



Cell Phone Radio Frequency Radiation Studies

Cell phones are used by 97% of American adults.¹ Given the large number of users, any harmful effects associated with cell phone use could be a significant public health concern.

Cell phones use radio frequency radiation (RFR) to transmit signals. The U.S. Food and Drug Administration (FDA) nominated RFR for study by the National Toxicology Program (NTP), due to widespread human exposure and limited information about the potential health effects of long-term cell phone use.

What did NTP study?

NTP conducted toxicology studies in rats and mice to help clarify potential health hazards, including cancer risk, from exposure to RFR used in 2G and 3G cell phones. 2G and 3G networks were standard when the studies were designed and are still used for phone calls and texting.

The NTP studies, completed in 2018, are the most comprehensive assessment, to date, of health effects in animals exposed to RFR.



What did the studies find?

In studies of high levels of RFR, like that used in 2G and 3G cell phones, NTP found:

- **Clear evidence of an association with tumors in the hearts of male rats.** The tumors were malignant schwannomas.
- **Some evidence of an association with tumors in the brains of male rats.** The tumors were malignant gliomas.
- **Some evidence of an association with tumors in the adrenal glands of male rats.** The tumors were benign, malignant, or complex combined pheochromocytoma.

For female rats, and male and female mice, it was unclear, also known as equivocal, whether cancers observed in the studies were associated with exposure to RFR.

The conclusions were based on NTP's four categories of evidence that a substance may cause cancer:

- Clear evidence (highest)
- Some evidence
- Equivocal evidence
- No evidence (lowest)

If you are concerned about potential health risks from RFR, the FDA suggests the following tips:²

- Use speaker mode, headset, headphones, or earbuds to place more distance between your head and the cell phone.
- Reduce the amount of time spent using your cell phone.
- Consider texting rather than talking — but don't text while you are driving.





Do the rat and mouse findings apply to humans?

The findings in animals cannot be directly applied to humans for two key reasons:

- The exposure levels and durations were greater than what people may receive from cell phones.
- The rats and mice received RFR across their whole bodies, which is different from the more localized exposures humans may receive, like from a cell phone in their pocket or next to their head.

However, the studies question the long-held assumption that RFR is of no concern as long as the energy level is low and does not significantly heat the tissues.

Did NTP find health effects other than cancer?

NTP found lower body weights among newborn rats and their mothers, especially when exposed to high levels of RFR during pregnancy and lactation, yet these animals grew to normal size. They also found that RFR exposure was associated with an increase in DNA damage. DNA damage, if not repaired, can potentially lead to tumors. Specifically, they found RFR exposure was linked with significant increases in DNA damage in the frontal cortex of the brain in male mice, the blood cells of female mice, and the hippocampus of male rats.

What factors contributed to the NTP conclusions?

In addition to seeing tumors in the male rats with higher exposures to RFR, NTP scientists also observed other changes in the hearts of exposed male and female rats that supported their conclusions.

The evidence for tumors in the brain and adrenal glands was not as strong as what NTP scientists saw in the heart. However, the type of brain cancer observed is similar to a type of brain tumor linked to heavy cell phone use in some human studies.³

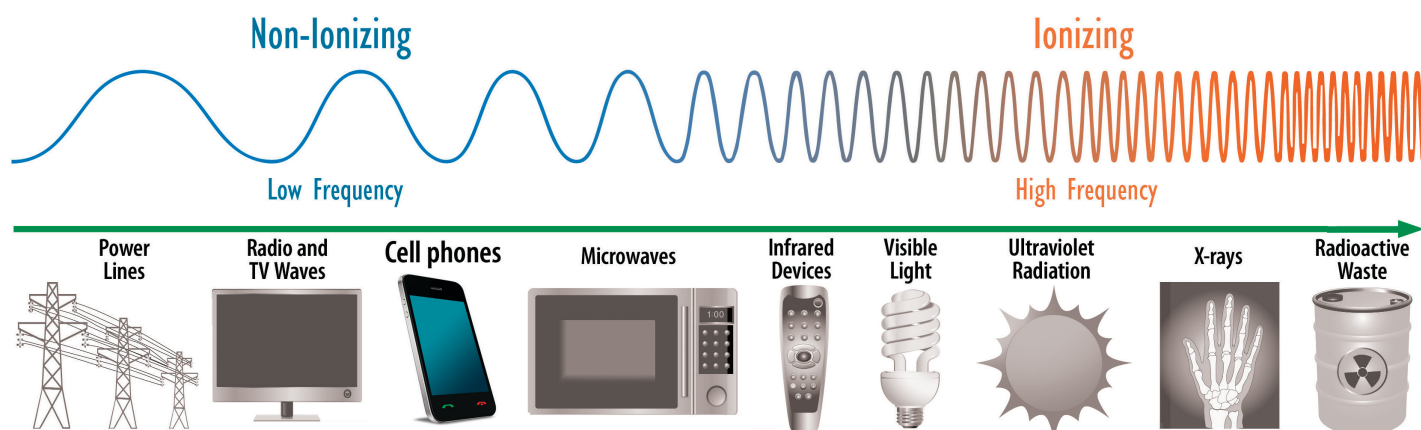
Still, the effects observed in the animals were relatively rare. NTP scientists are not sure why male rats appear to be at greater risk for developing tumors compared to female rats.

How do the RFR levels used in the studies compare to typical human exposures?

