to radiation from cellular telephones.

Overall, the mice exposed *in utero* to cell phone radiation were hyperactive, had decreased memory, and decreased anxiety.

Figure 1.





This is the first study to specifically identify effects of radio-frequency exposure on the mouse fetus.... Even small exposures during periods of neurogenesis have a more profound effect than exposures in adulthood.

Here we demonstrate that fetal exposure to 800-1900 Mhz radio-frequency radiation from cellular telephones leads to behavioral and neurophysiological alterations that persist into adulthood. **Mice exposed during pregnancy had impaired memory, were hyperactive, and had decreased anxiety, indicating that *in-utero* exposure to radio-frequency is a potential cause of neurobehavioral disorders.** We further demonstrated impairment of glutamatergic synaptic transmission onto pyramidal cells in the prefrontal cortex associated with these behavioral changes, suggesting a mechanism by which in-utero cellular telephone radiation exposure may lead to the increased prevalence of neurobehavioral disorders.

This is the first study to specifically identify effects of radio-frequency exposure on the mouse fetus. During critical windows in neurogenesis the brain is susceptible to numerous environmental insults; common medically relevant exposures include ionizing radiation, alcohol, tobacco, drugs and stress. The effects of these agents are dependent on dose and timing of exposure. Even small exposures during periods of neurogenesis have a more profound effect than exposure as an adult. Alcohol affects cerebral neurogenesis, patterning of brain development and subsequent behavior. Maternal smoking also affects fetal development; fetal tobacco exposure results in a higher incidence of behavioral and cognitive impairment including ADHD.

Similarly, prenatal exposure to cocaine can lead to behavioral disorders. Even prenatal maternal stress can lower intelligence and language abilities in offspring. As demonstrated by these examples, environmental exposures occurring in fetal life can lead to persistent neurological deficits.

Exposure to these insults as an adult does not carry the same consequences. It is therefore not surprising that studies exposing adult animals to radiofrequency radiation failed to find similar significant defects in behavior. The exposure to cellular telephones in pregnancy may have a comparable effect on the fetus and similar implications for

society as do exposures to other common neurodevelopmental toxicants. While these data demonstrate a clear association between fetal EMR exposure and neurodevelopment, it is important to recognize that the extrapolation of this animal model to humans is limited; the exposures used here are not identical to those experienced by the human fetus.

The molecular and cellular effects of radiofrequency exposure are not yet fully characterized. Multiple targets have been identified *in vitro.* Electromagnetic frequency exposure has been demonstrated to affect cell division and proliferation, both by inducing apoptosis and altering the cell cycle.[14] Electromagnetic radiation may promote the formation of reactive oxygen species (ROS) causing cell damage.[15]

One study specifically analyzing the effects of radiofrequency radiation on glioma cells demonstrated altered oxidative stress, a potential mediator of the alterations caused by electromagnetic radiation.[16] Electromagnetic frequency radiation has also been found to activate ERK and p38 MAPK signaling.[17] Although the precise molecular mechanisms that led to altered glutamatergic synaptic transmission in the prefrontal cortex identified in this study are not yet fully known, here we provide the first evidence that links changes in neuronal circuitry centered on layer V pyramidal neurons in the PFC with impaired memory and cognitive behaviors in animals exposed to radiation from cellular phone use.

Our results indicate that the release of glutamate from the nerve terminals on PFC neurons and response of PFC neurons to glutamate are impaired in mice prenatally exposed to cell phone radiation.

These results are consistent with previous reports that compromised glutamatergic transmission onto PFC neurons underlies impaired memory and cognitive functions in animals.[18, 19] Our results also imply that the effects of prenatal exposure to radiation on the brain might be global, since glutamatergic transmission onto neurons in another area of the brain (i.e., the ventral medial hypothalamus or VMH) was de-

The exposure to cellular telephones in pregnancy may have a comparable effect on the fetus and similar implications for society as do exposures to other common neurodevelopmental toxicants.

