



Cell Phone Towers and Radiofrequency (RF) Radiation Safety

Cell Phone Towers

Cell phone towers are also known as base stations. The base station antennas are usually located outdoors on rooftops, sides of buildings, or inside church steeples. The antennas are also situated on towers or monopole structures. For aesthetic purposes, many are camouflaged to look like brickwork on the side of a building or like an evergreen tree (monopine) along a roadway. Base stations typically contain antennas, control electronics, a GPS receiver for timing, digital signal processors, radio transmitters and power sources. Antennas are commonly arranged in groups of three, with one antenna used to transmit radio frequency (RF) signals to cellphones, and the other two used to receive RF signals from cellphones. Three groups of these antennas are installed to face in different directions (sectors) so as to provide 360 degree coverage.

Transmitted RF signals between the cellphone and base station are radio waves and can be characterized by their frequency and other coding features (e.g., modulation scheme) to carry information (voice or data). Cellphones operate at frequencies of about 900 megahertz (MHz) and 1900 MHz. RF energy is converted to heat when absorbed by the body, and the potential for tissue heating is the only established mechanism of interaction associated with potentially adverse effects. Exposure guidelines and standards for RF levels, as published by organizations such as the International Commission on Non-Ionizing Radiation (ICNIRP) and the Institute of Electrical and Electronic Engineers (IEEE), establish exposure limits to protect against adverse outcomes that could result from such heating. Between ~70 and 110 MHz, the human body (depending on a person's size) maximally absorbs the energy with complex spatial distribution due to differing body tissues. As the RF frequency increases, the energy's distribution is more concentrated near the body surface and by 3,000 MHz is almost all in the outer layers of skin.

Health Effects of RF

RF fields travel on a two-way path between base station and a cell phone user. Because the phone is often held in close proximity to the head, most exposure is attributable to RF emissions from the phone (called the uplink). However, measurable exposure is possible from a base station (the downlink) depending on its power rating, a person's proximity to the base station, and the directionality of its antenna's beam.

Over the last two decades, a large number of studies have been conducted to assess cellular phone health risk, particularly studies in human populations (epidemiologic studies) seeking to determine if cell phone use is a risk factor for brain cancer. A number of studies have also investigated the potential effects of RF exposure on cancer in laboratory animals, brain electrical activity, cognitive function, sleep, heart rate and blood pressure in volunteers. To date, there is no consistent scientific evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating.



It is generally accepted that damage to DNA molecules in living cells is necessary to initiate the carcinogenic process. For example, we know that ionizing radiation such as gamma ray and x-ray exposure, by virtue of its high energy, can cause initiation of cancers through unrepaired mutations of genes or disruption of chromosomal structure. This process may be mediated by the production of reactive oxygen species. The frequencies of RF fields are over 100,000 times lower than electromagnetic wave frequencies capable of breaking chemical bonds. Thus, RF energy is called "non-ionizing". It has not been found to cause cancer in animals or to enhance the cancer-causing effects of known chemical carcinogens in animals. For these reasons, the overwhelming majority of consensus documents from various health agencies worldwide agree that cell phones and base-station antennas are unlikely to cause cancer.

As stated above, epidemiological research on potential long-term health risks from radiofrequency exposure has focused on brain tumor risk and mobile phone use. For the most part, this literature has not uncovered a positive association between RF (mostly from cell phones) and brain cancer, although there are several exceptions. Since most cancers have a latency period of between 10 and 40 years and mobile phones were not widely used until the early 1990s, epidemiological studies can only assess cancers with shorter latency periods. However, animal studies consistently show no increased cancer risk for long-term exposure to radiofrequency fields, and despite considerable effort, no plausible biological mechanism has been identified whereby RF at levels emitted by cell phones can initiate cancer.

Prior to the advent of cellular technology, RF exposure has had a ubiquitous presence in modern society since the introduction of commercial AM radio in the 1920s, the expansion of FM radio (~88-108 MHz) after World War II, and the inception of TV (100s of MHz) in the 1940s, which spread from urban to rural areas in the US in the 1950s. Cellular technology has introduced higher frequency sources, but has not changed physical interactions, when compared to our exposure to radio and TV transmissions.

Radiation Regulations

Since 1985, the United States FCC (Federal Communications Commission) has exercised regulatory authority over RF exposures produced by its licensees (see OET Bulletin 65, 1997). The FCC's current rules are based on interagency consensus that include the EPA, FDA, National Institute for Occupational Safety and Health (NIOSH), and Occupational Safety and Health Administration (OSHA). Moreover, many international public health groups, such as the International Commission on Non-ionizing Radiation Protection (ICNIRP) and the European Commission (an arm of the EU) monitor and review RF health effects research.

The current FCC guidelines are based on recommendations by the National Council on Radiation Protection and Measurements (NCRP) and the Institute of Electrical and Electronics Engineers (IEEE) made in the early 1990s. Both the NCRP and the IEEE documents were developed by interdisciplinary groups of expert scientists and engineers after extensive reviews of scientific literature related to RF biological effects. These "blue-ribbon" reviews of the science (by FCC,



IEEE, ICNIRP) are periodically updated ¹ to include research in additional areas such as "non-thermal" effects of RF.

