

20-1025 (Lead); 20-1138 (Consolidated)

**UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT**

ENVIRONMENTAL HEALTH TRUST; CONSUMERS FOR SAFE CELL
PHONES; ELIZABETH BARRIS; THEODORA SCARATO

CHILDREN'S HEALTH DEFENSE; MICHELE HERTZ; PETRA BROKKEN;
DR. DAVID O. CARPENTER; DR. PAUL DART; DR. TORIL H. JELTER; DR.
ANN LEE; VIRGINIA FARVER, JENNIFER BARAN; PAUL STANLEY, M.Ed.
Petitioners

v.

FEDERAL COMMUNICATIONS COMMISSION;
UNITED STATES OF AMERICA
Respondents

Petition for Review of Order Issued by the
Federal Communications Commission

DEFERRED JOINT APPENDIX**VOLUME 16**

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Audio and Summary, Children's Health Expert Panel June 2013:***“Cell Phones & WiFi – Are Children, Fetuses and Fertility at Risk?”***

Dr. Devra Davis Hugh Taylor, MD David Carpenter, MD Martin Blank, PhD Camilla Rees, MBA



Listen to the Audio Recording <https://vimeo.com/73165877>

Panelist Bios: <http://electromagnetichealth.org/electromagnetic-health-blog/ct-childrens-health-panel/#panelists>

Dedication to Ronald Herberman, MD

The program June 28, 2013 was dedicated to the late Ronald B. Herberman, Founding Director of the University of Pittsburgh Cancer Institute, Vice Chancellor of Cancer Research at University of Pittsburgh and the first head of an NCI funded cancer center to speak out on the risks from cell phones. He issued a warning of these risks to his 3,000 employees, addressed Congress, and, regarding inaccurate media reporting on cell phone radiation health risks in the *Economist*, Dr. Herberman said:

“ A disservice has been done in inaccurately depicting the body of science, which actually indicates that there ARE biological effects from the radiation emitted by wireless devices, including damage to DNA, and evidence for increased risk of cancer and other substantial health consequences...The public the world over has been misled by this reporting.”

May we all find within us the courage Dr. Braverman repeatedly exhibited during his life.

Conference Highlights: Discussion of Key Evidence EMFs Negatively Impact Children, Fetuses and Fertility

The panel presented a wide range of scientific evidence that electromagnetic radiation of the kind emitted by portable phones, Wi-Fi routers, baby monitors, Bluetooth earpieces, towers, antennas, smart boards, smart meters, Google glass and other devices is adversely affecting people across the globe, and especially children. This radiation may be 'non-thermal', but has clear and indisputable biological and health effects.

DNA is being damaged, and natural repair processes impaired, in this unnatural bath of radiation. Children are especially vulnerable to DNA effects due to the rapid growth and development of cells, as well as a longer lifetime of exposure. All frequencies react similarly with DNA, whether higher frequency or lower frequency. Some are faster, some are slower, but the effects are happening all the same. Cancer is believed to result from changes in DNA. DNA's coil of coil structure makes it exquisitely sensitive to EMF, more than other tissue in the body. The long-term impact for our species is unknown.

An increasing number of people listen, learn and think better in electromagnetically clean environments. The audience was asked to turn off their cell phones and wireless devices for this reason.

Cell phones, tablets and other wireless devices also have batteries that emit lower frequency forms of radiation—and these, too, along with RF and microwaves, have consequences, such as increased risk for childhood asthma and obesity when exposed in utero.

Impacts of electromagnetic fields on children*:

⇒ Research shows radiation emitted by cell phones and WiFi impacts children's development in utero, their cognitive function, attention, memory, perception, learning capacity, energy, emotions and social skills.

Cell Phones & WiFi—Are Children, Fetuses and Fertility at Risk?
Get the facts from leading scientific and medical experts
La Grua Center, Stonington, CT • 32 Water Street, Friday, June 28, 2013 • 6:00 - 7:30 p.m.



more info:
www.electromagnetichealth.org

⇒ There is also diminished reaction time, decreased motor function, increased distraction, hyperactivity, and inability to focus on complex and long-term tasks.

⇒ Cellular devices can lead to a heightened sense of anxiety in children, to isolation, and feelings of psychological and physical dependency.

⇒There are now 9 types of cancer linked to cell phone use:

1. Glioma (Brain Cancer)
2. Acoustic Neuroma (tumor on acoustic nerve)
3. Meningioma (tumor of the meninges)
4. Salivary Gland cancer (parotid gland in cheek)
5. Eye Cancer
6. Testicular Cancer
7. Leukemia
8. Thyroid Cancer
9. Breast Cancer

⇒There is a direct relationship between duration of cell phone use and sperm count decline. Sperm count is reduced by half in men who carry cell phones in their pants pockets for four hours per day. The motility of the sperm is also impaired. The testicular barrier, that protects sperm, is the most sensitive of tissues in the body, and is 100x more absorbent. Besides sperm count and function, the mitochondrial DNA of sperm are damaged 3x more if exposed to cell phone radiation.

⇒DNA mutations have been linked more to damage on the male side in research from Iceland (<http://www.nature.com/news/fathers-bequeath-more-mutations-as-they-age-1.11247>), the assumption being that male sperm is more vulnerable than female eggs, which are more protected. Mutations increase with the age of the father, and more autism and schizophrenia increase with the age of the father.

⇒WiFi in homes depletes melatonin and leads to poor sleep quality and difficulty falling asleep.

⇒Use of wireless devices after lights out has been associated with children's mental health risks and suicide.

⇒Some of the most profound effects in children from *in utero* EMF exposure are emotional and behavioral.

⇒Online time, particularly multi-tasking in young children, has been linked with a chronically distracted view of the world (<http://paw.princeton.edu/issues/2013/04/03/pages/3052/index.xml>) preventing learning critical social, emotional and relational skills.

⇒There is imbalanced development of the right and left hemispheres of the brain, resulting in children having impaired ability to remember basic things, to use handwriting, or to feel empathy. There is a physiological as well as psychological addiction that is taking place.



Think about what it would be like to have an entire generation that has not developed the capacity for empathy.”

—Devra Lee Davis, PhD MPH, Environmental Health Trust

⇒ Children are beginning to show signs of dementia, where they cannot remember basic things, a global phenomenon now being called “Digital Dementia”, (<http://www.telegraph.co.uk/news/worldnews/asia/southkorea/10138403/Surge-in-digital-dementia.html>) believed to potentially be irreversible. There are hundreds of digital detox camps in China and S. Korea; the first U.S. camp (<http://campgrounded.org/>) opened in Northern California this year.



Devra Davis, PhD,
Environmental Health Trust
Watch Video: vimeo.com/71749330

⇒ Dr. Taylor summarized his recent study (<http://www.yalemedicalgroup.org/cellphonestudy2012>) at Yale University: A standard cell phone with a SAR rating of 1.6W/kg was placed atop the cages of pregnant mice for the duration of their pregnancy. Their offspring showed hyperactivity, diminished memory, apathy, impulsiveness, and other behaviors, compared to unexposed controls, mirroring children with ADHD. The severity of the effect depended on the length of exposure.



Hugh Taylor, MD,
Yale University
Watch Video: vimeo.com/73431739

⇒ Dr. Taylor said the incidence of ADHD in the U.S. is on the rise (3-5% of school aged children or 2mm children have ADHD) and the growth parallels the increased use of cell phones.

⇒ Besides observing behaviors in the mice, the Yale researchers also measured electrical activity in the brain of the exposed and unexposed mice. They found the mice that had

been exposed briefly in utero had changes to the electrical signaling processes in the brain as adults. Note, the mice had only been exposed during pregnancy, not subsequently, but the brain function was “permanently altered”. There appears to have been a dose-response relationship, where the longer the mice had been exposed per day during the study the greater the changes in brain function. Continuous exposure throughout pregnancy was much more dangerous than briefer exposures.

⇒ Dr. Taylor reminded the audience that while we don’t think of ourselves as being on the cell phone 24 hours a day, the cell phone is still emitting radiation 24/7 and impacting us if it is turned on and near us, day or night. “It’s not talking on the phone that matters, it’s any time the phone is turned on”, he said. Every 900 milliseconds, whether you are using the phone or not, your cell phone has a

spike in radiation because it is looking for a signal from the tower, according to Dr. Davis.

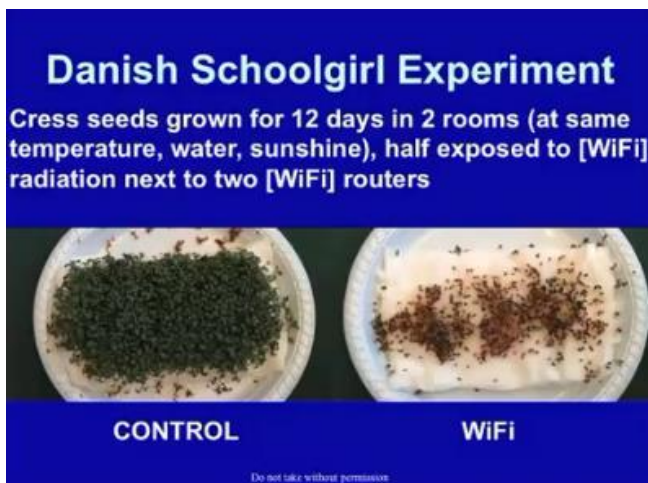
⇒ Researchers at UCLA (<http://www.ncbi.nlm.nih.gov/pubmed/18467962>) found that children of mothers who used cell phones most frequently during pregnancy showed nearly a two-fold increase in behavioral and emotional problems and hyperactivity by the time they reached school age. Dr. Hugh Taylor stated:

“ When you combine data like this—studies that show there is in fact an association in humans, with our studies in animals—it is clearly cause and effect.”

⇒ Wi-Fi in schools is an ‘enormous problem’. Some schools install massive, industrial strength routers right next to where children sit. Symptoms reported by children who sit near Wi-Fi routers include nausea, headaches, blurred vision, and poor sleep. The Israeli Health Ministry issued a report recommending against Wi-Fi in schools because there is simply no information about the effects of this type of chronic exposure.

⇒ Russians caused the same EHS symptoms in the U.S. Embassy in cold war. Symptoms of electrohypersensitivity in WiFi environments—of fatigue, irritability, concentration difficulty—are the same symptoms experienced by US Embassy personnel in Moscow in the cold war, that came to be known as microwave syndrome (or radiowave sickness).

⇒ There are reports of children dropping dead in Canada, or needing to wear pacemakers, after Wi-Fi installation in their schools.



⇒ Dr. Blank presented a simple study done by Danish high school girls wanting to study effects of WiFi. They took cress cells and exposed half to WiFi for 12 days. At left are the unexposed and exposed cress cells, the effects of WiFi on this plant having been made clear.

⇒ Turkish scientists recently discovered that mice exposed to cell phone radiation produced offspring with smaller brains, and more brain, liver, and eye damage. The Turkish government is launching a major campaign to raise awareness about cell phone radiation safety specifically geared towards pregnant women and young men interested in fathering healthy children.

⇒Prenatal exposure results in fewer cells in the hippocampus of the brain, the area we need for thinking, reasoning, judgment and significantly impairs the development of neurons in the brain.

⇒There is also irreversible DNA damage occurring from these devices, which effects the functioning of the child's body, and the quality of the genes they then pass on to future generations. Human cells, like all matter, are made up of charged particles, and these particles respond to EMFs. DNA has many different lengths and responds differently to various radiation frequencies—like different length antennas—and many effects are irreversible. DNA damage and mutations can cause cancer and other illnesses, but it can take years to detect symptoms.



The range of frequencies used today can cause damage to DNA, at levels that are currently being used."

—Martin Blank, PhD, Special Lecturer and Retired Associate Professor of Physiology and Cellular Biophysics, Columbia University

⇒Fetal effects from cellphone and wireless include faster heart rates, genetic changes, altered brain development, and increased behavioral and emotional problems after birth.

⇒**The strongest evidence for EMF effects are the science showing the connection between cell phone use and brain cancer (Hardell 2008, Kundi 2008), according to Dr. Carpenter.** The latency period between cell phone use and brain cancer is thought to be 20 to 30 years. Brain cancer rates are double for people who've been using cell phones for 10 years or more, appearing on the side of the head where they hold their phones, and risks are 5x greater for children using cell phones under the age of 20 than those over the age of 50.

⇒Because children's nervous systems are still developing, synapses and myelin are being laid down continuously. For the body to create proteins, it must have correct DNA coding. EMFs break DNA apart, resulting in bad coding and mutations that result in poor brain function. Teenagers and children using cell phones before the myelination process is completed in the 20s are having a "whopping impact" on their brains.

⇒There is some evidence that DNA mutations resulting from radiofrequency signals are part of what's driving today's increased autism and schizophrenia rates. The evidence was summarized in December in the landmark BioInitiative Report 2012 by Harvard Professor, Dr. Martha Herbert, MD who runs the Transcend Research Lab at Mass General.



Dr. Herbert stated:

“EMF/RFR from wifi and cell towers can exert a disorganizing effect on the ability to learn and remember, and can also be destabilizing to immune and metabolic function. This will make it harder for some children to learn, particularly those who are already having problems in the first place.”

“Powerful industrial entities have a vested interest in leading the public to believe that EMF/RFR, which we cannot see, taste or touch, is harmless, but this is not true.”

⇒Radio towers, not just cell towers, are also a factor. Based on 50 years of data, the closer a child lives to a radio tower, the higher his or her risk for developing cancer. The standard for “safe” power density remains 1,000 times too high. A 6x risk of cancer is still considered ‘safe’.

Politics of EMF Science



Martin Blank, PhD,
Columbia University
Watch Video: vimeo.com/71837266

No more research is needed in order to say with certainty that these effects are real, and there is sufficient cause to take action now to protect adults and children. More research is desirable to better understand certain connections, and to continue looking at the long-term trends with epidemiology, but there is sufficient scientific evidence today on which to take precautionary steps to minimize this radiation in our lives.

Regulatory bodies have allowed a trillion dollar wireless industry to emerge without pre-market health testing or post-market health surveillance.

A whole generation of people has been unaware of the risks of wireless radiation, and have not been taking precautions. This is why public health officials are so concerned. There is already evidence that exposure to radiofrequency radiation in excess leads to disease. And exposures have grown dramatically in the last few years.



Frank Clegg,
Canadians 4 Safe Technology
Watch Video: vimeo.com/71996834

Our grandchildren and children are “being used as lab rats in an experiment with no controls....that’s what we are doing with cell phone and wireless radiation with our children today.”—Devra Davis, PhD, MPH. Environmental Health Trust

Scientists who expose the truth about the risks from electromagnetic fields are intimidated and attacked and their careers jeopardized. Industry-associated science is also designed to underestimate risks, thereby refuting the independent science and 'Manufacturing Doubt'. Esteemed scientists are sometimes finding it hard to publish.

Just as Bill Moyers recently described was the case with suppression of evidence about lead ("The Toxic Politics of Science", <http://billmoyers.com/tag/lead-wars-the-politics-of-science-and-the-fate-of-americas-children/>), the wireless industry behaves as if risks from cell phones and wireless devices and infrastructure is 'a PR problem, not a public health problem'.

The FCC has inadequate exposure guidelines. US standards for radiofrequency/microwave exposure are based on an outdated, erroneous assumption that EMFs have no biological effects unless they cause tissue heating, like a high powered microwave oven heating your potato. Science has disproven this myth. The exposure guidelines fail to protect about 97 percent of the population, most especially children.



"The cell phone standards we use today for the 6.5 billion cell phones in the world were set 17 years ago and have never been updated, despite the fact that the users and uses of cell phones are very different now. And they've never been tested for their safety around children...We're in the midst of a huge experiment on ourselves and on our children"

—Devra Lee Davis, PhD, MPH, cancer epidemiologist and toxicologist, President of Environmental Health Trust, and author of *Disconnect: The Truth About Cell Phone Radiation, What the Industry Is Doing to Hide It, and How to Protect Your Family*

Lower power towers and devices are possible, though instead power levels are being continually increased. Cell phones and cell towers can be made safer, by using far less power. Also, most towers emit far more radiation than they're supposed to.

Many countries are issuing advisories: Australia advises limiting children's exposure to cell phones; Belgium has banned sales of cell phones for use by children under age 7; Turkey has banned ads targeting sales to children. The French National Assembly has banned WiFi in schools. Italy had a Supreme Court ruling in favor of a man who claimed his tumor was from cell phone use. A region of India, Rajasthan, has banned cell towers near schools, and won a court battle to defeat industries opposition. Standards in the Eastern block are 1,000 times stricter.

"It may take some sort of catastrophe to get people's attention."—Frank Clegg, former president of Microsoft Canada and founder of Canadians 4 Safe Technology, a member of the audience who later joined the panel to share his perspective.

Several panel members compared the current situation where health risks of cell phone and wireless radiation are being downplayed, and the science suppressed, to other well-known public health scandals driven by commercial interests, such as tobacco, lead, asbestos, DDT, Bisphenyl A, silica, vinyl chloride, PCBs, GMOs, pesticides in food, fracking, the neonicotinoid chemicals impacting bees.

