

Summary of Epidemiology Studies Evaluating the Biological and Health Effects of Living Near a Mobile Phone Base Station (Cell Tower)

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INTERIM REVISED DRAFT

Version 1.2 July 24, 2021

Introduction

We describe here the findings from peer-reviewed studies conducted by scientists and physicians in various countries regarding health effects of mobile phone base stations, also known as cell towers. This report provides context for maps we and others have created to make visible the levels of radio-frequency radiation (RFR) in residential neighborhoods.

Summary of Findings

Tables 1A and 1B reveal that a range of neurophysiological health effects can occur among populations living near cell towers. The ailments observed are typical of those associated with occupational exposure to radio-frequency radiation. We see from the tables that such relatively mild effects as headache and short-term memory loss can occur at a power density (field intensity) as low as about 100 microwatts per square meter ($\mu\text{W}/\text{m}^2$). We see also that such potentially more serious health effects as endocrine imbalance, depression, and DNA damage can occur when populations are exposed to somewhat higher exposures (approximately 1,000 $\mu\text{W}/\text{m}^2$ or more).

Tables 1A and 1B also reveal that to minimize health effects among a population a cellular antenna should be located at least 300 meters from any residential dwelling.

Table 2 lists some studies of populations living near radio and TV transmitters. Predating the cell-tower-related studies in Tables 1A and 1B, these papers demonstrate that health risks associated with radio-frequency radiation are not a new phenomenon. Note that many of these radio- and TV-related studies found an elevated risk of childhood leukemia, which some researchers suggest may follow from DNA damage—an effect also documented in some populations near cell towers.

Conclusion

A community's siting and design criteria for wireless transmission facilities should include a requirement that cell towers, including any so-called “small cells,” must be located at least 300 meters from houses, apartment buildings, and other dwellings. If such a requirement is not created and maintained, the population that works, studies, plays, dines, and sleeps within the community over months to years is more likely to include people who have chronic neurophysiological maladies and diseases, and perhaps certain kinds of cancer, than in the past.

Notes Regarding the Evolution of Studies

Epidemiological research on this topic has undergone a shift. Most of the studies carried out between 2000 and 2010 are based on questionnaire surveys, in which respondents filled out a form listing various medical symptoms. Since 2011, many of the studies are now looking for objective physiological changes that signal either (1) oxidative injury within the body at a cellular level, or (2) DNA damage.

The articles describing questionnaire studies are fairly easy to understand. See, for example, Navarro et al (2003), Eger et al (2004), Eger and Jahn (2010), and Shinjyo and Shinjyo (2014).

The post-2010 articles describing cellular biology-based studies can be a bit harder to understand. Examples are Gulati et al (2017) and Zothanslama et al (2017). Below are four tips that may help you navigate such papers if you are motivated to do so.

- Oxidative stress: Exposure to microwaves can cause oxidative stress within the body's cells. When this happens, the concentrations of the body's own antioxidants become depleted. Researchers look for that. Typically, they watch for decreases in the concentrations of the antioxidants glutathione (GSH), catalase (CAT), and superoxide dismutase (SOD).
- Oxidative injury: As the body's levels of antioxidants become depleted, cellular injury may occur as a result of excessive oxidation. The cell membrane typically contains lipid molecules that are oxidative targets. Researchers watch for an increase of lipid peroxidation (LOO), which may indicate injury.
- DNA fragmentation: Micronuclei (MN) are fragments of broken DNA. Researchers watch for an increasing concentration of those, as it may indicate an elevated rate of DNA damage.
- DNA damage: The “Comet Assay” is considered the “gold standard” when measuring DNA damage. The method involves preparing a molecular “snapshot” and looking to see whether the image is quite round (indicating normal DNA) or somewhat oblong with a tail like a comet (broken DNA).

Summaries of most of the scientific articles listed in Tables 1A and 1B are provided in the latter half of this report. We also include there a trio of review articles by researchers who have decades of experience studying the biological effects and human health effects of radio-frequency radiation.