The lowest exposure level used in the studies was equal to the maximum exposure to the local tissue (cells) currently allowed for cell phone users. This power level rarely occurs with typical cell phone use. The highest exposure level in the studies was four times higher than the maximum power level permitted for local tissues.



Electromagnetic Spectrum



RFR used in cell phones is at the lower frequency and lower energy end of the electromagnetic spectrum.



Why did NTP expose the animals' whole bodies to RFR?

Although many previous studies focused on exposure to the brain, NTP scientists wanted to make sure that they were considering health effects to the whole body, especially since many people do not hold their phones next to their head much of time.

What is the difference between electric and magnetic fields and RFR?

RFR is a subcategory of electric and magnetic fields (EMF), which are the invisible waves of force that surround any electrical device. The different types of EMF are distinguished by their frequencies. RFR is a form of low frequency, non-ionizing radiation that was thought to be relatively harmless.

How were the studies conducted?

Rats and mice were exposed to RFR in special chambers for up to two years, or most of their natural lives. NTP scientists looked for a range of cancers and noncancer health effects.

Exposure to RFR began in the womb for rats and at 5-6 weeks old for mice. The RFR exposure was intermittent, 10 minutes on and 10 minutes off, totaling about nine hours each day. The RFR levels ranged from 1.5 to 6 watts per kilogram of body weight in rats, and 2.5 to 10 watts per kilogram in mice.



Chambers at the IIT Research Institute in Chicago where the studies took place.

The chambers were shielded rooms with a transmitting antenna that radiated RFR fields, plus rotating stirrers that generated a uniform field.^{4,5} Pilot studies established field strengths that did not raise animal body temperatures excessively.⁶

The rats and mice were exposed to whole body RFR at frequencies of 900 and 1,900 megahertz, respectively, from two technologies: code division multiple access (CDMA) and global system for mobile communications (GSM).

NTP and RFR experts from the National Institute of Standards and Technology (NIST) and the IT'IS Foundation designed and built the chambers specifically for these studies.

What is the difference between CDMA and GSM?

CDMA and GSM are two common ways of transmitting cell phone signals in the U.S. and Europe. There are substantial differences in signal structure that may result in different RFR exposures, so NTP wanted to expose the animals to both modulations.

What additional studies have been done?

Scientists at the National Institute of Environmental Health Sciences (NIEHS) conducted follow-on research to better understand the biological mechanisms by which RFR produced tumor development and DNA damage. Specifically, they sought to learn if the health effects on rodents documented in the NTP studies resulted from direct RFR exposure or RFR-induced changes in body-tissue temperature.

This testing required the development of a small-scale RFR system that allowed monitoring of behavior of rodents during exposure, permitted greater control of exposures, and supported testing of 2G, 3G, 4G LTE, and unmodulated signals. Scientists also implanted temperature chips and data loggers into rodents, seeking to measure internal body temperature as exposure occurred.



What did those studies find?

Rats and mice exposed to RFR over a five-day period showed no changes in behavior during operation of the system. Researchers also found no evidence of DNA damage as a result of the continuous exposures.

Questions about RFR exposure and body heat remained unanswered. Neither the microchips nor the data loggers successfully measured internal body temperature of the rodents, preventing researchers from drawing conclusions about the role of tissue heating in RFR-induced toxicity and cancer.

What is the future for RFR research?

NTP and NIEHS have no plans for additional RFR exposure research, but the completed studies have established a foundation for others to build upon. Researchers around the world are conducting studies of RFR exposure to better understand the cancer risks and potential long-term effects to humans.

Where can I go for more information?

For more information on what the NTP and federal agencies are doing to determine whether RFR used in cell phones may affect human health, visit the following websites:

National Toxicology Program

<https://ntp.niehs.nih.gov/go/cellphone>

National Cancer Institute

<https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet>

U.S. Food and Drug Administration

<https://go.usa.gov/B5tx>

Federal Communications Commission

<https://fcc.gov/consumers/guides/wireless-devices-and-health-concerns>

Final reports and data tables are available on the NTP website at <https://ntp.niehs.nih.gov/go/cellphone>.



The National Toxicology Program is an interagency program headquartered at the **National Institute of Environmental Health Sciences** that tests and evaluates chemicals in our environment.

For more information on NTP, go to <https://ntp.niehs.nih.gov>.

¹ Pew Research Center. 2021. Mobile Fact Sheet. Available: <https://pewinternet.org/fact-sheet/mobile> [accessed February 6, 2023].

² FDA (U.S. Food and Drug Administration). 2020. Reducing Radio Frequency Exposure from Cell Phones. Available: <https://www.fda.gov/radiation-emitting-products/cell-phones/reducing-radio-frequency-exposure-cell-phones> [accessed February 6, 2023].

³ IARC (International Agency for Research on Cancer). 2013. *Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields*. IARC Monogr Eval Carcinog Risks Hum 102:1-481.

⁴ Capstick MH, et al. 2017. A radio frequency radiation exposure system for rodents based on reverberation chambers. *IEEE T Electromagn C* 59(4):1041-1052.

⁵ Gong Y, et al. 2017. Life-time dosimetric assessment for mice and rats exposed in reverberation chambers for the two-year NTP cancer bioassay study on cell phone radiation. *IEEE T Electromagn C* 59(6):1798-1808.

⁶ Wyde ME, et al. 2018. Effect of cell phone radiofrequency radiation on body temperature in rodents: Pilot studies of the National Toxicology Program's reverberation chamber exposure system. *Bioelectromagnetics* 39(3):190-199.