Safety Recommendations

- **Extreme caution was advised for pregnant women or women hoping to conceive due to the profound long-term impact of environmental factors.** “A lot of who we are right now has to do with what our mothers did when they were pregnant and what type of exposures they had.”—Hugh Taylor, MD, Chairman of Obstetrics and Gynecology and Reproductive Sciences, Yale University. As with DES and many other toxic substances, he said, the effects from exposure to the fetus may not appear for a generation.
- **Children should not be playing with radiating cell phones.** Young children should not be using cell phones, except in an emergency. If your child wants to play with the device, disconnect it from Wi-Fi and Internet, and put it in “airplane mode.”
- **Limit or eliminate WiFi exposures.** If you have Wi-Fi, get rid of it if you can. If you can’t, make sure your router is not in a high use area. Keep it turned off as much as possible, or put it on a timer.
- **Schools should not have WiFi.** Panelists strongly opposed the installation of Wi-Fi in schools. Cabled/wired connections do not have the same risks.
- **Resume using landline phones whenever possible.** Get rid of your portable phone and use a landline instead. If you have a portable phone, don’t sleep with it in your bedroom.
- **Keep your cell phone away from your body.** If you have a cell phone, keep it away from your body, as opposed to in your pocket or on your belt. If you’re pregnant, keep it away from your belly. Keep your cell at the other end of the room, or on the seat of the car. Use texting more than talking. Special cell phone cases are available that filter out a significant portion of the radiation, but not all. Many metal cases can actually magnify radiation.
- **Use a wired earpiece with cell phones.**
- **Caution about using cell phones in cars.** Signals bounce around inside your vehicle—and your head is the antenna.
- **Opt-out of new utility meters called ‘smart meters’.** When possible, prevent smart meters from being installed in your home.
- **Never use wireless baby monitors.** Avoid the use of baby monitors as they all operate on microwave frequency.
- **Know your exposures.** For about \$500, you or your community can purchase a meter (<http://emfsafetystore.com/>) with which to measure the EMF in any particular area—homes, schools, churches, etc.
- **EMF free zones are needed for pregnant women and children.** “Wi-Fi free” or “low Wi-Fi” zones should be designated for pregnant women and children, and others who are particularly sensitive to EMFs. The same applies in schools.
- **We need to be tracking biological effects.** “We need to seriously begin tracking the biological effects of EMFs...We need to be monitoring our children’s

health routinely. We have to train people how to do the research, and we have to invest in the research that's not being done.”—Devra Lee Davis, PhD MPH

- **We must take precaution.** “The precautionary principle is in order here—certain precautions should be taken as a result of the risk that’s been identified. That’s the reason we have seat belts in cars... not because every car is going to crash, but because we want to minimize the damage when they do.”—Martin Blank, PhD
- **A one-dollar fee has been proposed on the sale of all cell phones as a means of generating revenue for research and education.** Over several years, such a levy would generate billions of dollars to finalize any unanswered questions about risks.
- **Industry must become engaged.** Strategies must be introduced to get industry involved, such as providing incentives or rewards for safer technology, or even amnesty. If all else fails, lawsuits, some of which are in the works, will get their attention.
- **FCC safety guidelines must be updated.** Outdated, unrealistic safety guidelines must be replaced with new ones that reflect modern science, such as those suggested in the BioInitiative Report 2012 (<http://www.bioinitiative.org/>).
- **Support labeling laws** requiring cell phone manufacturers to list radiation levels in an obvious place on the packaging and at the retailer.
- **Educated parents need to become involved, especially to protect our children.** Contact www.ElectromagneticHealth.org or www.EnvironmentalHealthTrust.org to learn how you can become involved in raising awareness on this important children’s health issue, or by funding research, media communications and support for local communities. Keep abreast on this subject going forward as it related to children, fetuses and schools at Campaign for Radiation Free Schools (<https://www.facebook.com/login.php?next=https%3A%2F%2Fwww.facebook.com%2Fgroups%2F110896245588878%2F>) on Facebook.
- **Finding the Political Will.**



Find the place within that wants the truth about the degradation of our health and children’s health to be known, that wants the deeply held value for health, and for true caring, that we all certainly share, to be at the core of our society, guiding our representatives in Congress, as well as the media.”

—Camilla Rees, MBA, Founder, ElectromagneticHealth.org, co-author [“Public Health SOS: The Shadow Side of the Wireless Revolution”](#) and organizer of the Children’s Health Expert Forum “Cell Phones & WiFi—Are Children, Fetuses and Fertility at Risk?”

*** For References see:**

- **“Mobile Phone Health Risks: The Case for Action to Protect Children”**
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- **Bioinitiative Report 2012, Section on Autism**
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- **The Toxic Politics of Science,** (<http://billmoyers.com/tag/lead-wars-the-politics-of-science-and-the-fate-of-americas-children/>) Moyers & Co.
- **Campaign for Radiation Free Schools (Facebook)**
(<https://www.facebook.com/groups/110896245588878/>)
- **Letter to Parents on Fertility and Other Risks to Children from Wireless Technologies** (<http://electromagnetichealth.org/electromagnetic-health-blog/letter-to-parents/>), by Camilla Rees (Including Research Bibliography)
- **Clifford Nass, PhD, Thomas M. Storke Professor at Stanford University and director of the Communication between Humans and Interactive Media (CHIME) Lab.**
(<http://paw.princeton.edu/issues/2013/04/03/pages/3052/index.xml>)
- **ElectromagneticHealth.org’s Recommended EMF Books on Amazon**
(<http://astore.amazon.com/bescom08-20>)
- **Remediation Resources (meters, shielding materials, etc.):**
www.EMFSafetyStore.com

Media: Please contact Emily@ElectromagneticHealth.org.

To be notified when more content becomes available, please register here:
<http://electromagnetichealth.org/electromagnetic-health-blog/summary-and-audio/#register>

Prenatal & Children; Safe Schools 2012, Medical and Scientific
Experts Call for Safe Technologies in Schools

Safe Schools

2012



Healthy Schools

Safe Schools

Health Promoting Schools

Proactive Safeguarding

Healthy Development

Optimised Learning

Medical Associations, medical doctors and leading scientists call for safe technologies in schools

Introduction

More¹ Medical Associations, medical doctors and scientists, many of whom work on the biological effects of wireless technologies, have expressed their concerns about the safety of wireless devices for schools. They are asking for wired information and communication technologies to be used in order to safeguard² children and young people, protect and promote healthy development and maximise learning and achievement.

These experts do not agree with the health protection agencies which currently support or allow the use of microwave, radiofrequency-emitting technologies by children and young people in schools.

Other authorities have also called for the protection of children from wireless technologies.

- Council of Europe: Mobile phone use by pupils in schools to be strictly regulated and wired internet connections to be preferred (Resolution 1815, 2011³).
- World Health Organization's International Agency for Research on Cancer (IARC) classified radiofrequency radiation as a possible human carcinogen, class 2B (2011)⁴.
- UK Trades Union Congress (TUC): Caution should be taken to prevent exposure to Class 2B carcinogens in the workplace⁵.
- European Environment Agency: All reasonable measures to be taken to reduce exposures to electromagnetic fields, especially radiofrequencies from mobile phones and particularly the exposures to children and young adults. Current exposure limits to be reconsidered⁶.
- International Commission for Electromagnetic Safety (ICEMS): Strongly advise limited use of cell phones, and other similar devices, by young children and teenagers⁷.
- Russian National Committee on Non-Ionizing Radiation Protection have recommended the use of wired networks in schools and educational institutions, rather than wireless broadband systems, including Wi-Fi⁸. *"It is our professional obligation not to damage the children's health by inactivity"*⁹.
- German Government and Israeli Parliament recommended wired computer networks for schools or workplaces^{10,11}.
- Several countries have advised children and young people to limit their use of mobile/smart/cell phones¹.

This document serves to inform schools, Governing Bodies, Academy Trusts, School Boards, Education Authorities, teachers and parents of the professional, medical and scientific concerns about children using wireless technologies in schools. The information can be used to implement safe school policies, practices and guidance in order to safeguard the health and development of children and young people and to aid cognitive abilities, learning and achievement.

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Grateful appreciation is given to all those who have offered comments for this document and helped in its preparation.

Available electronically at: <http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

June 2012. To contribute to a future edition, please contact:

E-mail: contact@wifiinschools.org.uk, Address: BM Wifiinschools.org.uk, London, WC1N 3XX.

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Medical Associations

Dr Gerd Oberfeld, MD, Public Health Department, Salzburg, Austria, on behalf of the Austrian Medical Association.

Schools should provide the best possible learning environments. In this context low noise levels, good air quality and low radiofrequency / microwave radiation are crucial. Wi-Fi environments will lead to high microwave exposure for students and teachers which might increase the burden of oxidative stress. Oxidative stress might slow down the energy production especially in brain cells and may lead e.g. to concentration difficulties and memory problems in certain individuals. The Austrian Medical Association recommends Wi-Fi free school environments.

The American Academy of Environmental Medicine

The Board of Officers and Directors: Dr Alvis L. Barrier, MD, FAAOA; Dr Amy Dean, DO; Dr Charles L. Crist, MD; Dr James W. Willoughby, II, DO; Dr Robin Bernhoft, MD; Dr Gary R. Oberg, MD, FAAEM; Dr Craig Bass, MD; Dr Stephen Genius, MD, FRCSC, DABOG, FAAEM, DABEM; Dr Martha Grout, MD, MD(H); Dr W. Alan Ingram, MD; Dr Janette Hope, MD; Dr Derek Lang, DO; Dr Glen A. Toth, MD; Dr Ty Vincent, MD.

The Board of the American Academy of Environmental Medicine approved the following statement on Wi-Fi in schools on 9th June 2012:

Adverse health effects, such as learning disabilities, altered immune responses, headaches, etc. from wireless radio frequency fields do exist and are well documented in the scientific literature. Safer technology, such as using hard-wiring, must be seriously considered in schools for the safety of those susceptible individuals who may be affected by this phenomenon.

January 2012:

The Board of the American Academy of Environmental Medicine opposes the installation of wireless “smart meters” in homes and schools based on a scientific assessment of the current medical literature (references available on request). Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action.

The Board of the American Academy of Environmental Medicine also wishes to note that the US NIEHS National Toxicology Program in 1999 cited radiofrequency (RF) radiation as a potential carcinogen. Existing safety limits for pulsed RF were termed “not protective of public health” by the Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others) (From AAEM Letter, January 2012, <http://wifiinschools.org.uk/resources/AAEM.pdf>).

The AAEM asks for:

- Use of safer technology, including for “Smart Meters”, such as hard-wiring, fiber optics or other non-harmful methods of data transmission.
- Independent studies to further understand the health effects of electromagnetic and radiofrequency exposures.
- Understanding and control of this electrical environmental bombardment for the protection of society.

(For full list, see: <http://aaemonline.org/pressadvisoryemf.pdf>; AAEM Position Statement: http://aaemonline.org/emf_rf_position.html). References from the AAEM statements below can be found in: <http://aaemonline.org/pressadvisoryemf.pdf>.

The AAEM Position Statement on electromagnetic fields includes:

Multiple studies correlate radiofrequency exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity.

Arguments are made with respect to radiofrequency exposure from Wi-Fi, cell towers and smart meters that due to the distance, exposure to these wavelengths are negligible (2). However, many in vitro, in vivo and epidemiological studies demonstrate that significant harmful biological effects occur from non-thermal radiofrequency exposure and satisfy Hill’s criteria of causality (3). Genetic damage, reproductive defects, cancer, neurological degeneration and nervous system dysfunction, immune system dysfunction, cognitive effects, protein and peptide damage, kidney damage and developmental effects have all been reported in the peer-reviewed scientific literature.

The fact that radiofrequency exposure causes neurological damage has been documented repeatedly. Increased blood-brain barrier permeability and oxidative damage, which are associated with brain cancer and neurodegenerative diseases, have been found (4,7,15-17). Nittby et al. demonstrated a statistically significant dose-response effect between non-thermal radiofrequency exposure and occurrence of albumin across the blood-brain barrier (15). Changes associated with degenerative neurological diseases such as Alzheimer’s, Parkinson’s and Amyotrophic Lateral Sclerosis (ALS) have been reported (4,10). Other neurological and cognitive disorders such as headaches, dizziness, tremors, decreased memory and attention, autonomic nervous system dysfunction, decreased reaction times, sleep disturbances and visual disruptions have been reported to be statistically significant in multiple epidemiological studies with radiofrequency exposure occurring non-locally (18-21).

In an era when all society relies on the benefits of electronics, we must find ideas and technologies that do not disturb bodily function. It is clear that the human body uses electricity from the chemical bond to the nerve impulse and obviously this orderly sequence can be disturbed by an individual-specific electromagnetic frequency environment.

International Society of Doctors for the Environment (ISDE)**Irish Doctors Environmental Association (IDEA)**

Both the International Society of Doctors for the Environment [ISDE] and the Irish Doctors Environmental Association [IDEA] have stated, the former by an ad hoc majority opinion of the Directing Board and the latter by unanimous decision of the Executive Committee, that there is sufficient scientific evidence to warrant more stringent controls on the level and distribution of electromagnetic radiation [EMR].

ISDE and IDEA recommendations (full list in Appendix 1):

- *Avoid Wi-Fi in home or work if possible, particularly in schools or hospitals.*
- *Use wired technology whenever possible.*
- *Measure the radiation levels at sites which are occupied for prolonged periods, particularly by infants or young children.*
- *Base stations should not be located on or near [500m] schools or hospitals.*

The Interphone Study organised by the International Agency for Research on Cancer [IARC] – a \$20 million study in many countries over 5 years, presented partial results in 2011 of their analysis of 6,600 cancer cases in relation to cell phone use. The results were equivocal but IARC has since designated EMR as “possibly carcinogenic to humans” [Group 2B].

Attention deficit hyperactivity disorder [ADHD] is known to be increasing in prevalence by 3% per year in the USA for which there is no generally accepted explanation. There is evidence from an epidemiological study [Divan, H. et al Epidemiology 19 523-529] from 2008 indicating an association between maternal cell phone use and the prevalence of behavioural problems in children. This was supported by an experimental study in mice from Yale University which demonstrated neurobehavioural defects which persisted into adulthood and was shown to be due to dose-dependent altered neurodevelopmental programming [Aldad T. S. et al Mar 2012 www.nature.com/scientificreports].

Because of the potentially increased risks for the foetus, infants and young children due to their thinner more permeable skulls and developing systems, particularly the immune and neurological systems, based on the precautionary principal and on the mounting evidence for harm at the sub-cellular level, we recommend that EMR exposure should be kept to a minimum. The basic theory is that the younger they are the more likely they are to be damaged for the above reasons and also they will be exposed for a longer period over their lifetime on average.

The Parliamentary Assembly of the Council of Europe Resolution 1815 in 2011 made numerous specific recommendations relating to EMR, the basic message being to maintain radiation levels ‘as low as reasonably achievable’ [ALARA].

Dr P. Michael, April 2012

Interdisciplinary Society for Environmental Medicine (Interdisziplinäre Gesellschaft für Umweltmedizin e. V.), Germany.

In the Freiburger Appeal in 2002, medical doctors in Germany requested:

- *Ban on mobile telephone use and digital cordless (DECT) telephones in preschools and schools.*
- *Ban on mobile telephone use by small children and restrictions on use by adolescents.*
- *Education of the public, especially of mobile telephone users, regarding the health risks of electromagnetic fields.*
- (Appeal in full: www.planningsanity.co.uk/reports/md341.doc).

Swiss Doctors for Environmental Protection (Ärztinnen und Ärzte für Umweltschutz (AefU)).

The Swiss Doctors for Environmental Protection have not specifically mentioned schools, but have called for caution with respect to wireless technologies:

The International Agency for Research on Cancer (IARC) considers the waves emitted by wireless communication “possibly carcinogenic”. According to the IARC, the risk of cancer for this type of radiation is thus similar to that of the insecticide DDT, rightly banned. Doctors for the Environment is concerned that the limit values expected to protect the Swiss population, notably vulnerable groups such as children and pregnant women, constitute insufficient protection. In a communication sent to the Federal Assembly, Doctors for the Environment thus requests strict application of the principle of precaution and – in view of the risk of cancer – lower limit values.

Children’s rooms, housing, trams or offices are experiencing a growing exposure to radiation from diverse sources: baby monitors, mobile telephony, Wi-Fi, etc., yet more and more studies warn against the serious health consequences of electromagnetic pollution for human beings and animals.

Dr Peter Kälin, President, states “From the medical point of view, it is urgent to apply the precautionary principle for mobile telephony, Wi-Fi, power lines, etc.”
http://www.aefu.ch/typo3/fileadmin/user_upload/aefu-data/b_documents/Aktuell/M_120322_NIS.pdf

Scientists and Medical Doctors

Dr Igor Belyaev Dr.Sc., Head Research Scientist, Cancer Research Institute, Slovak Academy of Science, Slovak Republic; Associate Professor in Toxicological Genetics, Faculty of Natural Science, Stockholm University, Sweden.

To my opinion, which is based on 25-year research of non-thermal effects of microwaves, usage of Wi-Fi and cell/mobile/smart phones in the classroom should be either forbidden or reduced as much as possible. I believe that the majority of scientists with long lasting experience in this scientific field are of the same opinion. Several national authorities have already advised limiting usage of mobile communication by children. Please, see recent news from Israel by the link below <http://www.haaretz.com/business/knesset-backs-bill-requiring-cell-phones-to-bear-health-hazard-warning-1.415677>, recommendation of the RNCNIRP in the file attached (Appendix 2) and my recent review (Belyaev 2010)¹².

Professor Dr. Nesrin Seyhan, Medical Faculty and Chair of Biophysics Department, Gazi University, Turkey; WHO EMF International Advisory Committee; Panel Member NATO RTA Human Factors and Medicine.