To read a paper, find its summary, then click the title, activating a link to the text. (For a few articles we cite, the full text is not freely available and the link points only to an abstract.)

Table 1A. Health Effects Near Cell Towers—Studies 2002 to 2010**Studies Reporting Effects Relative to RFR Power Density**

<u>Study</u>	<u>RFR Level ($\mu\text{W}/\text{m}^2$)</u>	<u>Reported Health Effects</u>
Navarro (2003)	avg. 100 to 1,100	Fatigue, irritability, headache, nausea, appetite loss, feeling of discomfort, sleep disturbance, depressive tendency, difficulty in concentration, memory loss, dizziness, skin alterations, visual dysfunction, and cardiovascular alterations
Zwamborn (2003)	1,300	Anxiety, hostility, impaired cognition
Oberfeld (2004)	range 1 to 4,400	Same as for the study by Navarro, et al (2003)
Hutter (2006)	<100 to 4,100	Headaches, cold hands or feet, difficulty concentrating (all statistically significant, with $p < 0.05$), plus some tendency for tremor, sleep inefficiency, and loss of appetite (not quite significant, $p = 0.06\text{--}0.07$)
Thomas (2008)	50 to 400	Headaches, sleep disruption, difficulty concentrating
Eger and Jahn (2010)	1,300 to 3,600	Various neurophysiological ailments: sleep disruption, cognitive and memory problems, headache, depression, joint problems, skin problems, visual dysfunction, auditory disturbances (including loss of equilibrium), gastrointestinal disorders, cardiovascular problems
Heinrich (2010)	30 to 200	Headaches, irritability, difficulty concentrating
Thomas (2010)	30 to 200	Behavioral problems in children and adolescents
Mohler (2010)	50	Sleep disruption

Studies Reporting Effects Relative to Distance from Cell Tower

<u>Study</u>	<u>Distance to Tower</u>	<u>Reported Health Effects</u>
Santini (2002)	up to 300 m	Irritability, depression and dizziness (all within 100m), and fatigue (within 300m) in residents living near a cell phone transmitter station in France
Eger (2004)	up to 400 m	2X risk of malignant tumors within first 5 years of exposure; greater risk for same at longer duration
Wolf (2004)	up to 350 m	10X cancer risk for females, 4X for entire population

Table 1B. Health Effects Near Cell Towers—Studies 2011 to 2018

Studies Reporting Effects Relative to RFR Power Density

<u>Study</u>	<u>RFR Level ($\mu\text{W}/\text{m}^2$)</u>	<u>Reported Health Effects</u>
Buchner and Eger (2012)	30 to 240	Significant impact on stress hormones; children and the elderly most at risk
Shinjo (2014)	up to 280	Radio-wave illness (many different neuro-physiological symptoms)
Zothansiamma (2017)	2,800–7,500	DNA damage and oxidative cellular stress among a high-exposure population within 80 m of a cell tower relative to a low-exposure population more than 300 m from the tower (where RFR is much lower, 14–65 $\mu\text{W}/\text{m}^2$)

Studies Reporting Effects Relative to Distance from Cell Tower

<u>Study</u>	<u>Distance to Tower</u>	<u>Reported Health Effects</u>
Dode (2011)	up to 500 m	Elevated risk of cancer mortality
Eskander (2011)	up to 500 m	Endocrine effects: altered ACTH, cortisol, thyroid hormones, prolactin for females, testosterone for males
Gandhi (2014)	up to 300 m	DNA damage
Gulati (2015)	up to 300 m	DNA damage, loss of short-term memory, insomnia, depression