In this study we used cellular telephones as a source of EMR to closely mimic human exposure.... Definitive studies in humans are required prior to extrapolating these behavioral findings to humans.

creased as well. The effects of prenatal exposure to cell phone radiation may have more profound effects on brain functions than reported in this study. However, the effect was not identical; there are likely to be cell type specific or regional variations in susceptibility. Alternatively, the depth of the VMH may have shielded this region from maximal exposure. **In summary, our results suggest that the effects of prenatal exposure to cell phone radiation were not limited to the cortex.**

In this study we used cellular telephones as a source of EMR to closely mimic human exposure. However there are several limitations to this study that include lack of a defined exposure from a traditional EMF generator. Further we did not measure the level of exposure; the distance to the source was not fixed and power density measurements with respect to orientation, polarization, reflection, and interference were not considered. In order to determine the maximal effects and potential risks associated with exposure, the mice were directly exposed from conception to birth. While neurological effects were found here, future studies should focus on a more narrow gestational age of exposure, use EMF generators to more precisely define exposure, and limit variation in the distance from the source. Definitive studies in humans are required prior to extrapolating these behavioral findings to humans.

Methods

Over five separate experiments, a total of 27 breeding cages were set up each containing 3 CD-1 female mice [multipurpose research animals] and 1 CD-1 male mouse (13 experimental cages and 14 control cages). Each experimental cage was equipped with a muted and silenced 800-1900 Mhz cellular phone with a SAR of 1.6 W/kg placed over the feeding bottle area at a distance of 4.5–22.3 cm from the mice.

The cellular phones were then placed on an active call for 24 hours per day and the 33 experimental female mice were exposed throughout gestation (days 1-17). An additional six females were exposed to an active phone for either 9 or 15 hours per day. Each control cages were equipped with a deactivated phone and was kept under the same condi-

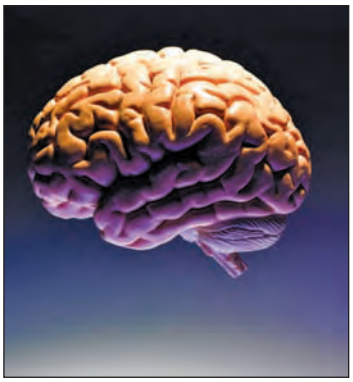
tions. To assure equal exposure time independent of the variable length of gestation (18-20 days), at the end of day 17 all phones were removed. On day 18 all female mice were separated and placed in their own cages yielding a total of 39 exposed pregnant females and 42 unexposed pregnant females.

Throughout the experiment, both the control and experimental mice were fed and given water ad libitum. The mice were maintained on a 12 hour light/dark cycle (07:00 on) and all procedures were approved by the Yale University Animal Care and Use Committee.

Memory was evaluated using a standard object recognition memory test. A total of 161 pups were tested (82 experimental mice and 79 control mice) at 8, 12, and 16 weeks. The test consisted of two learning days (Day 1 and 2) and one test day (Day 3). On Day 1 four opaque exploration chambers were set-up in the exam room at a luminosity of 420-440 Lux.

Prior to conducting each test, the mice were placed in the testing room and allowed 1 hour to acclimate to the light. Two identical objects were then placed in each of the four chambers and a single mouse was placed in each chamber to explore the two identical objects for 15 minutes. Before repeating the experiment, the objects and the chambers were cleaned thoroughly with a detergent solution to remove any scents or odors.

On Day 3 a video camera was placed over all 4 chambers and the objects were rearranged so that each chamber had one familiar object and one novel object. The mice were then allowed to explore both objects and were filmed for 5 minutes. Upon completing the experiment, 3 observers, blinded to the treatment regimen, viewed the first 2 minutes of footage to determine the time spent exploring the novel object. Exploration of the new object was defined as sniffing at less than 1cm. A preference index was then calculated by dividing the time spent exploring the new object by the total exploration time multiplied by one hundred. The percent time spent idle – not exploring either of the



The effects of prenatal exposure to cell phone radiation may have more profound effects on brain functions than reported in this study.

Though it is difficult to translate these findings to precise human risks and vulnerability, we identify a novel potential contribution to the increased prevalence of hyperactive children, one that is easily prevented.

objects – was also calculated in order to ensure that our findings are in fact due to memory deficits and not distractibility or hyperactivity.