Dr. Seyhan, founder of the Gazi Non-Ionizing Protection Center (GNRK), always opposes radiofrequency sources near schools. She believes that potential adverse health effects from the children's use of Wi-Fi and cell/mobile/smart phone would be greater than with respect to adults. She also recommends that children younger than 16-years-old should not have their own mobile phone. Please find her last publication attached¹³.

Professor Lukas H. Margaritis, PhD, Professor Emeritus of Cell Biology and Radiobiology, Dept of Cell Biology and Biophysics, University of Athens, Greece.

Having done experiments on cellular model systems we have found an effect from electromagnetic radiation of ordinary Wi-Fi. I have strongly suggested for years now that they should be used only if absolutely necessary in the home and not at all in schools. There is no reason for having Wi-Fi in schools since there is an alternative - wired connections which are safer and faster.

Dr Stelios A. Zinelis, BA, MD, Hellenic Cancer Society, Cefallonia, Greece

We should not subject and force electromagnetic radiation on school children. Technology can be applied by a wired connection. Effects of the electromagnetic radiation have been well documented and should not be ignored. The past has taught as many lessons, for example asbestos.

Dr Samuel Milham MD, MPH, Epidemiology and Public Health, Formerly Washington State Department of Health, USA.

Wireless technologies have no place in schools. I strongly recommend that where they exist, they be replaced by fiber-optic cable and hard wiring.

<http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

Professor Dr. Oleg Grigoriev, PhD, Director of the Russian Centre for Electromagnetic Safety and Vice-Chairman of the RCNIRP.

Professor Yuri Grigoriev, Dr. of Medical Science, Chairman of the Russian National Committee on Non-Ionizing Radiation Protection (RCNIRP); member of International Advising Committee on WHO EMF Project.

Our Committee and I are personally against the use of Wi-Fi systems in schools. Professor Yuri Grigoriev (chairman of the RCNIRP) has the same opinion. The reason is that it forms a very complex form of electromagnetic field, but in this case the probability of biological effect is higher than when the same total dose is created by one source of unmodulated electromagnetic field. This pattern is for non-thermal electromagnetic fields. There are very good studies that have shown that prolonged exposure to low-intensity radio waves in children disturbed cognitive function, and we trust this research.

RCNIRP recommendation about Wi-Fi in schools and educational institutions, June 2012: <http://international-emf-alliance.org/images/pdf/RussCNIRP%20WiFi%2019-06-12.pdf>.

Professor Dr. Alvaro Augusto A. de Salles, PhD, Electrical Engineering Department, Federal University of Rio Grande do Sul, Porto Alegre, Brazil.

I believe that responsible governments should act firmly to avoid the use of mobile/smart phones and Wi-Fi in schools.

The main reasons are due to the scientific evidence already available in the international literature (e.g., Bioinitiative report, Pathophysiology 2009, Interphone report, Hardell's group papers, etc) showing health risks even at low level exposure to the non-ionizing radiation (NIR), the 2011 IARC/WHO possible carcinogenic (2 B) classification of the NIR and because due to different reasons, the children are more susceptible to this radiation.

Then the "Precautionary Principle" should effectively be used in this subject and instead of wireless connection, other fixed connections such as twisted pairs, coaxial cables, optical fiber, etc should be available for each student, avoiding therefore exposure during several hours to the NIR.

If serious and responsible decisions are not taken in due time, the price in terms of future generations public health can be very high.

Dr Kevin O'Neill, FRCS (SN), Consultant Neurosurgeon, Charing Cross Hospital, London, UK.

Letter to the British Medical Journal¹⁴:

You reported (BMJ 2011;342:d3428) on the Council of Europe's recommendation that children be protected from the electro-magnetic radiation emitted by wireless equipment in schools. Since then, the International Agency for Research into Cancer (IARC) has classified such radiation as a possible carcinogen.

The evidence for children's particular vulnerability is accumulating. Most recently a study by the University of Orebro, published in the International Journal of Oncology (Int J Oncol. 2011 May;38(5):1465-74) found almost a fivefold increase of astrocytoma among subjects who started mobile phone use before the age of 20.

Since the Council of Europe has little influence over national health policy and the IARC classification will take time to translate into practical advice, we as medical practitioners and professional bodies have a role in ensuring timely action is taken to protect children. Previous public health threats (tobacco, asbestos, x-rays) indicate that the evidence of risk often increases as research progresses. Given a latency lag of up to 20 years for many tumours, we are in danger of repeating these public health disasters.

Dr David Carpenter, MD, Director Institute for Health and the Environment, University at Albany and Professor Environmental Health Sciences, School of Public Health, USA.

Chronic, such as all-day, school exposure, is more likely than short and intermittent exposure, such as cell phone use, to produce harmful health effects, and is likely to do so at lower exposure levels. Persons stationed close to school computers with WI-FI and especially those very near to any WI-FI infrastructure will receive considerably higher exposure than do others.

Exposure to high-frequency radiofrequency (RF) and microwave (MW) radiation and also the extreme low frequency (ELF) EM fields that accompany WI-FI exposure have been linked to a variety of adverse health outcomes. Some of the many adverse effects reported to be associated with and/or caused by ELF fields and/or RF/MW radiation include neurologic, endocrine, immune, cardiac, reproductive and other effects, including cancers. Human studies of comparable RF/MW radiation parameters show changes in brain function including memory loss, retarded learning, performance impairment in children, headaches and neurodegenerative conditions, melatonin suppression and sleep disorders, fatigue, hormonal imbalances, immune dysregulation such as allergic and inflammatory responses, cardiac and blood pressure problems, genotoxic effects like miscarriage, cancers such as childhood leukemia, childhood and adult brain tumors, and more.

Children are more vulnerable to RF/MW radiation because of the susceptibility of their developing nervous systems. RF/MW penetration is greater relative to head size in children, who have a greater absorption of RF/MW energy in the tissues of the head at WI-FI frequencies. Children are largely unable to remove themselves from exposures to harmful substances in their environments. Their exposure is involuntary. There is a major legal difference between an exposure that an individual chooses to accept and one that is forced upon a person, especially a dependent, who can do nothing about it. WI-FI must be banned from school deployment. <http://www.magdahavas.com/wordpress/wp-content/uploads/2012/01/Amended-Declaration-of-Dr-David-Carpenter.pdf>

Letter about Wi-Fi in schools: <http://wifiinschools.org.uk/resources/Carpenter+letter+Feb2011.pdf>.

Dr Martin Blank, Ph.D., Associate Professor of Physiology and Cellular Biophysics, College of Physicians and Surgeons, Columbia University, New York, USA.

Just because we allow microwaves, doesn't mean that Wi-Fi at the same frequency should be allowed into all classrooms.

There is now sufficient scientific data about the biological effects of electromagnetic fields (EMF), and in particular about radiofrequency (RF) radiation, to argue for adoption of precautionary measures. We can state unequivocally that EMF can cause single and double strand DNA breakage at exposure levels that are considered safe under the FCC guidelines in the USA.

EMF have been shown to cause other potentially harmful biological effects, such as leakage of the blood brain barrier that can lead to damage of neurons in the brain, increased micronuclei (DNA fragments) in human blood lymphocytes, all at EMF exposures well below the limits in the current FCC guidelines. Probably the most convincing evidence of potential harm comes from living cells themselves when they start to manufacture stress proteins upon exposure to EMF. The stress response occurs with a number of potentially harmful environmental factors, such as elevated temperature, changes in pH, toxic metals, etc. This means that when stress protein synthesis is stimulated by radiofrequency or power frequency EMF, the body is telling us in its own language that RF exposure is potentially harmful.

It is obvious that the safety standards must be revised downward to take into account the non-thermal as well as thermal biological responses that occur at much lower intensities. Since we cannot rely on the current standards, it is best to act according to the precautionary principle. The precautionary approach appears to be the most reasonable for those who must protect the health and welfare of the public and especially its most vulnerable members, children of school-age. (Letter, Appendix 3).

Dr Olle Johansson, Associate Professor, Karolinska Institute, Stockholm, and Professor, The Royal Institute of Technology, Stockholm, Sweden.

Wireless communication is now being implemented in our daily life in a very fast way. At the same time, it is becoming more and more obvious that the exposure to the electromagnetic fields used by these systems not only may induce acute thermal effects to living organisms, but also non-thermal effects, the latter often after longer exposures. This has been demonstrated in a very large number of studies and includes cellular DNA-damage, disruptions and alterations of cellular functions like increases in intracellular stimulatory pathways and calcium handling, disruption of tissue structures like the blood-brain barrier, impact on vessel and immune functions, association to cancer, and loss of fertility.

Wireless systems, such as Wi-Fi routers and cell/mobile/smart phones, cannot be regarded as safe in schools, but must be deemed highly hazardous and unsafe for the children as well as for the staff.

Dr Magda Havas, PhD, Associate Professor, Environmental and Resource Studies, Trent University, Ontario, Canada.

I am a scientist researching the adverse health outcomes of electromagnetic radiation exposure, including from sources such as WI-Fi networks and cell towers. I conducted a study that showed immediate and dramatic changes in both heart rate and heart rate variability associated with microwave exposure to a frequency of 2.4 GHz at levels well below (0.5 percent) federal guidelines. The reactions include heart irregularities, a rapid heart rate, up-regulation of the sympathetic nervous system, and down-regulation of the parasympathetic nervous system.

It is important that children be exposed to the important education, life experiences, and social structures that public education offers, but they must not be risking their health to do so! Children must not be exposed to a constant background of pulsed microwave radiation from WI-Fi (or other sources) while at school.

The Internet is an important learning device that should not be taken away. I simply urge that its access be made available through wires rather than Wi-Fi.

<http://www.magdahavas.com/wordpress/wp-content/uploads/2012/01/Declaration-of-Dr.-Magda-Havas.pdf>

Dr Erica Mallery-Blythe, BM, Emergency Room Registrar, Medical Advisor ES-UK

Radiofrequency radiation was classified last year (2011) as a class 2B carcinogen by the International Agency for Research on Cancer (IARC)/World Health Organization (WHO). This means that Global Health Authorities are concerned that this kind of radiation (used by many kinds of household wireless devices) may cause cancer. There are several convincing mechanisms via which cellular disruption is taking place and all bodily systems are potentially vulnerable. All persons should, in my opinion, take precaution to reduce their exposure to unnatural radiation, including that from non-ionizing, non-thermal sources such as cell phones, Wi-Fi routers, cordless landlines and many others. This advice is particularly important for parents and Education Authorities when creating home and school environments because children are more vulnerable to this kind of radiation.

Science has repeatedly and clearly demonstrated adverse effects of artificial electromagnetic fields on biological systems. It is far too late for timely intervention, but failure to act now with conviction and protect our children could lead to a national health disaster.

Professor Dr. Christos Georgiou, PhD, Professor of Biochemistry, University of Patras, Greece

Every child has the non-negotiable, obvious right to a healthy and safe school environment.

Governments and school boards can no longer trust the wireless communication industry's monotonous slogan that Wi-Fi and cell phones are safe. In May 2011, the World Health Organization (WHO) classified microwave radiation, emitted by such wireless devices, as a possible carcinogen. WHO could no longer ignore the scientific and social pressure from

<http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

numerous studies, which have shown that Wi-Fi/cell phone radiation penetrates the body, affects cell membranes, makes cells lose their ability to function properly over time, and disturbs the body's normal metabolism causing numerous abnormalities and diseases.

Children are especially vulnerable to microwave radiation because their nervous system and especially the brain are still developing. Moreover, their skulls are thinner and smaller than those of the adults, so the radiation penetrates their brains more freely and deeply.

Microwave radiation displays in children life threatening short and long term effects: the short term effects are experienced as headaches, dizziness, nausea, vertigo, fatigue, visual and auditory distortion (voices change volume, ringing ears), abnormal heart rates (racing heart rate or tachycardia, erratic heart rates), memory loss, attention deficit (trouble concentrating while in class), skin rash, hyperactivity, anxiety, autism, depression, night sweats, insomnia (microwaves affect melatonin levels), learning impairment, behavioural changes etc; the long term effects are expressed as stress, a weakened immune system, seizures, epilepsy, high blood pressure, brain damage, diabetes, fibromyalgia, infertility, birth defects, DNA damage, leukemia, cancer, etc.

Dr Isaac Jamieson, PhD, DIC RIBA DipAAS BSc (Hons) MInstP, Architect, Consultant and Environmental Scientist, UK.

Proactively addressing 'electromagnetic pollution' issues may significantly aid well-being and achievement in individual schools. It appears sensible for 'Health Promoting Schools', and other schools interested in the well-being of their staff and pupils to consider such matters. (Full Report in Appendix 4).

Professor Dr. Franz Adlkofer, MD, Chairman of Pandora - Foundation for Independent Research.

While the use of mobile phones is the result of people's free choice, their exposure to W-LAN and other wireless applications is mostly compulsory. Especially concerned are children in schools where this technology has been given preference to wired computers. Since our knowledge on possible adverse effects of radiofrequency electromagnetic fields is still rather poor, it is obvious that at present the biggest biophysical experiment of mankind is under way – with an uncertain outcome. In May 2011, the uncertainty has been strengthened by the International Agency for Research on Cancer (IARC) that classified radiofrequency electromagnetic fields as 'possibly carcinogenic to humans'. This decision was mainly based on the results of epidemiological studies that observed after long-term (>10 years) and intensive use of mobile phones an increased risk for brain tumours exactly at the side of the head at which the mobile phone was used. The results from animal experiments, although of minor significance, supported the decision. Yet, results from basic research that showed changes in structure and functions of genes in isolated human and animal cells as well as in living animals after exposure, and that would have given additional weight to the epidemiological

observations, were not taken into account. Had they been included in the evaluation, the classification would not have been 'possibly carcinogenic' but rather 'probably carcinogenic'.

The general public is confronted with two different views, one represented by politics and industry and one by the growing number of independent researchers. Ordinary people have either no idea of the probably adverse effects of radiofrequency radiation or have full confidence in the exposure limits that according to their governments reliably protect from any risk to the health. They do not know that the exposure limits are based on pseudo-science thought to create the necessary legal frame for a telecommunication industry that wants to make use of the new technology without being hampered by medical considerations.

For a medical doctor like me, the conclusion from the present state of knowledge must be that a precautionary approach is overdue and must not be delayed anymore. (Full Statement in Appendix 5).

Dr Vini G. Khurana, MBBS, BSc (Med), PhD, FRACS, Associate Professor of Neurosurgery, Australian National University Medical School; Currently Visiting Attending Neurosurgeon, Royal Melbourne Hospital.

The concerns raised regarding the unnecessary and prolonged exposure of children to near-field radiofrequency electromagnetic radiation (RF-EMR) from mobile phones, wireless laptops (on their laps), and nearby Wi-Fi transmitters in schools are shared by many.

A precautionary approach is realistically achieved without compromising convenience and safety. See for example: http://www.brain-surgery.us/brain_spine_health.html

There are good grounds for adopting such an approach in children, particularly in the context of the WHO's recent classification of RF-EMR as "possibly carcinogenic to humans", and the fact that children may be more susceptible to any adverse health effects of RF-EMR owing to their thinner scalp and skull, increased brain water content, lower brain volume, and rapidly developing neural connections.

Dr Annie Sasco, MD, PhD, Director, Epidemiology for Cancer Prevention, INSERM (Institut national de la santé et de la recherche médicale) Research Unit, School of Public Health, Victor-Segalen Bordeaux 2 Université, France. Formerly International Agency for Research on Cancer (IARC) Unit Chief of Epidemiology for Cancer Prevention.

If we want to wait for final proof, at least in terms of cancer, it may still take 20 years and the issue will become that we will not have unexposed population to act as control. We may never have the absolute final proof. But we have enough data to go ahead with a precautionary principle to avoid exposures (radiofrequencies) which are unnecessary if our goal is to reduce somewhat the burden of cancer in the years to come and other chronic diseases.

Dr Alfonso Balmori, PhD, Biologist, Researcher on effects of electromagnetic fields on wildlife, Valladolid, Spain.

The ongoing invasion of radiation caused by Wi-Fi transmitters and other radiofrequency sources represents a denial of scientific evidence and extreme myopia. It is absurd when cable can be used with much greater speeds than schools choose to do so by air. Moreover health must take priority over access to information. Wi-Fi systems are being senselessly installed, even for young children. Society is performing an extremely dangerous and suicidal experiment with them. In it are included not only the children of those who are convinced that electromagnetic radiation is harmful but also the children of the promoters of such systems, both politicians and those who work in the communications industry and also the scientists who deny the evidence. The problems of depression, attention deficit and insomnia in children are increasing worldwide at an alarming rate.

Dr Mae-Wan Ho, PhD, FRSA, Director of the Institute of Science in Society, London, UK.

It is very important for schools and other public places frequented by children to be free of Wi-Fi. The evidence on 'non-thermal' biological effects of very weak electromagnetic fields is now indisputable and children are many times more at risk than adults.

Dr Norbert Hankin, PhD, Environmental Scientist, Office of Radiation and Indoor Air, Environmental Protection Agency, USA.

The growing use of wireless communications by children and by schools will result in prolonged (possibly several hours per day), long-term exposure (12 or more years of exposure in classrooms connected to computer networks by wireless telecommunications) of developing children to low-intensity pulse modulated radiofrequency radiation.