Table 2. Health Effects Near Radio and TV Antennas

Studies Reporting Effects Relative to Distance from Antenna Tower

<u>Study</u>	<u>Distance to Tower</u>	<u>Reported Health Effects</u>
Maskarinec (1994)	up to 4 km	Increased childhood leukemia near radio towers in Hawaii
Hocking (1996)	various	Increased cancer and mortality near TV towers in Australia
Dolk (1997a)	up to 2 km	2X odds of leukemia for people living near Sutton Coldfield transmitter, England
Dolk (1997b)	up to 10 km	Increased odds for leukemia near 20 transmitters in England
Cherry (1999)	various	Increased cancer rate for people living near cell towers in Australia
Cherry (2000)	up to 6 km	3X to 8X rate of childhood leukemia near Sutro Tower in San Francisco, Calif.
Michelozzi (2001)	up to 6 km	Increased odds ratio for leukemia near Radio Vatican transmitter

Studies in Table 1A on the Health of People Living or Working Near Mobile Phone Base Stations (Cell Towers)

Santini R, et al, 2002. [Investigation on the health of people living near mobile telephone relay stations: incidence according to distance and sex.](#) Pathol Biol (Paris), Volume 50, Issue 6 (Jul 2002), p 369–73. [article in French]

- This study revealed that people living near a mobile phone base station (cell tower) experience higher than normal incidence of headache, sleep disturbance, discomfort, irritability, depression, memory loss, and concentration problems. The effect was greater, the closer people lived to such an installation.
- Study authors recommended that any new base station be located at least 300 meters from homes.

Navarro EA, et al, 2003. [The microwave syndrome: a preliminary study.](#) Electromagnetic Biology and Medicine, Volume 22, Issue 2, p 161–169.

- Researchers demonstrated a statistically-significant association between radio-frequency radiation (RFR) and such ailments as fatigue, irritability, headache, nausea, appetite loss, feeling of discomfort, sleep disturbance, depressive tendency, difficulty in concentration, memory loss, dizziness, skin alterations, visual dysfunction, and cardiovascular alterations.
- All of the above symptoms can occur in people suffering from “microwave sickness,” also known as “radio-wave illness” or “RF syndrome,” a condition well-documented from the 1970s through the 1990s in clinical and research reports from Russia and Eastern Europe.

Bortkiewicz, et al, 2004. [Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review.](#) Med Pr. 2004, Volume 55, Issue 4, p 345–51. [article in Polish]

- People in Poland living near mobile phone base stations reported more incidences of circulatory problems, sleep disturbances, irritability, depression, blurred vision, and concentration difficulties than those living farther away from such facilities.
- This review article concluded that a relationship exists between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station.

Eger, et al, 2004. [The influence of being physically near to a cell phone transmission mast on the incidence of cancer.](#) Umwelt-Medizin-Gesellschaft, Volume 17, Issue 4. [English translation of article in German]

- This study in Germany revealed that the prevalence of newly-developing cancer cases was significantly higher than normal among patients who had lived during the past ten years within 400 meters of a cell tower.
- The study also revealed that patients living near a cell tower became ill with cancer on average eight years earlier than those living far from a tower.
- The incidence of malignant tumors had increased by 200% after five years’ exposure for those people living within a 400-meter radius of a cell tower.

Oberfeld AE, Navarro M, Portoles C, Maestu C, Gomez-Perretta. 2004. [The microwave syndrome: further aspects of a Spanish study.](#)

- This was a follow-up to a health survey carried out in La Ñora, Murcia, Spain, in the vicinity of two mobile phone base stations, as originally reported by Navarro (2003). An adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Wolf R, and Wolf D. 2004. [Increased incidence of cancer near a cell-phone transmitter station.](#) International Journal of Cancer Prevention, Volume 1, Number 2 (Apr 2004).

- This study examined cancer incidence among people living in two different areas in the city of Netanya, Israel. Area A consisted of homes within 350 meters of a mobile phone base station. Area B consisted of similar homes away from the base station. The exposure to radio frequency radiation for residents in Area A was 3,000 to 5,000 $\mu\text{W}/\text{m}^2$.
- A comparison of the relative risk revealed that there were 4.15 times more cancer cases overall in Area A than in the entire population of Netanya.
- Relative cancer rates for females were 10.5 for area A, 0.6 for area B and 1.0 for the whole town. Cancer incidence among women in area A was thus significantly higher ($p < 0.0001$) compared with that of area B and the whole city.