The light-dark box test was conducted using a light-dark box, constructed of black and white Plexiglas (45 x 27 x 27cm). The dark compartment (18 x 27 cm) was made of black Plexiglas with a black Plexiglas cover and the light compartment (27 x 27 cm) was made of white Plexiglas and remained open. The light compartment was kept at a luminosity of 420-440 Lux. An opening (7.5 x 7.5 cm) was located in the wall between the two chambers allowing free access between the light and dark compartments. A video camera was then placed over the box for filming.

Prior to conducting each test, the mice were placed in the testing room and allowed 1 hour to acclimate to the light. A single mouse was then placed in the light chamber and was allowed to explore the box for five minutes while being filmed. Before repeating the experiment, the chambers were cleaned thoroughly with a detergent solution to remove any scents or odors. Three observers, blinded to the treatment regimen, then viewed the footage and recorded the total time spent in the dark as well as the total number of transitions. This data was then interpreted as described in the text to analyze anxiety and hyperactivity.

The Step Down Assay was performed to determine fearful behavior by placing a mouse gently on a platform (96 well plate) and recording the time on the platform. The timer was stopped once the mouse stepped off the platform with all four paws. Before repeating the experiment, the platform was cleaned thoroughly with a detergent solution to remove any scents or odors.

Gestational stress was analyzed by collecting serum on Day 12 of gestation from 6 exposed and 6 unexposed pregnant females. Serum samples were tested for corticosterone levels using an enzyme immunoassay kit (Assay Designs, Ann Arbor, MI) as recommended by the manufacturer.

Findings

This is the first study to specifically identify effects of radiofrequency exposure on the mouse fetus. During critical windows in neurogenesis the brain is susceptible to numerous environmental insults. The effects of these agents are dependent on dose and timing of exposure. Even small exposures during periods of neurogenesis have a more profound effect than exposures in adulthood.

Environmental exposures occurring in fetal life can lead to persistent neurological deficits. Exposure to these insults as an adult does not carry the same consequences. It is therefore not surprising that studies exposing adult animals to radiofrequency radiation have failed to find similar significant defects in behavior.

Environmental exposures occurring in fetal life can lead to persistent neurological deficits. Exposure to these insults as an adult does not carry the same consequences.

The exposure to cellular telephones in pregnancy may have a comparable effect on the fetus and similar implications for society as do exposures to other common neurodevelopmental toxicants.

The molecular and cellular effects of radiofrequency exposure are not yet fully characterized. Multiple targets have been identified *in vitro.* Electromagnetic frequency exposure has been demonstrated to affect cell division and proliferation, both by inducing apoptosis and altering the cell cycle.[20]

Release of glutamate from the nerve terminals on PFC neurons and response of PFC neurons to glutamate are impaired in mice prenatally exposed to cell phone radiation, consistent with previous reports that compromised glutamatergic transmission onto PFC neurons underlies impaired memory and cognitive functions in animals.[18, 19]

Our results also imply that the effects of prenatal exposure to radiation on the brain might be global, since glutamatergic transmission onto neurons in another area of the brain (VMH) was decreased as well.

The effects of prenatal exposure to cell phone radiation may have more profound effects on brain functions than reported in this study. Our findings indicated significant electrophysiological and behavioral changes

Further testing is warranted in humans to better understand the neuropathological mechanisms behind these findings and to establish safe exposure limits during pregnancy.

in mice exposed *in utero* to radiation. The significant trend between the groups treated for 0, 9, 15, and 24 hours/day demonstrates that the effects are directly proportional to usage time, and suggests that safety limits, particularly for pregnant women, can be established.

Though it is difficult to translate these findings to precise human risks and vulnerability, we identify a novel potential contribution to the increased prevalence of hyperactive children, one that is easily prevented. However, it is important to note that hyperactivity and anxiety are closely related and may confound one another. In order to ensure that our findings are in fact due to memory deficits and not distractibility or hyperactivity, we controlled for those factors.