Recent studies involving short-term exposures have demonstrated that subtle effects on brain functions can be produced by low-intensity pulse modulated radiofrequency radiation. Some research involving rodents has shown adverse effects on short-term and long-term memory. The concern is that if such effects may occur in young children, then even slight impairment of learning ability over years of education may negatively affect the quality of life that could be achieved by these individuals, when adults¹⁵.

The individuals listed below signed the Porto Alegre Resolution in 2010, which stated:

We strongly recommend these precautionary practices:

- 1. Children under the age of 16 should not use mobile phones and cordless phones, except for emergency calls;*
- 2. The licensing and/or use of Wi-Fi, WIMAX, or any other forms of wireless communications technology, indoors or outdoors, shall preferably not include siting or signal transmission in ... schools ... or any other buildings where people spend considerable time.*

Franz Adlkofer, Prof. Dr. Med., Verum Foundation, Germany.
Carl Blackman, PhD., CFB, USA.
Martin Blank, PhD. Prof. Columbia Univ., USA.
Devra L. Davis, PhD , MPA , Founder, Environmental Health Trust, USA.
Om P. Gandhi, Sc.D. , Univ. of Utah, USA.
Michael Kundi, PhD. , Medical Univ. of Vienna, Austria.
Henry Lai, PhD., Univ. of Washington, USA.
Leif Salford, MD, PhD., Lund Univ., Sweden.
Carlos E. C. Abrahão, M.D. , Campinas, SP, Brazil.
Adilza C. Dode, M. Sc., MRE, MG, Brazil.
Claudio R. Fernández, M. Sc., IFSUL, Pelotas, RS, Brazil.
Robson Spinelli Gomes, Dr., MP/RJ, Brazil.
Sergio Koifman, M.D., ENSP/Fiocruz, RJ, Brazil.
Renato R. Lieber, Dr., UNESP, Guaratinguetá, SP, Brazil.
Alvaro A. de Salles, Ph.D., UFRGS, RS, Brazil.
Solange R. Schaffer, M.Sc., Fundacentro, SP, Brazil.
Helio A. da Silva, Dr., UFJF, MG, Brazil.
Francisco de A. Tejo, Dr. , UFCG, Pb, Brazil.
Geila R. Vieira, M.D., CGVS/SMS, P. Alegre, RS, Brazil.
Rodrigo Jaimes Abril, Vice Dean, Electrical Engineer, National University of Colombia,
Bogota, Col.
Betânia Bussinger, M.D., Biological Effects of Non Ionizing Radiation, UFF, RJ, Brazil.
Simona Carrubba, PhD, Louisiana State Univ. Health Science Center, Shreveport, La, USA.
Claudio Gómez-Perretta, MD, PhD. Centro Investigación, Hospital Universitario La
Fe, Valencia. Spain.
Christos Georgiou, PhD., ICEMS, Prof. Biochemistry, University of Patras, Greece.
Karl Braun-von Gladiß. Dr. med., Arzt für Allgemeinmedizin, Deutsch Evern, Germany.
Yury Grigoriev, Professor, Dr. of Medical Science, Chairman of Russian National
Committee on Non-Ionizing Radiation Protection, Moscow (Russian Federation).
Magda Havas, PhD. Prof. Environmental Science, Trent University, Peterborough, Ontario,
Canada.
Olle Johansson, Assoc. Prof., The Experimental. Dermatology Unit, Department of
Neuroscience, Karolinska Institute; and Professor, The Royal Institute of Technology,
Stockholm, Sweden.
Lukas H. Margaritis, Professor of Cell Biology and Radiobiology, Athens University, Greece.
L. Lloyd Morgan, Electronics Engineer (retired), USA.
Wilhelm Mosgoeller, MD, Prof. Medical University of Vienna, Austria.
Jerry L. Phillips, PhD. Prof. Dir. Science Learning Ctr. Univ. Colorado, Colorado Springs,
USA.
Nesrin Seyhan, PhD., ICEMS, Prof. Medical Faculty of Gazi University, Chair, Biophysics
Dept. Turkey Rep/WHO EMF IAC, Panel member, NATO RTO, HFM, Turkey.
David Servan-Schreiber, MD, PhD. Clinical Professor, Psychiatry, Univ. Pittsburgh USA.
Stanislaw Smigielski, MD, ICEMS, Military Institute of Hygiene & Epidemiology, Poland.
Stelios A Zinelis MD, ICEMS, Hellenic Cancer Society, Cefallonia, Greece.
Jose Maria Tiburcio Barroso, engineer, Niteroi, RJ, Brazil.
Elza Antonia Pereira Cunha Boiteux, Prof. Dra., Faculdade de Direito, Universidade de São
Paulo, BR.

Sergio A. Pereira De Borja, Prof. Direito Constitucional, PUC/RS e da Instituicoes de Direito, UFRGS.

Elaine S. A. Cabral, M. Sc., Education, Environmental Law; member, Human Rights Commission - of Attorney Association-OAB, J. de Fora, MG, Brazil.

Bill Curry, PhD. Physics, ret. Argonne National Labs, Board Member, EMR Network, USA.

Adamantia F. Fragopoulou, B.Sc., M.Sc., Ph.D. Candidate, EMF Bioeffects, Athens Univ. Greece.

Cristiano M. Gallep, Prof. Dr., DTT, Unicamp, Brazil.

Carol C. Georges, PhD. Psychologist, Italy.

Andrew Goldsworthy BSc PhD, Lecturer in Biology (retired) Imperial College, London, UK.

Laura Elza L. F. Gomes. M.Sc., Prof. da Escola de Arquitetura e Urbanismo da UFF – Universidade - Federal Fluminense.

Sue Grey, LLB(Hons), BSc (Microbiology and Biochemistry), RSHDipPHI, New Zealand.

João Henrique C. Kanan, PhD, UFRGS, RS, Brazil.

Luiz Roberto Santos Moraes, Professor Titular em Saneamento, Universidade Federal da - Bahia, Brazil.

Daniel Oberhausen, Prof. Physics (retired), Association PRIARTÉM, France.

Fanny Helena Martins Salles, psychologist, public official, Prof. University of Bage, RS, Brazil.

Sarah J. Starkey, PhD. Neuroscientist, UK.

Alex W. Thomas, Ph.D, CIHR University-Industry, Chair, Bioelectromagnetics, Lawson Health Research - Institute, University of Western Ontario.

Casper Wickman, PhD, Chalmers University of Technology, Sweden.

Porto Alegre Resolution in full, with all signatures:

http://www.icems.eu/docs/resolutions/Porto_Alegre_Resolution.pdf

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<http://wifiinschools.org.uk/resources/wireless+technologies+and+young+people+Oct2011.pdf>
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Protecting children and learners from maltreatment; preventing impairment of children's and learners' health or development; ensuring that children and learners are growing up in circumstances consistent with the provision of safe and effective care; undertaking that role so as to enable those children and learners to have optimum life chances and to enter adulthood successfully.
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Papers finding biological or health effects of Wi-Fi signals or Wi-Fi-enabled technologies can be found here: <http://wifiinschools.org.uk/22.html>

Appendix 1

Statement on Electromagnetic [radio frequency] Radiation [EMR] and Health Risks.

International Society of Doctors for the Environment [ISDE] and the Irish Doctors Environmental Association [IDEA].

Both the International Society of Doctors for the Environment [ISDE] and the Irish Doctors Environmental Association [IDEA] have stated, the former by an ad hoc majority opinion of the Directing Board and the latter by unanimous decision of the Executive Committee, that there is sufficient scientific evidence to warrant more stringent controls on the level and distribution of EMR.

The Interphone Study organised by the International Agency for Research on Cancer [IARC] – a \$20 million study in many countries over 5 years, presented partial results in 2011 of their analysis of 6,600 cancer cases in relation to cellphone use. The results were equivocal but IARC has since designated EMR as “possibly carcinogenic to humans” [Group 2B].

ADHD is known to be increasing in prevalence by 3% per year in the USA for which there is no generally accepted explanation. There is evidence from an epidemiological study [Divan, H et al *Epidemiology* 19 523-529] from 2008 indicating an association between maternal cell phone use and the prevalence of behavioural problems in children. This was supported by an experimental study in mice from Yale University which demonstrated neurobehavioural defects which persisted into adulthood and was shown to be due to dose-dependent altered neurodevelopmental programming [Tamir S Aldad et al Mar 2012 www.nature.com/scientificreports]

Because of the potentially increased risks for the foetus, infants and young children due to their thinner more permeable skulls and developing systems, particularly the immune and neurological systems, based on the precautionary principal and on the mounting evidence for harm at the sub-cellular level, we recommend that EMR exposure should be kept to a minimum. The basic theory is that the younger they are the more likely they are to be damaged for the above reasons and also they will be exposed for a longer period over their lifetime on average.

The Parliamentary Assembly of the Council of Europe Resolution 1815 in 2011 made numerous specific recommendations relating to EMR, the basic message being to maintain radiation levels ‘as low as reasonably achievable’ [ALARA].

Recommendations

Personal:

Avoid totally or minimise to essential usage below the age of 14 years

Use 'hands free' at all ages.

Minimise duration of calls.

Avoid having the phone on standby on your person, particularly adjacent to the gonads [testicles and ovaries] or heart.

Avoid using in a motor car or enclosed space.

Avoid use in pregnancy.

Use phone with the lowest Specific Absorption Ratio [SAR].

General:

Avoid living or working within 100m of a base station.

Avoid Wi-Fi in home or work if possible, particularly in schools or hospitals.

If Wi-Fi is present only switch it on when in use.

Measure the radiation levels at sites which are occupied for prolonged periods, particularly by infants or young children.

Base stations should not be located on or near [500m] schools or hospitals.

Use wired technology whenever possible.

Dr P. Michael May 2012

Appendix 2

Children and mobile phones: The Health of the Following Generations is in Danger.

Russian National Committee on Non-Ionizing Radiation Protection.

April 2008
(Page iv)

**CHILDREN AND MOBILE PHONES:
THE HEALTH OF THE FOLLOWING GENERATIONS IS IN DANGER**

Moscow, Russia

14 April 2008

For the first time in history, we face a situation when most children and teenagers in the world are continuously exposed to the potentially adverse influence of the electromagnetic fields (EMF) from mobile phones.

Electromagnetic field is an important biotropic factor, affecting not just a human health in general, but also the processes of the higher nervous activity, including behavior and thinking. Radiation directly affects human brain when people use mobile phones.

Despite the recommendations, listed in the Sanitary Rules of the Ministry of Health, which insist that persons under 18 years should not use mobile phones (SanPiN 2.1.8/2.2.4.1190-03 point 6.9), children and teenagers became the target group for the marketing the mobile communications.

The 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. The WHO considers the protection of the children's health from possible negative influence of the EMF of the mobile phones as a highest priority task. This problem has also been confirmed by the Scientific Committee of the European Commission, by national authorities of the European and Asian countries, by participants of the International scientific conferences on biological effects of the EMF.

Potential risk for the children's health is very high:

- the absorption of the electromagnetic energy in a child's head is considerably higher than that in the head of an adult (children's brain has higher conductivity, smaller size, thin skull bones, smaller distance from the antenna etc.);
- children's organism has more sensitivity to the EMF, than the adult's;
- children's brain has higher sensitivity to the accumulation of the adverse effects under conditions of chronic exposure to the EMF;
- EMF affects the formation of the process of the higher nervous activity;
- today's children will spend essentially longer time using mobile phones, than today's adults will.

According to the opinion of the Russian National Committee on Non-Ionizing Radiation Protection, the following **health hazards** are likely to be faced by the children mobile phone users in the **nearest** future: disruption of memory, decline of attention, diminishing learning and cognitive abilities, increased irritability, sleep problems, increase in sensitivity to the stress, increased epileptic readiness.

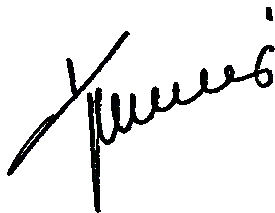
Expected (possible) remote health risks: brain tumors, tumors of acoustical and vestibular nerves (in the age of 25-30 years), Alzheimer's disease, "got dementia", depressive syndrome, and the other types of degeneration of the nervous structures of the brain (in the age of 50 to 60).

The members of the Russian National Committee on Non-Ionizing Radiation Protection emphasize ultimate urgency to defend children's health from the influence of the EMF of the mobile communication systems. We appeal to the government authorities, to the entire society to pay closest attention to this coming threat and to take adequate measures in order to prevent negative consequences to the future generation's health.

The children using mobile communication are not able to realize that they subject their brain to the EMF radiation and their health – to the risk. We believe that this risk is not much lower than the risk to the children's health from tobacco or alcohol. It is our professional obligation not to let damage the children's health by inactivity.

On behalf of members of Russian National Committee on Non-Ionizing Radiation Protection

Chairman, professor



46, Zhivopisnaya Str., 123182 Moscow, RUSSIA
+7-499-193-0187 rcnirp@mail.ru

Appendix 3

Columbia University, College of Physicians and Surgeons

Department of Physiology and Cellular Biophysics Telephone: (212) 305-3644

630 West 168 Street

New York, NY 10032

Telefax: (212) 305-5775

EMAIL: mb32@columbia.edu

May 22, 2009

Ms. Julie Korenstein

Board Member

Los Angeles Unified School District

Board of Education

333 South Beaudry Avenue, 24th Floor

Los Angeles, CA 90017

Re: Health effects of cell tower radiation

Dear Ms. Korenstein,

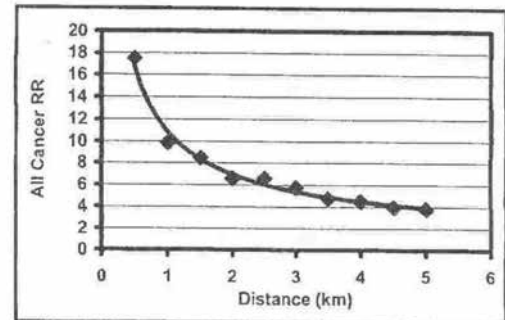
As an active researcher on biological effects of electromagnetic fields (EMF) for over twenty five years at Columbia University, as well as one of the organizers of the 2007 online Bioinitiative Report on the subject, I am writing in support of a limit on the construction of cell towers in the vicinity of schools.

There is now sufficient scientific data about the biological effects of EMF, and in particular about radiofrequency (RF) radiation, to argue for adoption of precautionary measures. We can state unequivocally that EMF can cause single and double strand DNA breakage at exposure levels that are considered safe under the FCC guidelines in the USA. As I shall illustrate below, there are also epidemiology studies that show an increased risk of cancers associated with exposure to RF. Since we know that an accumulation of changes or mutations in DNA is associated with cancer, there is good reason to believe that the elevated rates of cancers among persons living near RF towers are probably linked to DNA damage caused by EMF. Because of the nature of EMF exposure and the length of time it takes for most cancers to develop, one cannot expect 'conclusive proof' such as the link between helicobacter pylori and gastric ulcer. (That link was recently demonstrated by the Australian doctor who proved a link conclusively by swallowing the bacteria and getting the disease.) However, there is enough evidence of a plausible mechanism to link EMF exposure to increased risk of cancer, and therefore of a need to limit exposure, especially of children.

EMF have been shown to cause other potentially harmful biological effects, such as leakage of the blood brain barrier that can lead to damage of neurons in the brain, increased micronuclei (DNA fragments) in human blood lymphocytes, all at EMF exposures well below the limits in the current FCC guidelines. Probably the most convincing evidence of potential harm comes

<http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

from living cells themselves when they start to manufacture stress proteins upon exposure to EMF. The stress response occurs with a number of potentially harmful environmental factors, such as elevated temperature, changes in pH, toxic metals, etc. This means that ***when stress protein synthesis is stimulated by radiofrequency or power frequency EMF, the body is telling us in its own language that RF exposure is potentially harmful.***



There have been several attempts to measure the health risks associated with exposure to RF, and I can best summarize the findings with a graph from the study by Dr. Neil Cherry of all childhood cancers around the Sutro Tower in San Francisco between the years 1937 and 1988. Similar studies with similar results were done around broadcasting antennas in Sydney, Australia and Rome, Italy, and there are now studies of effects of cellphones on brain cancer. The Sutro tower contains antennas for broadcasting FM (54.7 kW), TV (616 kW) and UHF (18.3 MW) signals over a fairly wide area, and while the fields are not uniform, and also vary during the day, the fields were measured and average values estimated, so that one could associate the cancer risk with the degree of EMF exposure.

The data in the figure are the risk ratios (RR) for a total of 123 cases of childhood cancer from a population of 50,686 children, and include a 51 cases of leukaemia, 35 cases of brain cancer and 37 cases of lymphatic cancer. It is clear from the results that the risk ratio for all childhood cancers is elevated in the area studied, and while the risk falls off with radial distance from the antennas, as expected, it is still above a risk ratio of 5 even at a distance of 3km where the field was $1\mu\text{W}/\text{cm}^2$. This figure is what we can expect from prolonged RF exposure. In the Bioinitiative Report, we recommended $0.1\mu\text{W}/\text{cm}^2$ as a desirable precautionary level based on this and related studies, including recent studies of brain cancer and cellphone exposure.

As I mentioned above, many potentially harmful effects, such as the stress response and DNA strand breaks, occur at nonthermal levels (field strengths that do not cause a temperature increase) and are therefore considered safe. It is obvious that the safety standards must be revised downward to take into account the nonthermal as well as thermal biological responses that occur at much lower intensities. Since we cannot rely on the current standards, it is best to act according to the precautionary principle, the approach advocated by the European Union and the scientists involved in the Bioinitiative report. In light of the current evidence, the precautionary approach appears to be the most reasonable for those who must protect the health and welfare of the public and especially its most vulnerable members, children of school-age.