Studies have shown that environmental levels of RF fields (produced by cellphone base stations, radio and TV broadcasting, GPS) routinely encountered by the general public are typically far below the FCC limits. From 30 to 300 MHz the FCC MPE (Maximum Permissible Exposure) for the general public is 0.2 milliwatts per square centimeter (mW/cm²) increasing to 1 mW/cm² at 1,500 MHz. Across radio, TV and cellular bands the highest fields the public might typically experience are between 0.1% to 0.5% of the FCC limit, translating to an absolute value of about 1 microwatt per square centimeter (μW/cm²).

Frequently Asked Questions about of Cell Phone Towers

1. Who oversees cell phone tower safety for the public in Massachusetts?

Cell phone antennas must be approved by Massachusetts governmental agencies before they are built. In order to get permits, cell phone providers must satisfy all of FCC regulations.

2. Is it safe to live or work on the top floor of a building that has a mobile phone base station antenna on it?

We believe the answer is "yes." In urban areas, most cell phone antennas are installed on the tops of buildings. RF energy from the antennas is directed horizontally. The roofs of buildings reflect and absorb large fractions of RF energy on the roofs surface. Typically, a roof is expected to decrease signal strength by a factor of 5 to 10 (more for a reinforced concrete or metal roof). For antennas mounted on the sides of buildings, the energy level behind a fixed antenna is hundreds to thousands of times lower than in front. Even a worst-case calculation predicts that power density on the floor below a rooftop antenna will meet all current RF safety guidelines. Actual measurements in top floor apartments and corridors confirm that power density is far below all current RF safety guidelines.

3. Do more cell phone towers mean higher RF exposure levels?

Not really. Cellphone user's RF exposures come from two sources. One is cellphone towers, which send signals to cellphones through RF waves. The RF fields, created by cellular base stations, in typical public areas may be equal to or less than a few

¹ FCC "Wireless Devices and Health Concerns." March 2014. www.fcc.gov/encyclopedia/radio-frequency-safety AND <http://transition.fcc.gov/cgb/consumerfacts/mobilephone.pdf>
IEEE document "C95.1-2005 RF Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" [2006].
ICNIRP statement on the "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)". International Commission on Non-Ionizing Radiation Protection. *Health Phys.* 97(3):257-8 [2009].



microwatts per square centimeter (10^{-6} Watts/cm²). The cellphone itself sends signals to base station antennas with the power of thousands of microwatts (10^{-3} Watts). Because a cell phone is typically held against the side of the head when in use, much of the RF energy is delivered to very small volumes of the user's body. The greatest RF exposures are from cellphones, not from base stations.

Cell phone communication is two-way. RF signals from a base station decay with distance. All things being equal, the greater the distance between a cell phone and a base station then the weaker the signal. However, a cell phone needs to operate at greater power for its signal to reach base stations further away. This leads to more RF exposure to the cell-phone users when base stations are widely spaced. When phone users are close to towers, the cell phone will emit signals at lower power, which means less RF exposure to a user, so more towers generally reduce a user's RF exposure.

Many factors affect a person's RF exposure, including:

- The amount of time a person is on the phone.
 - Using a speaker or hand-free device will keep the phone away from your head.
 - Text messaging reduces exposures to the head when the user types in front of the body.
- Cell phone reception quality
 - Cell phones adjust their power to make a connection based on the phone's signal strength at the relevant base station. The phone uses minimum power with a good signal and increases the power in poor reception areas.

Tips to Minimize Exposure

The following cellphone tips may help you reduce unnecessary RF exposure:

- 1) Use the speaker or a headset whenever possible.
- 2) Keep your phone at least five feet away from your bed.
 - a) Avoid placing a cell phone under pillows, on beds or on bedside tables, which may expose you to RF fields while you sleep.
- 3) Avoid using cellphones in moving vehicles (cars and all forms of public transportation) since the cellphone may need to operate at a higher power as its signal is handed off from one base station to another. ***[Risk from RF is minor compared to accident risk, if one uses a cellphone or text messages in a moving vehicle!]***
- 4) Minimize use of a cell phone in poor signal areas.
- 5) If you wear a pacemaker or defibrillator, do not place a cell phone in a pocket adjacent to the heart.



Organizations and RF Safety Web Sites:

- 1) Environmental Protection Agency (EPA)
<http://www.epa.gov/radtown/wireless-tech.html>
- 2) Federal Communications Commission (FCC)
www.fcc.gov/oet/rfsafety
- 3) Food and Drug Administration (FDA)
<http://www.fda.gov/radiation-emittingproducts/radiationemittingproductsandprocedures/homebusinessandentertainment/cellphones/default.htm>
- 4) World Health Organization (WHO)
www.who.int/mediacentre/factsheets/fs304/en/index.html

References:

1. OET Bulletin 65: Federal Communications Commission Office of Engineering and Technology, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Edition 97-01, August 1997.
2. 105 CMR 122.000: Massachusetts Department of Public Health, Non-Ionizing Radiation Limits for: The General Public from Non-Occupational Exposure to Electromagnetic Fields, Employees from Occupational Exposure to Electromagnetic Fields, and Exposure from Microwave Ovens.
3. National Council on Radiation Protection and Measurements (NCRP); Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, NCRP Report 86, 1986.
4. Norwegian Institute of Public Health. 2013. "Low level radiofrequency electromagnetic fields: An assessment of health risks and evaluation of regulatory practice."
<http://www.fhi.no/dokumenter/545eea7147.pdf>
5. Valberg, PA; Van Deventer, TE; Repacholi, MH. 2007. "Base stations and wireless networks: Radiofrequency (RF) exposures and health consequences." *Environ. Health Perspect.* 115:416-424.