In summary, we demonstrate that fetal radiofrequency radiation exposure led to neurobehavioral disorders in mice. The rise in behavioral disorders in developed countries may be, at least in part, due to a contribution from fetal cellular telephone irradiation exposure. Further testing is warranted in humans to better understand the neuropathological mechanisms behind these findings and to establish safe exposure limits during pregnancy.

Here we demonstrate that *in-utero* radiofrequency exposure from cellular telephones does in fact affect behavior. Mice exposed *in utero* were hyperactive and had impaired memory as determined using the object recognition test, light/dark box test and step-down assay. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) revealed that these behavioral changes were due to an effect on neuronal developmental programming.

We present the first experimental evidence of neuropathology due to *in- utero* cellular telephone radiation. Overall, the mice exposed *in utero* to radiation were hyperactive, had decreased memory, and decreased anxiety. Further experiments are needed to determine safe exposure levels during pregnancy.

Laws, Regulations and Policies

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

- 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.[82]

- The 1986 U.S. Air Force study showed adverse behavioral effects in animals after they absorb enough RF energy to increase their body temperature by one degree Celsius.[83] 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."[84] Some governments, including Switzerland, Germany and the U.K., recommend using a cell phone with a low SAR.

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 energy (RF) 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

that research is continuing into the possible biological effects of exposure to RF and microwave radiation from radios, cellular 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.[85]

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.

- 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. 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 Specific Absorption Rate.[86] The study's cell phone model set the SAR at 0.901W/kg for the head, well under the FCC's SAR limit of 1.6 W/Kg for cell phones.

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

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

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.

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 measurement instruments.[87]

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.[88] 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, due to the thinness of the outer ear and skull of young children.[89] [90]

- Experimental models have shown that smaller head models produce statistically higher SAR values than larger models.[91] 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 such children.[92]

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.[93]

- The first precautionary recommendation discouraging mobile phone use by children was issued in the U.K. in 2004 by a group of independent scientists.[94] Recently, the European Parliament,

Table 8. Foreign Cell Phone Restrictions/Advisories for Children

Government	Advisory
Canada[96]	"… 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[97]	"…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[98]	"Parents should restrict the number and duration of calls as well as encourage the use of hands-free units."
France[99]	"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[100]	Limited use of mobile phones by children; children below 16 should be discouraged from using mobile phones.
Israel[101]	Limits children's use of mobile phones.
U.K.[102]	"Widespread use of mobile phones by children (under the age of 16) should be discouraged for non-essential calls."
Russia[103]	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[104]	Children and teens should keep their calls short or send a text message.

France, Germany, Russia, Sweden, Switzerland, India, Israel, and Finland have issued warnings that children 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.[95]

- 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.[105]

- Ireland's Department of Health issued a similar warning in 2011.[106] 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.[107]

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

- The International Commission for Electromagnetic Safety (ICEMS), "strongly advises limited use of cell phones, and other similar devices, by young children and teenagers."[108]

- 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 have been 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 5- to 7-year-olds and 75 percent of 10-year-olds have their own mobile phone.[109]

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.

- 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. [104] Similar bills have proposed labeling potential health risks of cell phones in Oregon, Pennsylvania and Maine.

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	Department of Health and the Department of Environment submitted a report on effects of cell phone radiation, with recommendations by November 1, 2011
Oregon	SB 679	"Warning: This is a radio-frequency (RF), radiation-emitting device that has nonthermal biological belongings for which no safety discipline have nonetheless been established. Controversy exists as to [whether they] are toxic to humans."		
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]

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.

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

Table 10. International Efforts to Label Cell Phones

Government	Label Requirement	Date
France[113]	"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[114]	Blue Angel Certification label on mobile phones with a SAR below legal limits.	2007
European Parliament[115]	"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[116]	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

- 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."[117]

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

- **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."[118]

- **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**."[119]

- **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**."[120]

- 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.