Sincerely yours,

Martin Blank, Ph.D.

Associate Professor of Physiology and Cellular Biophysics.

<http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

Appendix 4

A Commentary on Schools & Best Practice EMF Legislation

Dr Isaac Jamieson March 2012

Comments on use of Wi-Fi & smart/mobile phones in schools

A Need for Caution?

The recent classification of RF/microwave radiation as a Class 2B carcinogen by the International Agency for Research on Cancer (IARC) (WHO/IARC 2011), the Council of Europe's recommendation that electromagnetic emissions should be *"as low as reasonably achievable"* (PACE 2011) and calls - such as that of the Seletun Resolution (Fragopoulou et al. 2010) - to reduce electromagnetic fields (EMF) exposures, indicate it may be wise to reassess current UK policies as related to the use of Wi-Fi and smart/mobile phone use in schools, particularly as low field alternatives are available. UK unions state *"Caution should be used to prevent exposure to substances in Group 2B,"* and that *"the aim should be to remove all exposure to any known or suspected carcinogen in the workplace"* (TUC 2008).

Influence of field regimes on clumping of red blood cells

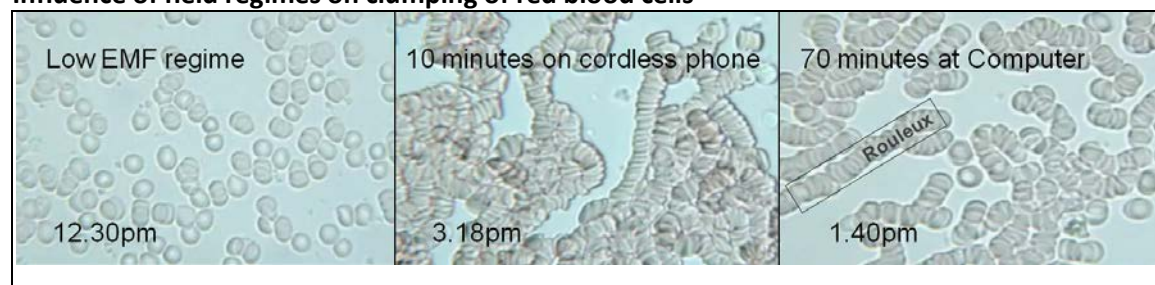


Image source: Havas (2010).

"Wireless communication is now being implemented in our daily life in a very fast way. At the same time, it is becoming more and more obvious that the exposure to electromagnetic fields not only may induce acute thermal effects to living organisms, but also non-thermal effects, the latter often after longer exposures. This has been demonstrated in a very large number of studies and includes cellular DNA-damage, disruptions and alterations of cellular functions like increases in intracellular stimulatory pathways and calcium handling, disruption of tissue structures like the blood-brain barrier, impact on vessel and immune functions, and loss of fertility," Johansson (2011).

Comet Assay - a typical picture after RF-EMF-exposition of HL60 leukaemia cells

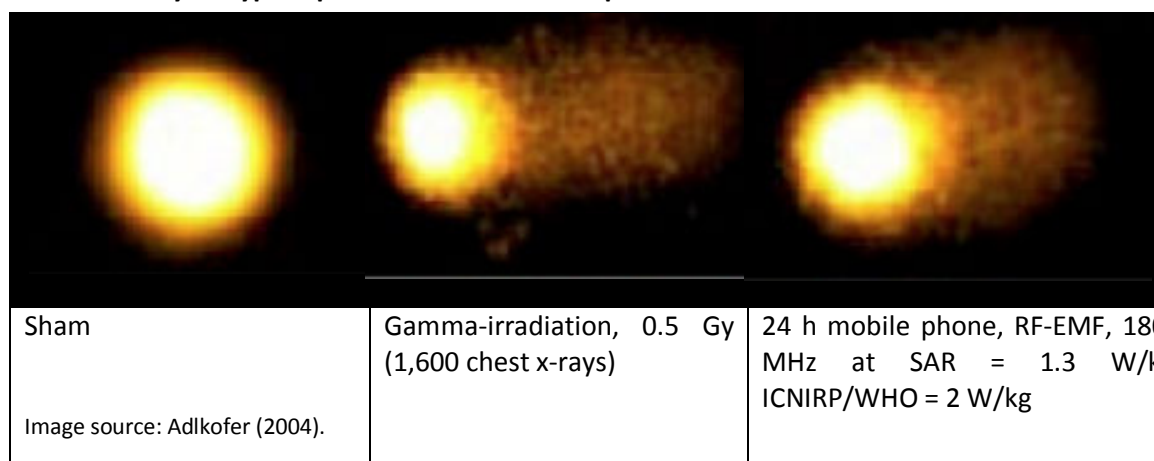


Image source: Adlkofer (2004).

<http://www.wifiinschools.org.uk/resources/safeschools2012.pdf>

The photos above show the effects of different types of radiation on gene expression of human HL60 cells. The damage from radiation from the mobile phone [at levels below current ICNIRP/WHO standards [and which the UK's Health Protection Agency (HPA 2012) currently adheres to], are similar to those resulting from the high dosage of gamma radiation (Adlkofer 2004).

It is noted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) that *"... children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of [non-ionising radiation] exposure than the rest of the population."* (ICNIRP 2002).

Some Within Industry Also Suggest Caution

When wishing to consider whether the use of Wi-Fi and smart/mobile phones in schools (and exposing school occupants to such radiation) is appropriate, it is perhaps worth also considering what is being said within some sectors of the telecommunications industry:

"I want to be very clear. Industry has not said once - once - that ... [RF / microwave radiation is] safe. The federal government and various interagency working groups have said it is safe." K. Dane Snowden, Vice President, External & State Affairs, CTIA-The Wireless Association®* (Safeschool 2010).

* CTIA - The Wireless Association®, is the International Association for the Wireless Telecommunications Industry. It is "Dedicated to Expanding the Wireless Frontier".

"The influence of electrosmog [created by inappropriately design technology – present author's comment] on the human body is a known problem. ... The risk of damage to health through electrosmog has also become better understood as a result of more recent and improved studies. When for example, human blood cells are irradiated with electromagnetic fields, clear damage to hereditary material has been demonstrated and there have been indications of an increased cancer risk. ..." Swisscom AG - major Swiss telecommunications provider (Swisscom AG 2003).

Warnings - Mobile phone manuals too now carry warnings: As an example, one states that studies *"have suggested that low levels of RF could accelerate the development of cancer in laboratory animals. In one study, mice genetically altered to be predisposed to developing one type of cancer developed more than **twice as many cancers** [emphasis by current author] when they were exposed to RF energy compared to controls,"* (Motorola 2011).

Another mobile phone manual gives the following guidance: ***"When using iPhone near your body for voice calls or wireless data transmission over a cellular network, keep iPhone at least 15 mm (5/8 inch away from the body),*** [emphasis by current author] *and only use carrying cases, belt clips, or holders that do not have metal parts and that maintain at least 15 mm (5/8 inch) separation."* (Apple 2010). The text for that warning was originally in grey in 6 font, making it particularly difficult for many people to read:

"When using iPhone near your body for voice calls or wireless data transmission over a cellular network, keep iPhone at least 15 mm (5/8 inch away from the body), and only use carrying cases, belt clips, or holders that do not have metal parts and that maintain at least 15 mm (5/8 inch) separation."

Studies on Learning Ability & RF/Microwave Exposure

The hippocampus

The brain's hippocampus plays a vital role in consolidating information from short-term memory to the long-term memory and in matters related to spatial navigation in both children and adults. Some RF/microwave regimes have been indicated as damaging it and also compromising its development. Animal tests by Salford et al. (2003) reported exposure to 915 MHz RF/microwave regimes from mobile phones for 2 hours produced highly significant ($p < 0.002$) evidence of neuronal damage in the hippocampus and other parts of the brain.

Memory function

Nittby et al. (2008) also investigated the possible effects of exposure to 900 MHz radiation on animals' cognitive functioning; 32 out of 56 rats (the rest being either sham exposed or controls) were exposed for 2 hours every week for 55 weeks to RF/microwave mobile phone radiation. After this protracted exposure, they were compared to sham exposed controls. The RF/microwave exposed animals exhibited impaired memory for objects and temporal order of presentation compared to the sham exposed controls ($p = 0.02$). Their results indicated significantly reduced memory functions occurred after 900 MHz RF/microwave exposures ($p = 0.02$).

Research by Fragopoulou et al. (2009) demonstrated that exposing test-animals for approximately 2 hours per day to 900 MHz RF/microwave radiation from a mobile for four days caused cognitive deficits in spatial learning and memory. In that study, the exposed animals were shown to be less proficient in transferring learned information to the following day, and exhibited deficits in consolidation and/or retrieval of learned information.

Narayanan et al. (2009), undertaking tests on 10-12 week old male rats, found exposing them to the 900/1800 MHz RF/microwave radiation of 50 missed calls a day from a mobile phone daily for 4 weeks induced behavioural changes, though the exact cause of these was undetermined. The animals exposed to RF/microwave radiation took longer to undertake tasks, had poorer spatial navigation and exhibited poorer memory function than those unexposed.

2.4 GHz exposures

Research undertaken by Wang & Lai & (2000) indicated that exposure to some 2.45 GHz RF/microwave regimes may affect memory. In that work, the long-term memory and navigational skills of rats appeared negatively influenced by one hour of exposure to 2.45 GHz radiation (pulse width 2ms, 500 pulses/s, average power density of $2,000 \mu\text{W}/\text{cm}^2$) as compared to the unexposed control group. Whilst some studies by others failed to replicate this work (MMF 2005), the need for caution with regard to introducing exposures RF/microwave regimes is indicated.

A later study by Li et al. (2008), found exposing rats to a 2.45 GHz pulsed RF/microwave field at an average power density of 1,000 $\mu\text{W}/\text{cm}^2$ for 3 hours daily for up to 30 days resulted in significant deficits in spatial learning and memory performance in the exposed animals.

As a precautionary measure to improve health, wellbeing and learning ability in schools, it may prove prudent to introduce low field regimes wherever possible.

As noted by the U.S. President's Cancer Panel in its 2008-2009 report, "... *just as there are many opportunities for harmful environmental exposures, ample opportunities also exist to intervene in, ameliorate, and prevent environmental health hazards. Governments, industry, the academic and medical communities, and individuals all have untapped power to protect the health of current and future generations ... and reduce the national burden of cancer.*" (US DHSS 2010).

One of these international initiatives is the creation of Health Promoting Schools. This is an initiative that the UK can greatly contribute to.

Health Promoting Schools (HPS)

Schools, Wellbeing & Achievement

It is recognised by the UK Secretary of State for Education, the Right Honourable Michael Gove MP, that "... *the five outcomes for Every Child Matters... are: being healthy, staying safe, enjoying and achieving, making a positive contribution and securing economic well-being. As a statement of five things that we'd like for children - ... They are unimpeachable ...*" (Gove & Bell 2010).

This foresight is also shared by the UK's Directgov, "*Everyone in the education system must do what is sensible to keep pupils safe and healthy. This includes making the school environment as safe as possible. ...*" Directgov (2011). It therefore appears prudent, where possible, for the UK to minimise electromagnetic pollution in kindergartens, schools and colleges, and use wired alternatives to standard RF/microwave emitting technologies and other low cost/no cost mitigative measures where feasible.

The creation of environments that actively encourage wellbeing may also help contribute deliverables to Prime Minister David Cameron's groundbreaking National Well-being Debate initiative with parameters that might be easily assessed.

The presence or absence of environmental pollutants, such as electromagnetic pollution, may significantly impact on the learning and wellbeing of some individuals and reductions often be achieved at low or no cost. "*Healthy students learn better. The core business of a school is maximising learning outcomes. Effective Health Promoting Schools (HPS) make a major contribution to schools achieving their educational and social goals.*" IUHPE (2010).

The essential elements required in HPS, as based on the WHO's Ottawa Charter for Health Promotion (WHO 1986), include having 'Healthy school policies' that are clearly defined in documents or accepted best practices which promote health and well-being; and that the school's physical environment (buildings, grounds and equipment) help promote health.

Another of the essential elements required in HPS is that potential environmental contaminants detrimental to health are addressed (IUHPE 2009).

The reduction of such potential stressors as electromagnetic pollution could be brought in through appropriate low cost/no cost 'best practice' legislation to help protect children. As noted by the UK Secretary of State for Education, when talking about child protection, *"It is critically important that we make some big changes early on and then allow change to be driven from within the system rather than from Whitehall."* (Gove & Bell 2010). Might introducing suitable legislation on electromagnetic hygiene initiatives to create Health Promoting Schools that encourage health, well-being and improved performance for current and future generations be one of the initiatives he champions?

The Parliamentary Assembly of the Council of Europe (PACE) recommends that the member states of the Council of Europe take *"all reasonable measures"* to reduce the exposure of children and young people to manmade electromagnetic fields to those that are 'As Low As Reasonably Achievable' (ALARA) and that preference should be given to adopting wired as opposed to wireless connections to reduce potential exposures (PACE 2011). The question is can the UK take the initiative and lead the way on this issue, or will another country?

"Systematic assessment of the health impact of a rapidly changing environment – particularly in areas of technology, work, energy production and urbanization - is essential."
WHO (1986).

"Pupil's education, health and wellbeing should be at the centre of any initiatives to introduce new technologies into schools. The technologies need to be adding value and need to be safe." WFIS (2011). It is proposed by the present author that introducing appropriate electromagnetic hygiene measures and legislation for schools could significantly benefit the UK and lead the way to improved scholastic performance, the development of new generations of 'bio-friendly' technology and increased National Well-being.

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http://www.radiationresearch.org/index.php?option=com_content&view=article&id=173

Appendix 5

Governmental Protection Against Radiation is in Conflict With Science

Professor Dr. Franz Adlkofer, MD.

There is no technology that made its way as quickly and as extensively into people's daily life like wireless communication. In only 30 years, the number of mobile phone users has world-wide increased from zero to about five billion. While the use of mobile phones is the result of people's free choice, their exposure to W-LAN and other wireless applications is mostly compulsory. Especially concerned are children in schools where this technology has been given preference to wired computers. Since our knowledge on possible adverse effects of radiofrequency electromagnetic fields is still rather poor, it is obvious that at present the biggest biophysical experiment of mankind is under way – with an uncertain outcome.

In May 2011, the uncertainty has been strengthened by the International Agency for Research on Cancer (IARC) that classified radiofrequency electromagnetic fields as 'possibly carcinogenic to humans'. This decision was mainly based on the results of epidemiological studies that observed after long-term (>10 years) and intensive use of mobile phones an increased risk for brain tumours exactly at the side of the head at which the mobile phone was used. The results from animal experiments, although of minor significance, supported the decision. Yet, results from basic research that showed changes in structure and functions of genes in isolated human and animal cells as well as in living animals after exposure and that would have given additional weight to the epidemiological observations were not taken into account. Had they been included in the evaluation, the classification would not have been 'possibly carcinogenic' but rather 'probably carcinogenic'.

The biggest dilemma is caused by the fact that the general public is confronted with two different views, one represented by politics and industry and one by the growing number of independent researchers. Ordinary people have either no idea of the probably adverse effects of radiofrequency radiation or have full confidence in the exposure limits that according to their governments reliably protect from any risk to the health. They do not know that the exposure limits are based on pseudo-science thought to create the necessary legal frame for a telecommunication industry that wants to make use of the new technology without being hampered by medical considerations. For this purpose, the exposure limits were based on physical deliberations solely accepting the existence of biological effects through temperature increase. The occurrence of biological effects far below the exposure limits, meanwhile demonstrated in numerous studies, was totally neglected. The human brain contains hundred billions of living cells, which operate and communicate with each other on the basis of electrochemical mechanisms. That these mechanisms can be deranged quite easily by electromagnetic fields has been shown many times by now. However, it is well known that

findings in conflict with industrial policies require decades of research and discussion until they are finally accepted.

For a medical doctor like me, the conclusion from the present state of knowledge must be that a precautionary approach is overdue and must not be delayed anymore.

As the organizer and coordinator of the EU funded REFLEX study carried out between 2000 and 2004 by 12 research groups from seven European countries, I had to realize that radiofrequency radiation far below the exposure limits owes - opposite to our expectations – a genotoxic potential, thus, contradicting the reliability of the current exposure limits. Our results are in line with those reported in many other scientific papers that in the meantime add up to more than 100. Up to now, all these findings are not considered in the radiation protection policy of most countries all over the world. Based on my experience gathered in more than 20 years of research in the area of electromagnetic fields, I came to the conclusion that institutional corruption is responsible (1) for the still miserable state of knowledge on biological effects of electromagnetic fields, and (2) for the blindness of most governments in regard of the growing set of data that cry out for the acceptance of the precautionary principle. The poor state of knowledge is due to selective funding of research by government and industry and the willingness of hired scientists to adjust their findings to the needs of the awarding authorities, while the governmental blindness is the result of lobbyism in the antechambers of political power (http://www.pandora-foundation.eu/downloads/harvard_23-03-2012_en.pdf). To those who are mostly affected by such an irresponsible attitude belong certainly our children. This is due to a higher susceptibility of juvenile tissue to radiofrequency radiation and – probably more important – to their high life expectancy that gives any tumour enough time to grow.

It remains to be seen how long the truth about the effects of radiofrequency radiation on the health of people can be suppressed by denying the facts. History teaches that early warnings are far too often followed by late insights for which a great number of people may have to pay with disease and premature death.