Hutter HP, et al. 2006. [Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations.](#) Occup Environ Med., Volume 63, Issue 5, p 307–313.

- Researchers studying 365 people living near cell towers found a relationship between subjects' cognitive symptoms and their exposure to radio-frequency radiation. The association was most significant for headaches. Also, at higher exposure levels, perceptual speed was higher, yet accuracy was lower.

Abdel-Rassoul, et al. 2007. [Neurobehavioral effects among inhabitants around mobile phone base stations.](#) NeuroToxicology, Volume 28, p 434–440.

- This study found that living near a mobile phone base station increased the risk for neurophysiological problems such as headaches, short-term memory loss, dizziness, tremors, depression, and sleep disruption. Researchers also noted changes in the performance of certain neurobehavioral functions.

Eger H, and Jahn, M. 2010. [Specific Health Symptoms and Cell Phone Radiation in Selbitz \(Bavaria, Germany\)—Evidence of a Dose-Response Relationship.](#) Umwelt-Medizin-Gesellschaft, Volume 23, Issue 2, p 130–139.

- Over 250 residents of the municipality of Selbitz participated in a health survey.
- Based on the distance of their homes to a cellular phone base station, persons surveyed were considered to be in Groups 1&2 (average exposure 1.17 V/m), Groups 3&4 (0.7 V/m), or Group 5 (0.18 V/m).

- For such symptoms as sleep disruption, depression, cognitive problems, joint problems, infections, skin problems, and cardiovascular problems, as well as for disorders of the visual and auditory systems and the gastrointestinal tract, a significant dose-response relationship was observed in relation to exposure.
- Significant health effects were observed as far away from the base station as 400 meters.
- According to the authors, “The impact of microwave radiation on the human nervous system serves as an explanation.”

Studies in Table 1B on the Health of People Living or Working Near Mobile Phone Base Stations (Cell Towers)

Buchner K, and Eger H. 2011. [Changes of neurochemically important transmitters under the influence of modulated RF fields—a long term study under real life conditions](#). Umwelt-Medizin-Gesellschaft Volume 24, Issue 1, pages 44–57.

- This German study revealed elevated levels of stress hormones (adrenaline, noradrenaline) and decreased levels of dopamine and PEA in urine of people living near a cell tower during the first six months after the tower went live.
- Even after one and a half years, the levels did not return to normal.

Eskander EF, et al. 2011. [How does long term exposure to base stations and mobile phones affect human hormone profiles?](#) Clinical Biochemistry, Volume 45, pages 157–161.

- RFR exposures significantly impacted ACTH, cortisol, thyroid hormones, prolactin for females, and testosterone levels for males.

Dode et al. 2011. [Mortality by neoplasia and cellular telephone base stations](#). Science of the Total Environment, Volume 409, Issue 19, pages 3649–3665.

- This 10-year study on cell phone antennas by the Municipal Health Department in Belo Horizonte and several universities in Brazil found a clearly elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell phone transmission towers.
- Shortly after the study was published, the city prosecutor sued several cell phone companies and requested that almost half of the city's antennas be removed. Many antennas were dismantled.

Gandhi G, et al. 2014. [A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station](#). Electromagnetic Biology and Medicine, Volume 34, Issue 4, pages 344–354.

- This cross-sectional case control study of individuals living near cell towers found genetic damage parameters of DNA significantly elevated.
- The authors conclude the article by stating, “The genetic damage evident in the participants of this study needs to be addressed against future disease risk, which in addition to neurodegenerative disorders, may lead to cancer.”

Shinjo T, and Shinjo A. 2014. [Signifikanter Rückgang klinischer Symptome nach Senderabbau – eine Interventionsstudie. \(English-Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal – An Intervention Study\)](#). Umwelt-Medizin-Gesellschaft, Volume 27, Issue 4, pages 294–301.