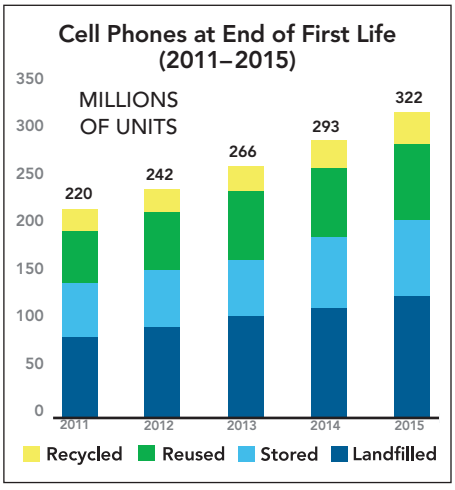
- Despite warning consumers to "keep the BlackBerry device at least 0.98 inches (25 mm) from your body when the BlackBerry device is turned on and connected to a wireless network," the Blackberry website runs the following ad that targets young people: ***"BlackBerry Pearl – Carry Your Friends in Your Pocket."*** [121]

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.

Cell Phone Recycling Problems

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

- 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 U.S., 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. While an estimated 55 million of these will end up stored in people's homes, many more will end up in landfills.
- 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 exposes 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.[122]



Summary of Findings

Cell Phone Patterns of Use

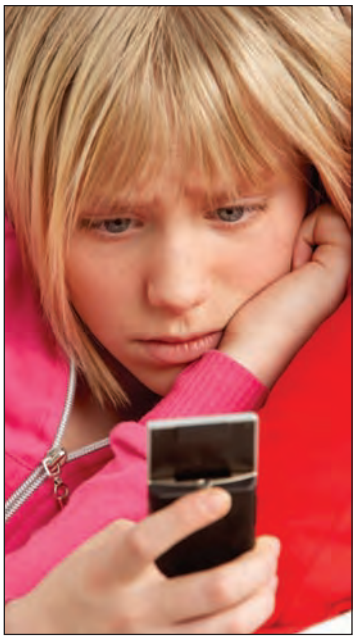
Use of cellular devices for voice conversations is declining as texting and other forms of non-verbal communication increase.

- **Cellular Device Adoption Rates:** There are nearly 276 million cell phone subscribers in the U.S., 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 smart phones, 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



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.

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.

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.

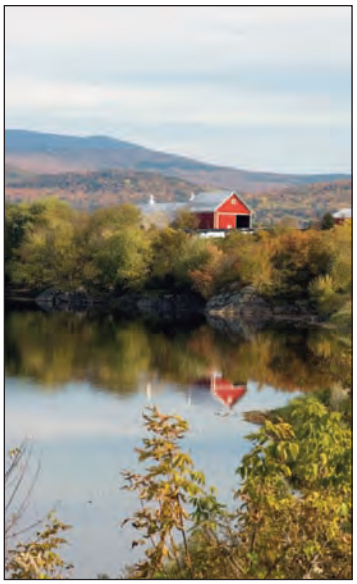
- **Children's Exposure is Greater Than Adults:** The thinner skulls of young children permit cell phone radiation to penetrate more deeply into the brain than is the case with adults. Children and fetuses' rapidly developing nervous systems, their more rapid rates of cell division, and longer potential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

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.



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.

- **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.

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 exposure 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 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 make understanding patterns of individual exposure to electromagnetic radiation emitted from devices difficult to reconstruct historically, and nearly impossible to predict. Some types of tumors take 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

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

Cell phones have enjoyed freedom from government scrutiny and control that otherwise would protect against health and environmental hazards before devices could be marketed.

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 materials. Other studies find 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% 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% 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% 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, 10 states had banned cell phone use while driving, and 35 states banned texting while driving. Widespread disregard for these statutes poses a serious enforcement challenge to

local and state police forces. The exceptionally small probability of being caught is well known, so most 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% and texting fell 75% as a result of the campaign.

- The number of electronic distractions in vehicles is increasing quickly. Televisions, video games, internet access, MP3 music player connections to sound systems are all added to more traditional electronics, including 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.

Regulations

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

  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

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.

packaging for many pharmaceuticals, alcohol, tobacco products, and pesticides.

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.

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

- **Federal Communication Commission Authority:** 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% 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 so.

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 sale's 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 with in 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 by 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 require the adoption of 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 Cellphone:** 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 speaker-phone, 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 EMR 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 pur-chasing 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.