Prenatal & Children - Stem Cells; Microwaves from Mobile Phones
Inhibit 53BP1 Focus Formation in Human Stem Cells More Strongly
Than in Differentiated Cells: Possible Mechanistic Link to Cancer Risk.
Environmental Health Perspectives (Markova, Belyaev et al); 2010

Microwaves from Mobile Phones Inhibit 53BP1 Focus Formation in Human Stem Cells More Strongly Than in Differentiated Cells: Possible Mechanistic Link to Cancer Risk

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BACKGROUND: It is widely accepted that DNA double-strand breaks (DSBs) and their misrepair in stem cells are critical events in the multistage origination of various leukemias and tumors, including gliomas.

OBJECTIVES: We studied whether microwaves from mobile telephones of the Global System for Mobile Communication (GSM) and the Universal Global Telecommunications System (UMTS) induce DSBs or affect DSB repair in stem cells.

METHODS: We analyzed tumor suppressor TP53 binding protein 1 (53BP1) foci that are typically formed at the sites of DSB location (referred to as DNA repair foci) by laser confocal microscopy.

RESULTS: Microwaves from mobile phones inhibited formation of 53BP1 foci in human primary fibroblasts and mesenchymal stem cells. These data parallel our previous findings for human lymphocytes. Importantly, the same GSM carrier frequency (915 MHz) and UMTS frequency band (1947.4 MHz) were effective for all cell types. Exposure at 905 MHz did not inhibit 53BP1 foci in differentiated cells, either fibroblasts or lymphocytes, whereas some effects were seen in stem cells at 905 MHz. Contrary to fibroblasts, stem cells did not adapt to chronic exposure during 2 weeks.

CONCLUSIONS: The strongest microwave effects were always observed in stem cells. This result may suggest both significant imbalance in DSB repair and severe stress response. Our findings that stem cells are most sensitive to microwave exposure and react to more frequencies than do differentiated cells may be important for cancer risk assessment and indicate that stem cells are the most relevant cellular model for validating safe mobile communication signals.

KEY WORDS: 53BP1 foci, DNA double-strand breaks, microwaves, mobile phones, stem cells. *Environ Health Perspect* 118:394–399 (2010). doi:10.1289/ehp.0900781 available via <http://dx.doi.org/> [Online 23 October 2009]

The intensity levels of exposure to microwaves (MWs) from mobile telephones are lower than the International Commission on Non-ionizing Radiation Protection (ICNIRP) standards, which are based on thermal effects of acute MW exposures (ICNIRP 1998). However, effects of prolonged exposure to nonthermal (NT) MWs at intensities comparable with those of mobile phones have also been observed in many studies that indicate a relationship between NT MW exposure and permeability of the brain–blood barrier (Nittby et al. 2008), cerebral blood flow (Huber et al. 2005), stress response (Blank and Goodman 2004), and neuronal damage (Salford et al. 2003). The data obtained by the comet assay (Diem et al. 2005; Lai and Singh 1997) and the micronuclei assay (d'Ambrosio et al. 2002; Trosic et al. 2002; Zotti-Martelli et al. 2005) imply possible genotoxic effects of NT MWs, whereas other studies did not support this genotoxicity (Meltz 2003). Experimental data have indicated that the NT MW effects occur depending on several physical parameters, including carrier frequency, polarization, modulation, and intermittence (Belyaev 2005a). Differences in these physical parameters and biological variables, including genetic background and physiologic state,

may explain various outcomes of studies with NT MWs (Belyaev 2005b; Huss et al. 2007).

A recent review of available epidemiologic studies concluded that the use of mobile phones for > 10 years is associated with increased risk of ipsilateral gliomas and acoustic neuromas (Hardell et al. 2008). For a long time stem cells have been considered an important cellular target for origination of cancer—both tumors and leukemia (Feinberg et al. 2006; Soltysova et al. 2005). Gliomas are believed to originate from stem cells in the brain (Altaner 2008). DNA double-strand breaks (DSBs) and their misrepair are critical molecular events resulting in chromosomal aberrations, which have often been associated with origination of various leukemias and tumors, including gliomas (Fischer and Meese 2007). Only one study on possible MW-induced DSBs in stem cells is available (Nikolova et al. 2005). Surprisingly, the data obtained in that study by the neutral comet assay suggested that prolonged exposure time abolished the DSB formation observed at the shorter exposure time. Furthermore, the neutral comet assay has limited applicability to detect DSBs because similar increases in comet tails may be also caused by nongenotoxic effects that imply changes in

chromatin conformation, such as relaxation of DNA loops (Belyaev et al. 1999).

Several proteins involved in DSB repair, such as phosphorylated histone 2A family member X (γ -H2AX) and tumor suppressor TP53 binding protein 1 (53BP1), have been shown to produce discrete foci that colocalize to DSBs, referred to as DNA repair foci (Kao et al. 2003; Sedelnikova et al. 2002). Analysis of DNA repair foci is currently accepted as the most sensitive and specific technique for measuring DSBs in untreated cells, as well as in cells exposed to cytotoxic agents (Bocker and Iliakis 2006; Bonner et al. 2008). By analysis of the DNA repair foci in normal human fibroblasts, we were able to detect DSBs induced by a very low dose of ionizing radiation, 1 cGy, which results in only 0.4 DSB/cell on average (Marková et al. 2007). We have also used this technique to analyze 53BP1/ γ -H2AX foci in human lymphocytes exposed to MWs from Global System for Mobile Communication (GSM)/Universal Global Telecommunications System (UMTS) phones (Belyaev et al. 2005, 2009; Marková et al. 2005). We have found that MW exposure inhibited formation of endogenous 53BP1/ γ -H2AX foci (Belyaev et al. 2005, 2009; Marková et al. 2005). This inhibition might be caused by a decrease in accessibility of DSBs to proteins because of stress-induced chromatin condensation (Belyaev et al. 2009). Inability to form DNA repair foci has been correlated to radio-sensitivity, genomic instability, and other

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repair defects (Bassing et al. 2002; Celeste et al. 2002; Kuhne et al. 2004; Olive and Banath 2004; Taneja et al. 2004). Inhibition of DSB repair may lead to chromosomal aberrations by either illegitimate recombination events (Bassing and Alt 2004) or reduced functionality of nonhomologous end-joining (Fischer and Meese 2007). Therefore, if similar effects on endogenous DNA repair foci are detected in stem cells, this might provide a direct mechanistic link to the epidemiologic data showing association of MW exposure with increased cancer risk.

Although γ -H2AX foci have been used to analyze endogenous and induced DSBs in most studies, recent data have indicated that γ -H2AX foci may also be produced by chromatin structure alternations and may not contain DSBs (Banath et al. 2004; Han et al. 2006; Suzuki et al. 2006; Yu et al. 2006). Accordingly, some γ -H2AX foci may not associate with DNA damage-response proteins such as 53BP1 (Belyaev et al. 2009; Marková et al. 2005, 2007; McManus and Hendzel 2005). High expression of endogenous γ -H2AX in pluripotent mouse embryonic stem cells (~ 100 large γ -H2AX foci per cell) was not explained by DSBs, DNA degradation, or apoptosis, but it was attributed to the unusual organization of chromatin in mouse embryonic stem cells (Banath et al. 2009). The number of endogenous 53BP1 foci (< 3 foci/nucleus) appeared normal in mouse embryonic stem cells and is comparable with that found in other cell types (Banath et al. 2009). In contrast to γ -H2AX foci, which may be produced by the DSB-relevant and DSB-unrelated mechanisms, 53BP1 is relocalized to DSBs, along with other DNA damage-response proteins, such as phosphorylated ATM (ataxia telangiectasia mutated), Rad50, and MRE11 (meiotic recombination 11), and there is no indication that DSB-unrelated events would result in the formation of the 53BP1 foci (Medvedeva et al. 2007; Yoshikawa et al. 2009). Therefore, in this study we analyzed only 53BP1 foci as a more relevant marker for DSBs.

The differences in the DSB repair pathways between mouse and human stem cells have been described (Banuelos et al. 2008). In general, the comparisons of stem cells across species suggest that significant differences may be observed, so extrapolation from animal stem cell models to human health risk assessment should be done with care (Brons et al. 2007; Ginis et al. 2004). For the present study, we chose human adipose-tissue derived mesenchymal stem cells (MSCs). This cell type displays multipotency with the ability under the correct conditions to differentiate into lineages that cover a wide range of organs and tissues, such as bone, fat, cartilage, muscle, lung, skin, hepatocytes, and neurons (Bunnell et al. 2008; Porada et al. 2006; Sasaki et al. 2008).

Of note, MSCs are at higher risk of malignant transformation than are embryonic stem cells (Solytsova et al. 2005).

In contrast to GSM exposure at the frequency of 915 MHz that consistently inhibited DNA repair foci in lymphocytes from 26 persons in total, GSM exposure at 905 MHz did not inhibit DNA repair focus formation, thereby providing evidence that MW effects depend on carrier frequency (Belyaev et al. 2005, 2009; Marková et al. 2005). In previous studies we investigated MW effects on lymphocytes. However, it would be of interest to analyze the response of human stem cells, which are usually exposed to the mobile phone MWs along with differentiated human cells such as lymphocytes and fibroblasts. Therefore, in the present study we exposed human stem cells and primary human fibroblasts to GSM/UMTS MWs at the same frequencies as we used previously in experiments with human lymphocytes.

Materials and Methods

Cells. Human diploid VH-10 fibroblasts from the foreskin of a normal boy (a gift from A. Kolman, Department of Molecular Biology and Genome Research, Stockholm University) were maintained at 5% CO₂ and 37°C in a humidified incubator as previously described (Marková et al. 2007). Human MSCs separated from adipose tissue of two healthy persons (described previously by Kucerova et al. 2007), a gift from V. Altanerova (Cancer Research Institute), were cultivated in minimal essential medium (Alpha Medium, low glucose; Gibco Invitrogen, Carlsbad, CA, USA) supplemented with 10% MSC-stimulating supplement (human; StemCell Technologies, Grenoble, France) and 1% antibiotic/antimycotic mix (Gibco Invitrogen; concentration per milliliter of medium: penicillin, 100 U; streptomycin, 100 µg; Fungizone, 0.25 µg). Suspensions of cells 1×10^5 (MSC) or 2×10^5 (VH-10) in 3 mL of medium were seeded on cover slides in Petri dishes (35 × 10 mm; Sarstedt, Nümbrecht, Germany) and incubated at 37°C in 5% CO₂ humidified atmosphere for 36–40 hr until reaching 80% confluence of cells.

Cell exposure. Cells were exposed to GSM/UMTS MWs essentially as described previously (Belyaev et al. 2009; Sarimov et al. 2004). Briefly, exposures were performed using two specially designed installations, each based on a transverse electromagnetic line cell (TEM-cell) and a test mobile phone. The output of each phone was connected by the coaxial cable to the corresponding TEM-cell. Cells were exposed to either GSM (905 MHz or 915 MHz) or UMTS (1947.4 MHz, middle channel), with identical output power (0.25 W), at least three times for each exposure condition. All exposures were performed at 37°C in a 5% CO₂

incubator using Petri dishes containing 3 mL medium per dish. The specific absorption rate (SAR) was 37 mW/kg for the 905/915 MHz frequency and 39 mW/kg for the 1947.4 MHz frequency. Taking into account all possible uncertainties, the SAR values at all locations within exposed samples were always well below thermal effects. Temperature was measured in the MW-exposed samples before, during, and after exposure with a precision of 0.1°C. No changes in temperature were induced in the samples during exposures.

In addition to MWs, mobile phones emit electromagnetic fields of extremely low frequency (ELF) that can also contribute to the exposure effects (Weisbrot et al. 2003). To avoid eventual effects of ELF exposure, the test mobile phones were situated 1 m from the CO₂ incubator containing exposed samples. Accordingly, the ELF emission of our test mobile phones did not increase background ELF field, which did not exceed 200 nT (root mean square), as measured with a three-dimensional microteslameter (Field Dosimeter 3; Combinova, Bromma, Sweden) at the location of MW exposure.

We performed sham exposures in the same TEM-cells with MW power off. The order of MW- and sham-exposures was randomized among sessions. In each experiment, the sham exposures were performed in duplicate in the TEM-cell for GSM exposure and in the TEM-cell for UMTS exposure. No differences were observed between sham-exposed samples (sham – sham exposures). Therefore, we compared the MW effects with reference to combined sham-exposures. Heat treatment (41°C) was used as a positive control for stress response. As a positive control for genotoxic effect, the cells were irradiated with ¹³⁷Cs γ -rays (3 Gy) using a Gammacell 1000 (Atomic Energy of Canada Limited, Ottawa, Canada) source at 10.6 Gy/min.

Immunostaining and foci analysis. Immediately after exposure, the cells were placed on ice for 1 hr to prevent repair of eventual DSBs. The immunostaining was performed essentially as described previously (Marková et al. 2005, 2007). The images were recorded from 5–10 fields of vision that were randomly selected from two slides on a Zeiss Axiovert 100M confocal laser scanning microscope using a plan-apochromat 63×/1.4 numerical aperture oil-immersion objective and LSM 510 software (LSM Image Browser 4.2.0.121; Carl Zeiss Microscopy, Jena, Germany). Through-focus maximum projection images were acquired from optical sections 1.00 µm apart and with a section thickness of 2.00 µm in the z-axis. Resolutions in the x- and y-axes were 0.20 µm. Eight optical sections were usually obtained for each field of vision, and the final image was obtained by projection of all sections onto one plane. For each independent exposure

experiment and for each exposure condition (type of cell, type of exposure, exposure duration), we analyzed approximately 300 cells in double-blind fashion.

Statistical analysis. We used Statistica 8.0 (StatSoft Inc., Tulsa, OK, USA) and SPSS Statistics 17.0 (SPSS Inc., Chicago, IL, USA) software for statistical analyses, according to the manufacturer's instructions. Using analysis of variance (ANOVA) for several means, we set the statistical power to 0.80 based on estimates of sample variation and effect size obtained in our pilot experiments. The cell distributions of foci were analyzed using the Kolmogorov-Smirnov test. Most data did not fulfill the Poisson distribution. We analyzed either mean values from independent experiments or all raw data representing foci in each individual cell, using both nonparametric and parametric statistics. Bonferroni adjustment was used in multiple comparisons by ANOVA. In general, all methods provided similar results and conclusions. Results were considered significantly different at $p < 0.05$.

Results

Both in fibroblasts and in MSCs, γ -irradiation (3 Gy) led to significant increases in 53BP1 foci caused by radiation-induced DSBs. In accordance with previously published data (Marková et al. 2007), 26 foci/cell were found in fibroblasts 2 hr after irradiation, and a slightly higher level, 32 foci/cell, was detected in MSCs [see Supplemental Material, Figure 1 (doi:10.1289/ehp.0900781.S1 via dx.doi.org)]. Although we saw approximately one endogenous 53BP1 focus/cell in sham-exposed fibroblasts (see Supplemental Material, Figure 2), we observed a distinct MW-induced reduction in the level of these foci in response to 915 MHz (Figure 1). UMTS MWs also consistently reduced formation of endogenous 53BP1 foci in fibroblasts (Figure 1). Of note, the MW-induced reduction in 53BP1 foci was the same regardless

of the duration of exposure within 1–3 hr, showing that saturation in the effects occurred after a 1-hr exposure (Figure 1). Analysis with the factorial ANOVA confirmed that the data did not depend on the exposure time. To verify the hypothesis that MW exposure for 1–3 hr affected formation of 53BP1 foci, we compared the effects using the Kruskal-Wallis ANOVA by ranks, the median test, and ANOVA. All tests showed that MWs affected formation of 53BP1 foci at highly significant levels ($p < 0.001$). Multiple comparisons showed significant effects of 915 MHz ($p < 0.003$) and UMTS ($p < 0.01$) at 1–3 hr exposure. On the other hand, exposure at 905 MHz did not affect fibroblasts. We observed a statistically significant difference between effects of 915 MHz and 905 MHz exposure ($p < 0.01$). These data parallel our findings for human lymphocytes (Belyaev et al. 2009) and suggest that both lymphocytes and fibroblasts respond to MWs at the same carrier frequencies, whereas other carrier frequencies do not affect these cells. Heat shock significantly inhibited formation of 53BP1 foci, similar to 915 MHz and UMTS MWs ($p < 0.001$). These data are in accordance with our previous findings for human lymphocytes (Belyaev et al. 2005, 2009; Marková et al. 2005), suggesting that NT MW exposure at specific carrier frequencies induces stress responses similar to heat shock.

The levels of endogenous 53BP1 foci in MSCs were approximately double those in fibroblasts [Figure 2; see also Supplemental Material, Figure 3 (doi:10.1289/ehp.0900781.S1)]. These data parallel the findings of others with mouse embryonic stem cells (Banath et al. 2009). Interestingly, we detected almost no foci in mitotic spreads of chromosomes of both MSCs and fibroblasts. The level of foci in mitotic cells was statistically significantly lower than in interphase cells (data not shown). These results are in line with previously published data indicating that many endogenous

53BP1 foci may not pass mitosis (Marková et al. 2007).