- This study in Japan demonstrated statistically significant adverse health effects resulting from the radiation emitted by cell towers on the roof of a condominium building.
- Many residents of the building suffered from various symptoms of radio-wave illness during the years the antennas were active. Residents were examined medically before and after the antennas were removed.

- Most of the affected people recovered significantly after the antennas were gone.

Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R. 2015. [Effect of GSTM1 and GSTT1 polymorphisms on genetic damage in human populations exposed to radiation from mobile towers.](#) Arch Environ Contam Toxicol., Volume 70, Issue 3, pages 615–625.

- In this study 116 people exposed to radiation from mobile phone towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes. In addition, DNA damage in peripheral blood lymphocytes was determined by alkaline comet assay.
- Results indicated that DNA damage was higher in the exposed population than in the control group, and that the difference is statistically significant. The study also found that such health symptoms as depression, short-term memory loss, insomnia, and hair loss were significantly associated with exposure to radio-frequency radiation.
- The authors noted, “Damaging effects of non-ionizing radiation result from the generation of reactive oxygen species (ROS) and subsequent radical formation, as well as from direct damage to cellular macromolecules, including DNA.”

Zothansiam, et al. 2017. [Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations.](#) Electromagnetic Biology and Medicine, Volume 36, Issue 3, pages 295–305.

- This study evaluated effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters away).
- Results showed that higher exposures to radio-frequency radiation are associated with statistically significant differences in subjects' blood. The group living closer to the antennas had, for example, higher frequency of micronuclei and a rise in lipid peroxidation in their blood. As noted by the authors, such changes are considered biomarkers predictive of cancer.

Three Significant Reviews of the Literature on Health Effects from Radio Frequency Radiation Near Mobile-phone Base Stations (Cell Towers)

Khurana VG, et al. 2010. [Epidemiological evidence for a health risk from mobile phone base stations](#). International Journal of Occupational Environmental Health, Volume 16, Issue 3, p 263–267.

- This review looked at ten epidemiological studies—four from Germany and one each from Austria, Egypt, France, Israel, Poland, and Spain.
- The authors found that eight of the ten studies reported increased prevalence of adverse neurophysiological symptoms or cancer in populations living at distances less than 500 meters from base stations. They also note that some studies reported impairments in cognitive performance in individuals living less than 80 meters from base stations.
- None of the reviewed studies reported exposure above accepted international guidelines.

Levitt LB, and Lai H. 2010. [Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays](#). Environmental Reviews, 2010, 18(NA): 369–395

- This review of 100 studies found approximately 80% showed biological effects near towers.
- From the abstract: “Both anecdotal reports and some epidemiology studies have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations.”

Yakymenko I. 2011. [Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems](#). Exp Oncology, Volume 33, Issue 2, p 62–70.

- This paper examined epidemiological and experimental studies that indicate a possible carcinogenic effect of long-term exposure to low-intensity microwave radiation.
- The epidemiological studies reveal that the carcinogenic effect of microwave irradiation in humans typically is manifested after long-term exposure—up to 10 years, or more. Yet, some studies also demonstrate that even a year of operation of a powerful cellular transmission tower can result in a dramatic increase of cancer incidence among the population living nearby.
- Model (rodent) studies reveal a significant increase in carcinogenesis after 17–24 months of microwave exposure. Also, such metabolic changes as overproduction of reactive oxygen species under exposure to low-intensity microwaves confirm a stress impact of this factor on living cells.
- The author points out that from the research summarized in this review it is evident safety guidelines regarding health effects of non-ionizing radiation can no longer be based on a purely physical (thermal-only) mechanism, as is assumed by certain advisory or regulatory bodies, including the USA's Federal Communications Commission (FCC). Instead, he says, safety limits for non-ionizing radiation must be re-established using recently-obtained knowledge regarding the long-term biological effects of low-intensity radiation exposure.