Similar to our findings for fibroblasts, we observed a distinct MW-induced reduction in the level of endogenous 53BP1 foci in MSCs exposed to 915 MHz and UMTS MW (Figure 2). However, these inhibitory effects of MW exposures were about 2-fold more pronounced in MSCs than in fibroblasts (Figures 1 and 2). As shown in Figure 2, prolongation of exposure did not result in increased inhibition, providing evidence that effects of MW exposure saturated at 1 hr of exposure. Analysis with factorial ANOVA confirmed that the data did not depend on exposure time. The Kruskal-Wallis ANOVA by ranks, the median test, and ANOVA showed that MWs affected formation of 53BP1 foci at very highly significant levels ($p < 0.0001$). The effects of exposure to 915 MHz and UMTS for 1–3 hr were highly significant ($p < 0.0005$). In contrast to fibroblasts, approximately 5% of MSCs had multiple foci [> 10 foci/cell; see Supplemental Material, Figure 4 (doi:10.1289/ehp.0900781.S1)]. The origin of these foci is unknown, but they were completely inhibited by MW exposure (Figure 3). Heat shock at 41°C also inhibited formation of 53BP1 foci in MSCs (Figure 2), although this inhibition was stronger than in the heat-shocked fibroblasts (Figure 1). Altogether, the data provide evidence that exposure to 915 MHz or UMTS MWs, as well as heat shock, results in stronger stress response in MSCs than in fibroblasts. Although we observed some reduction in formation of foci after exposure of MSCs to GSM MW at 905 MHz (Figures 2 and 3), this effect was not statistically significant. The effects of 905 MHz and 915 MHz were also not statistically different. These findings indicate that MWs may affect MSCs at more carrier frequencies compared with differentiated cells.

We further tested whether MSCs and fibroblasts can adapt to MW effects during chronic exposure by exposing the cells for

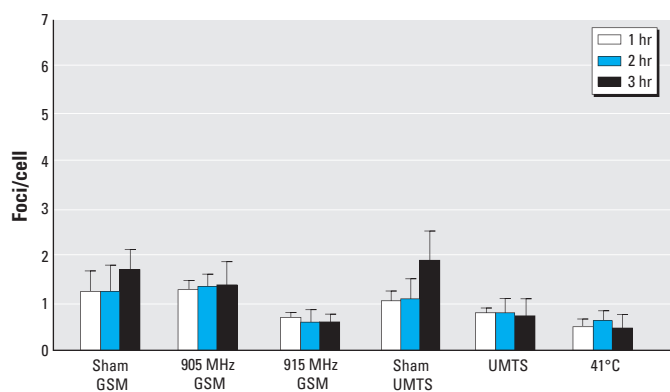


Figure 1. 53BP1 foci in VH-10 fibroblasts after 1-, 2-, or 3-hr exposure to GSM MWs at 905 or 915 MHz, UMTS MWs at 1947.4 MHz, or heat shock at 41°C, as determined by immunostaining and confocal laser microscopy. Values shown are mean $\pm$ SD of cells from three to five experiments.

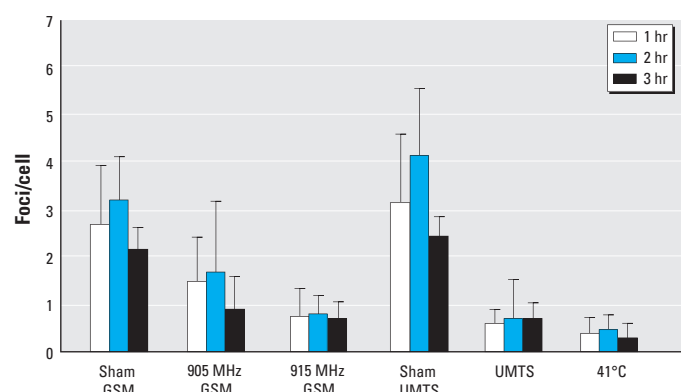


Figure 2. 53BP1 foci in human MSCs after 1-, 2-, or 3-hr exposure to GSM MW at 905 or 915 MHz, UMTS MW at 1947.4 MHz, or heat shock at 41°C. Values shown are mean $\pm$ SD from three to five experiments.

2 weeks (5 days/week, 1 hr/day). Interestingly, MSCs with multiple foci almost disappeared during 2 weeks of cultivation of untreated cells. Thus, the levels of endogenous foci did not differ between MSCs and fibroblasts (Figure 4). Fibroblasts almost completely adapted to the chronic MW exposure (Figure 4); however, we saw no such adaptation in MSCs. All statistical tests we used showed that chronic MW exposure affected formation of 53BP1 foci in MSCs ($p < 0.05$, multiple comparisons by Kruskal-Wallis ANOVA by ranks and median tests; $p < 0.001$, ANOVA). Inhibitory effects of MW exposures at the 915 MHz GSM and 1947.4 MHz UMTS were statistically significant during the 2 week exposure of MSCs ($p < 0.05$, Kruskal-Wallis ANOVA; $p < 0.005$, ANOVA). Comparison of arrays containing data from each individual cell confirmed that chronic MW exposure resulted in significant effects in MSCs [see Supplemental Material, Statistics (doi:10.1289/ehp.0900781.S1)]. In addition, these comparisons revealed the effect of 905 MHz GSM exposure and showed that UMTS exposure affected MSCs more strongly than did the GSM exposures.

Discussion

We report here for the first time that exposure of human MSCs and human primary fibroblasts to MWs from GSM/UMTS mobile phones inhibits formation of endogenous 53BP1 foci. Similar although not the same inhibitory effects of MWs from GSM/UMTS mobile phones have previously been found in primary human lymphocytes (Belyaev et al. 2009). We used these cell types for two main reasons. First, the emerging data show that effects of low-intensity MWs are cell-type dependent (Sanchez et al. 2006; Schwarz et al. 2008). In particular, immortalized and primary cells may respond differently to MWs. Therefore, the data obtained with human primary cells would be of utmost relevance for assessing possible health risks of MW exposure from mobile phones. Second, it now appears that most, if not all, adult tissues and organs, including blood, skin, and brain, contain stem cells (Metcalf and Ferguson 2008).

Therefore, stem cells, like blood cells and fibroblasts, are always subjected to exposure from mobile phones.

Our data indicate that fibroblasts are more resistant to MWs than are MSCs (present study) and human peripheral blood lymphocytes (Belyaev et al. 2009). Moreover, we show here that fibroblasts are able to adapt to MWs during chronic exposure. These results are consistent with the suggestion that adaptive cell behavior in response to MW exposure is unlikely to have adverse effects at the skin level (Sanchez et al. 2006). However, we saw no adaptation in MSCs. Thus, although our findings with chronic exposure of fibroblasts may suggest no health risks at the skin level, high sensitivity of stem cells may imply such risks.

No heat was induced in the samples exposed to MW. The SAR values at different locations of the exposed samples were always well below thermal effects. Therefore, the MW effects could not be attributed to heating, although we observed a similar response after both MW exposure and heat shock. This similarity indicates that MW exposure at 915 MHz/1947.4 MHz is a stress factor for fibroblasts and especially for human stem cells, where we saw stronger effects.

Modifications of 53BP1, such as phosphorylation, are needed for repair of DSBs (Ward et al. 2006). Thus, our finding on the inhibition of DNA repair foci can be accounted for by inhibition of phosphorylation of 53BP1 protein. Experimental evidence for such a mechanism has recently been reported (Leszczynski et al. 2002). Alternatively, MW exposure can result in chromatin condensation that prevents DSBs from accessing DNA repair proteins (Belyaev et al. 2005; Marková et al. 2005; Sarimov et al. 2004). Regardless of the molecular mechanism, inhibition of DSB repair in stem cells may result in chromosomal aberrations by either illegitimate recombination events (Bassing and Alt 2004) or reduced functionality of nonhomologous end-joining (Fischer and Meese 2007).

We have found that the constitutive level of 53BP1 foci in human MSCs is significantly higher than in differentiated primary

human cells such as fibroblasts (present study) and lymphocytes (Belyaev et al. 2009). Importantly, we did not observe adaptation to NT GSM/UMTS MW chronic exposure in stem cells. Altogether, our findings show that human stem cells are more sensitive than differentiated primary cells to MW exposure from mobile phones. Thus, inhibition of 53BP1 foci in stem cells may account for higher risks in these cells than in differentiated cells with lower constitutive 53BP1 levels.

In the present study we found that the inhibitory effect of MWs on the 53BP1 foci leveled off at 1 hr of exposure, and we observed no further increase in effects both in MSCs and fibroblasts after prolonging exposure to 3 hr. These data are in agreement with previous results that MW effects were the same at 1 hr and 2 hr exposures in human peripheral blood lymphocytes (Belyaev et al. 2005; Marková et al. 2005). Preliminary data indicate that saturation in the MW effect is observed at an even shorter exposure time (30 min), whereas almost linear dependence on exposure time is present within shorter exposure times (Belyaev IY, Marková E, unpublished data).

Both the 1947.4 MHz UMTS frequency band and the 915 MHz GSM signal affected all tested human cell types: stem cells and fibroblasts (present study) and lymphocytes (Belyaev et al. 2009). On the other hand, MW exposure at another GSM frequency (905 MHz) did not result in statistically significant effects in lymphocytes or fibroblasts. Thus, GSM MW exposure may either inhibit or not inhibit DNA repair foci depending on carrier frequency. Neither SAR nor the SAR measurement uncertainty depended on carrier frequency in the range of 905–915 MHz. Therefore, the difference in the effects at 905 and 915 MHz could not be attributed to the differences in the MW absorption. The “frequency” and “intensity” windows have often been reported for NT MW effects (for review, see Belyaev 2005b; Blackman 1992; Grundler 1992). Correspondingly, there may be “effective” and “ineffective” carrier

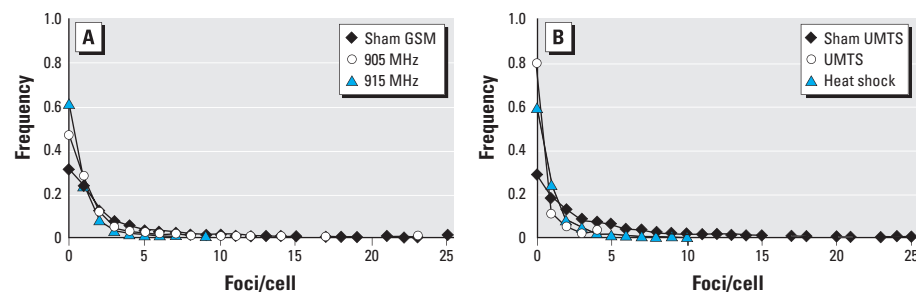


Figure 3. Distribution of 53BP1 foci among MSCs exposed to GSM (A) or UMTS (B) MWs. Distribution of cells according to number of foci per cell is shown as normalized frequency of cells versus the number of foci per cell. Heat shock (41°C) served as the positive control for MW exposure.

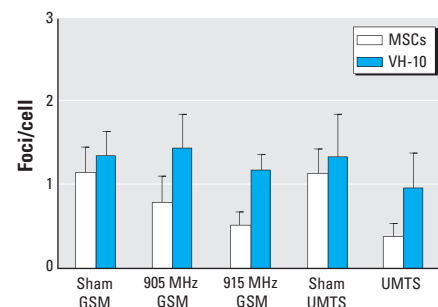


Figure 4. 53BP1 foci in VH-10 fibroblasts and MSCs after chronic exposure during 10 days (5 days/week, 1 hr/day) to GSM MW at 905 MHz or 915 MHz, and UMTS MW at 1947.4 MHz. Values shown are mean $\pm$ SD from three experiments.

GSM frequencies that either affect human cells or induce no effect. Several physical mechanisms have been suggested to account for the frequency-dependent effects of NT MW (Belyaev et al. 1996; Binh 2002; Kaiser 1995; Matronchik and Belyaev 2008). Our previous findings indicated that the intensity windows may not coincide for various carrier frequencies (Belyaev et al. 1996; Shcheglov et al. 1997). Correspondingly, the SAR value of 39 mW/kg used here may be optimal for the effects at 915 MHz but not for those at 905 MHz. Alternatively, but less likely, it is possible that the cells have molecular components that have different electrical properties, thus altering the effective intensity (Joines and Blackman 1980). In either case, future testing of the cell response as a function of exposure intensities at 905 and 915 MHz should help to resolve this issue. Regardless of physical mechanism, our findings suggest that specific carrier frequencies and bands that do not induce adverse effects can be validated in laboratory studies with primary human cells as the prerequisite for the development of safe wireless technologies.

Although we saw no statistically significant effects in stem cells exposed to 905 MHz, by comparing mean values, we observed a trend to inhibition of the DNA repair foci in these cells both under acute and chronic exposures (Figures 2–4). Moreover, the MW effects at 905 and 915 MHz were not statistically significantly different in stem cells, and analysis of the individual cell arrays revealed effects of exposure to 905 MHz. These findings indicate that stem cells may react to more frequencies than do differentiated primary human cells. Higher biological significance of MW effects in stem cells and apparently wider range of effective frequencies suggest that stem cells are the most relevant cellular model for assessment of health risks from mobile communication.

Endogenous 53BP1 foci are typically considered sensitive markers for endogenous DSBs, resulting in intrinsic genomic instability (Adams and Carpenter 2006; Banath et al. 2009; Sedelnikova et al. 2008). However, 53BP1 foci represent only indirect DSB measurements. There is no direct evidence that 53BP1 plays a role in the repair of endogenous DSBs. If irrelevance of the endogenous 53BP1 foci to DSBs is proven, the MW effects described here should be interpreted solely as a manifestation of stress response. This alternative interpretation is supported by the data that MW exposure inhibits 53BP1 foci similar to heating of cells (Figures 1–3). Stress response has previously been suggested as a criterion for adverse effects of electromagnetic fields (Blank and Goodman 2004). In fact, the currently accepted safety standards assume that MW exposure is harmful only if its effects are similar

to those of heating (ICNIRP 1998). Stress may be especially important for stem cells because it is believed to be an important factor in the multistage origination of cancer from human stem cells (Feinberg et al. 2006; Tez 2008). Both interpretations of the data—either disruption of the balance between cellular repair systems and DNA damage or stress response—are not mutually exclusive, and both may provide a mechanistic link to the epidemiologic data showing association of prolonged MW exposure with brain cancer risk (Hardell et al. 2008). It should also be mentioned that stress can reduce neurogenesis (Sohur et al. 2006).

The best indications of the role of stem cells in cancer arise from hematologic disorders such as leukemia. In several epidemiologic studies, ELF exposure has been associated with increased childhood leukemia (Kabuto et al. 2006). On the other hand, no association of ELF exposure with leukemia has been found in adults. This discrepancy has not yet been clarified at the mechanistic level, although ELF has been classified as a possible carcinogen based on these studies (International Agency for Research on Cancer 2002). In a recent study Yang et al. (2008) suggested a possible association between electric transformers and power lines and the *XRCC1* Ex9+16A allele in patients with childhood acute leukemia. ELF exposure has often been reported to result in biological effects similar to those caused by exposures to NT MWs (Adey 1981; Blackman 1992), and ELF and MW exposures similarly inhibited formation of DNA repair foci in human lymphocytes (Belyaev et al. 2005). Stem cells are more active in children than in adults (Williams et al. 2006). This increased activity of stem cells may clarify the differences between results obtained in ELF–leukemia studies with children and adults and may call for studies on possible cancer risks of MW exposure of children.

Conclusion

We have demonstrated that GSM/UMTS MWs from mobile phones inhibit formation of endogenous 53BP1 foci in human primary fibroblasts and MSCs. In contrast to fibroblasts, MSCs did not adapt to MWs during chronic exposure. Together, our results indicate that stem cells are more sensitive to MW exposure than are differentiated human primary cells, lymphocytes, and fibroblasts, whereas fibroblasts are least sensitive. Inhibitory effects of MW exposure on DSB repair in stem cells may result in formation of chromosomal aberrations and therefore origination of cancer. Alternatively, MW exposures may induce a stress response. Both possible interpretations provide a mechanistic link to increased cancer risk. Our finding that MSCs may react to more carrier frequencies than differentiated cells may

indicate that stem cells are the most relevant cellular model for validating safe mobile communication signals. Because almost all organs and tissues possess stem cells and because stem cells are more active in children, the possible relationship of chronic MW exposure and various types of tumors and leukemia—especially in children—should be investigated.

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Radiation Sickness - Children; Angela Tsiang Comments, Sep. 26, 2016

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Brief Comment

I am in opposition to 5G rollout, because the government has not done any studies on long-term health effects from exposure to 5G spectrum. In May 2016 the NTP showed a statisical increase in rare brain and heart cancers from rats exposed to cell phone radiation below thermal levels, yet the FCC has not done anything to revise its safety guidelines which are thermal based. To roll out 5G without doing studies on health first is NEGLIGENT. My children became sick from 4G LTE cell towers next to their school, and now we have to avoid cell towers. With FCC plan to put MILLIONS of small cells on residential streets, my children will become more ill. Health effects of 5G should be studied, not ignored!

Radiation Sickness - Children; Abigail DeSesa Comments, Mar. 4, 2013

Ever since the 'Smart Meter' was installed directly below my 13 year old son's bedroom on our neighbor's house he has had nonstop headaches. We feel there needs to be more restrictions on this service. Please help our children!

Cell Towers - Research Abstract Compilation; 78 Studies Showing Health
Effects from Cell Tower Radio Frequency Radiation; 2016

Studies that show **Cell Tower** Health Effects**Table of Contents****78 Studies Showing Health Effects from Cell Tower Radio
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Cancer

Wolf R, Wolf D. Increased incidence of cancer near a cell-phone transmitter station. Inter J Cancer Prev 1(2):123-128, 2004.

Significant concern has been raised about possible health effects from exposure to radiofrequency (RF) electromagnetic fields, especially after the rapid introduction of mobile telecommunication systems. Parents are especially concerned with the possibility that children might develop cancer after exposure to the RF emissions from mobile telephone base stations erected in or near schools. The few epidemiologic studies that did report on cancer incidence in relation to RF radiation have generally presented negative or inconsistent results, and thus emphasized the need for more studies that should investigate cohorts with high RF exposure for changes in cancer incidence. The aim of this study is to investigate whether there is an increased cancer incidence in populations, living in a small area, and exposed to RF radiation from a cell-phone transmitter station.

This is an epidemiologic assessment, to determine whether the incidence of cancer cases among individuals exposed to a cell-phone transmitter station is different from that expected in Israel, in Netanya, or as compared to people who lived in a nearby area. Participants are people (n=622) living in the area near a cell-phone transmitter station for 3-7 years who were patients of one health clinic (of DW). The exposure began 1 year before the start of the study when the station first came into service. A second cohort of individuals (n=1222) who get their medical services in a clinic located nearby with very closely matched, environment, workplace and occupational characteristics was used for comparison.

In the area of exposure (area) eight cases of different kinds of cancer were diagnosed in a period of only one year. This rate of cancers was compared both with the rate of 31 cases per 10,000 per year in the general population and the 2/1222 rate recorded in the nearby clinic (area B). Relative cancer rates for female were 10.5 for area A. 0.6 for area B and 1 for the whole town of Netanya. Cancer incidence of women in area A was thus significantly higher ($p < 0.0001$) compared with that of area B and the whole city. A comparison of the relative risk revealed that there were 4.15 times more cases in area than in the entire population. The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Yakymenko I, Sidorik E, Kyrylenko S, Chekhun V. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. Exp Oncol. 33(2):62-70, 2011.

In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a

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powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

Michelozzi P, Ancona C, Fusco D, Forastiere F, Perucci CA, Risk of leukemia and residence near a radio transmitter in Italy. Epidemiology 9 (Suppl) 354p, 1998.

We conducted a small area study to investigate a cluster of leukemia near a high power radio-transmitter in a peripheral area of Rome. The leukemia mortality within 3.5 km (5,863 inhabitants) was higher than expected (SMR=2.5, 95% confident interval 1.07-4.83); the excess was due to a significant higher mortality among men (7 cases observed, SMR=3.5). The results of the Stone's test, after adjusting for socio-economic confounding, showed a significant decline in risk with distance from the transmitter only among men (p=0.005), whereas the p-value for both sexes was p=0.07.

Lourencini da Silva R , Albano F, Lopes dos Santos LR , Tavares AD, Felzenszwalb I, The effect of electromagnetic field exposure on the formation of DNA lesions. Redox Rep 5(5):299-301, 2000.

In an attempt to determine whether electromagnetic field (EMF) exposure might lead to DNA damage, we exposed SnCl₂-treated pBR322 plasmids to EMF and analysed the resulting conformational changes using agarose gel electrophoresis. An EMF-dependent potentiation of DNA scission (i.e. the appearance of relaxed plasmids) was observed. In confirmation of this, plasmids pre-exposed to EMF also were less capable of transforming Escherichia coli. The results indicate that EMF, in the presence of a transition metal, is capable of causing DNA damage. These observations support the idea that EMF, probably through secondary generation of reactive oxygen species, can be clastogenic and provide a possible explanation for the observed correlation between EMF exposure and the frequency of certain types of cancers in humans.

Li CY, Liu CC, Chang YH, Chou LP, Ko MC. A population-based case-control study of radiofrequency exposure in relation to childhood neoplasm. Sci Total Environ. 435-436:472-478, 2012.

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This population-based case-control study in Taiwan considered incident cases aged 15 years or less and admitted in 2003 to 2007 for all neoplasm (ICD-9-CM: 140-239) (n=2606), including 939 leukemia and 394 brain neoplasm cases. Controls were randomly selected, with a case/control ratio of 1:30 and matched on year of birth, from all non-neoplasm children insured in the same year when the index case was admitted. Annual summarized power (ASP, watt-year) was calculated for each of the 71,185 mobile phone base stations (MPBS) in service between 1998 and 2007. Then, the **annual power density (APD, watt-year/km(2))** of each township (n=367) was computed as a ratio of the total ASP of all MPBS in a township to the area of that particular township. Exposure of each study subject to radio frequency (RF) was indicated by the averaged APD within 5 years prior to the neoplasm diagnosis (cases) or July 1st of the year when the index case was admitted (controls) in the township where the subject lived. Unconditional logistic regression model with generalized estimation equation was employed to calculate the covariate-**adjusted odds ratio [AOR]** of childhood neoplasm in relation to RF exposure. A higher than median averaged APD (approximately 168 WYs/km(2)) was significantly associated with an increased AOR for all neoplasms (1.13; 1.01 to 1.28), but not for leukemia (1.23; 0.99 to 1.52) or brain neoplasm (1.14, 0.83 to 1.55). This study noted a significantly increased risk of all neoplasms in children with higher-than-median RF exposure to MPBS. The slightly elevated risk was seen for leukemia and brain neoplasm, but was not statistically significant. These results may occur due to several methodological limitations.

Johnson EH, Chima SC, Muirhead DE, A cerebral primitive neuroectodermal tumor in a squirrel monkey (*Saimiri sciureus*). J Med Primatol 28(2):91-96, 1999.

An adult squirrel monkey with a history of long-term exposure to microwave radiation was found at necropsy to have a malignant tumor of the right cerebral cortex. Gross examination revealed a mass with expanding borders in the right frontoparietal cortex with compression of the adjacent lateral ventricle. Microscopy revealed a tumor composed of sheets of moderate-sized cells, resembling an oligodendroglioma, with clear cytoplasm and central nuclei interrupted by delicate vasculature. Malignant features were present in the form of marked nuclear pleomorphism, frequent mitotic figures, and focal necrosis. A neuronal cell origin for this tumor was supported by immunohistochemical analysis, which revealed immunopositivity for neurofilament proteins and neuron-specific enolase. Staining for vimentin and glial fibrillary acid protein was negative, except in reactive astrocytes at the tumor margins and adjacent to intra-tumoral blood vessels. Antibody activity against Ki-67 antigen, a marker of rapidly proliferating tumor cells, and p53 oncoprotein was strongly positive, indicative of the aggressive and malignant nature of this tumor. The tumor was diagnosed as a cerebral primitive neuroectodermal tumor.

Neurological Effects

Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M, Ahonen M.

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Epidemiological evidence for a health risk from mobile phone base stations. *Int J Occup Environ Health.* 16(3):263-267, 2010.

Human populations are increasingly exposed to microwave/radiofrequency (RF) emissions from wireless communication technology, including mobile phones and their base stations. By searching PubMed, we identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone base stations. Seven of these studies explored the association between base station proximity and neurobehavioral effects and three investigated cancer. We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact.

Hocking B, Westerman R. Neurological abnormalities associated with CDMA exposure. *Occup Med (Lond)* 51(6):410-413, 2001.

Dysaesthesiae of the scalp and neurological abnormality after mobile phone use have been reported previously, but the roles of the phone per se or the radiations in causing these findings have been questioned. We report finding a neurological abnormality in a patient after accidental exposure of the left side of the face to mobile phone radiation [code division multiple access (CDMA)] from a down-powered mobile phone base station antenna. He had headaches, unilateral left blurred vision and pupil constriction, unilateral altered sensation on the forehead, and abnormalities of current perception thresholds on testing the left trigeminal ophthalmic nerve. His nerve function recovered during 6 months follow-up. His exposure was 0.015-0.06 mW/cm(2) over 1-2 h. The implications regarding health effects of radiofrequency radiation are discussed.

Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, El-Batanouny M, Salem E. Neurobehavioral effects among inhabitants around mobile phone base stations. *Neurotoxicology.* 28(2):434-40, 2007.

BACKGROUND: There is a general concern on the possible hazardous health effects of exposure to radiofrequency electromagnetic radiations (RFR) emitted from mobile phone base station antennas on the human nervous system. **AIM:** To identify the possible neurobehavioral deficits among inhabitants living nearby mobile phone base stations. **METHODS:** A cross-sectional study was conducted on (85) inhabitants living nearby the first mobile phone station antenna in Menoufiya governorate, Egypt, 37 are living in a building under the station antenna while 48 opposite the station. A control group (80) participants were matched with the exposed for age, sex, occupation and educational level. All participants completed a structured questionnaire containing: personal, educational and medical histories; general and neurological examinations; neurobehavioral test battery (NBTB) [involving tests for visuomotor speed, problem solving, attention and memory]; in addition to Eysenck personality questionnaire (EPQ). **RESULTS:** The prevalence of neuropsychiatric complaints as headache (23.5%), memory

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changes (28.2%), dizziness (18.8%), tremors (9.4%), depressive symptoms (21.7%), and sleep disturbance (23.5%) were significantly higher among exposed inhabitants than controls: (10%), (5%), (5%), (0%), (8.8%) and (10%), respectively ($P < 0.05$). The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory [Paced Auditory Serial Addition Test (PASAT)]. Also, the inhabitants opposite the station exhibited a lower performance in the problem solving test (block design) than those under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (Digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls. The last available measures of RFR emitted from the first mobile phone base station antennas in Menoufiya governorate were less than the allowable standard level. CONCLUSIONS AND RECOMMENDATIONS: Inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition. So, revision of standard guidelines for public exposure to RER from mobile phone base station antennas and using of NBTB for regular assessment and early detection of biological effects among inhabitants around the stations are recommended.

Akbari A, Jelodar G, Nazifi S. Vitamin C protects rat cerebellum and encephalon from oxidative stress following exposure to radiofrequency wave generated by a BTS antenna model. Toxicol Mech Methods. 24(5):347-352, 2014.

Radio frequency wave (RFW) generated by base transceiver station has been reported to produce deleterious effects on the central nervous system function, possibly through oxidative stress. This study was conducted to evaluate the effect of RFW-induced oxidative stress in the cerebellum and encephalon and the prophylactic effect of vitamin C on these tissues by measuring the antioxidant enzymes activity, including: glutathione peroxidase, superoxide dismutase, catalase, and malondialdehyde (MDA). Thirty-two adult male Sprague-Dawley rats were randomly divided into four equal groups. The control group; the control-vitamin C group received L-ascorbic acid (200 mg/kg of body weight/day by gavage) for 45 days. The RFW group was exposed to RFW and the RFW+ vitamin C group was exposed to RFW and received vitamin C. At the end of the experiment, all groups were killed and encephalon and cerebellum of all rats were removed and stored at -70°C for measurement of antioxidant enzymes activity and MDA. The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased MDA compared with the control groups ($p < 0.05$). The protective role of vitamin C in the treated group improved antioxidant enzymes activity and reduced MDA compared with the test group ($p < 0.05$). It can be concluded that RFW causes oxidative stress in the brain and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Bak M, Dudarewicz A, Zmyślony M, Sliwinska-Kowalska M. Effects of GSM signals during exposure to event related potentials (ERPs). Int J Occup Med Environ Health. 23(2):191-199, 2010.

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Objectives: The primary aim of this work was to assess the effect of electromagnetic field (EMF) from the GSM mobile phone system on human brain function. The assessment was based on the assay of event related potentials (ERPs). **Material and Methods:** The study group consisted of 15 volunteers, including 7 men and 8 women. The test protocol comprised determination of P300 wave in each volunteer during exposure to the EMF. To eliminate possible effects of the applied test procedure on the final result, the test was repeated without EMF exposure. P300 latency, amplitude, and latency of the N1, N2, P2 waves were analysed. **Results:** The statistical analysis revealed an effect of EMF on P300 amplitude. In the experiment with EMF exposure, lower P300 amplitudes were observed only at the time in which the volunteers were exposed to EMF; when the exposure was discontinued, the values of the amplitude were the same as those observed before EMF application. No such change was observed when the experiment was repeated with sham exposure, which may be considered as an indirect proof that lower P300 amplitude values were due to EMF exposure. No statistically significant changes were noted in the latencies of the N1, N2, P2 waves that precede the P300 wave, nor in the latency of the P300 itself. **Conclusions:** The results suggest that exposure to GSM EMF exerts some effects on CNS, including effects on long latency ERPs.

Hinrichs H, Heinze HJ. Effects of GSM electromagnetic field on the MEG during an encoding-retrieval task. *Neuroreport*. 15(7):1191-1194, 2004.

Potential effects of GSM 1800 electromagnetic fields (EMF) on verbal memory encoding were investigated by recording event-related magnetic fields (ERMF) from the brain during subsequent memory retrieval. Twelve normal subjects participated in the study. After encoding words from a study list presented in the first phase they had to discriminate old from new words mixed together in a test list presented during the second phase. All subjects performed two experimental sessions, one with exposure to EMF during the study phase, and one without. Exposure to EMF changed an early (350-400 ms) task-specific component of the ERMF indicating an interference of EMF and item encoding. Behavioural measures were not significantly affected. Adverse health effects cannot be derived from these data.

Effects on Reproductive Organs and Fertility Effects

Magras, IN, Xenos, TD, RF radiation-induced changes in the prenatal development of mice. *Bioelectromagnetics* 18(6):455-461, 1997.

The possible effects of radiofrequency (RF) radiation on prenatal development has been investigated in mice. This study consisted of RF level measurements and in vivo experiments at several places around an "antenna park." At these locations RF power densities between 168 nW/cm² and 1053 nW/cm² were measured. Twelve pairs of mice, divided in two groups, were placed in locations of different power densities and were repeatedly mated five times. One hundred eighteen newborns were collected. They were measured, weighed, and examined macro- and microscopically. A progressive decrease in the number of newborns

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per dam was observed, which ended in irreversible infertility. The prenatal development of the newborns, however, evaluated by the crown-rump length, the body weight, and the number of the lumbar, sacral, and coccygeal vertebrae, was improved.

Jelodar G, Nazifi S, Akbari A. The prophylactic effect of vitamin C on induced oxidative stress in rat testis following exposure to 900 MHz radio frequency wave generated by a BTS antenna model. Electromagn Biol Med. 2013 Jan 16. [Epub ahead of print]
Radio frequency wave (RFW) generated by base transceiver station (BTS) has been reported to make deleterious effects on reproduction, possibly through oxidative stress. This study was conducted to evaluate the effect of RFW generated by BTS on oxidative stress in testis and the prophylactic effect of vitamin C by measuring the antioxidant enzymes activity, including glutathione peroxidase, superoxide dismutase (SOD) and catalase, and malondialdehyde (MDA). Thirty-two adult male Sprague-Dawley rats were randomly divided into four experimental groups and treated daily for 45 days as follows: sham, sham+vitamin C (l-ascorbic acid 200 mg/kg of body weight/day by gavage), RFW (exposed to 900 MHz RFW) 'sham' and 'RFW' animals were given the vehicle, i.e., distilled water and the RFW+vitamin C group (received vitamin C in addition to exposure to RFW). At the end of the experiment, all the rats were sacrificed and their testes were removed and used for measurement of antioxidant enzymes and MDA activity. The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased MDA compared with the control groups ($p < 0.05$). In the treated group, vitamin C improved antioxidant enzymes activity and reduced MDA compared with the test group ($p < 0.05$). It can be concluded that RFW causes oxidative stress in testis and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Lukac N, Massanyi P, Roychoudhury S, Capcarova M, Tvrda E, Knazicka Z, Kolesarova A, Danko J. In vitro effects of radiofrequency electromagnetic waves on bovine spermatozoa motility. J Environ Sci Health A Tox Hazard Subst Environ Eng. 46(12):1417-1423, 2011.

In this study the effects of 1800 MHz GSM-like radiofrequency electromagnetic waves (RF-EMW) exposure on bovine semen was monitored. The experimental samples were analyzed in vitro in four time periods (0, 30, 120 and 420 min) and compared with unexposed samples (control). Spermatozoa motility was determined by computer assisted semen analyzer (CASA). Evaluation of the percentage of motile spermatozoa showed significant ($P < 0.001$) decrease in experimental groups after 120 and 420 min of culture when exposed to microwaves, in comparison to control. Similar spermatozoa motility inhibition was detected for the percentage of progressively motile spermatozoa, too. Average path distance decreased significantly ($p < 0.001$) in experimental groups after 30 and 420 min of culture. Path velocity increased in the experimental groups exposed to RF-EMW after 30 minutes of culture, but subsequently decreased after 420 min of culture, in comparison to control. This indicates a possible initial stimulation and subsequent velocity inhibition of bovine spermatozoa under RF-EMW exposure. Changes in spermatozoa motility were also detected for some fine parameters, too. A significant decrease ($P < 0.001$) was noted for amplitude of lateral

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head displacement in the experimental group after 420 minutes of culture. Detailed in vitro motility analysis of bovine spermatozoa exposed to microwave radiation suggested that the parameters of path and velocity at the beginning of the culture significantly increase, but after longer culture (420 minutes) a significant decrease occur in the experimental group as compared to control. In general, results of this experiment indicate a negative time-dependent effect of 1800 MHz RF-EMW radiation on bovine spermatozoa motility.

Effects on Wellbeing

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. Study of the health of people living in the vicinity of mobile phone base stations: I. Influence of distance and sex. Pathol Biol (Paris) 50(6):369-373, 2002. [Article in French]

A survey study using questionnaire was conducted in 530 people (270 men, 260 women) living or not in vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaints frequencies (CHI-SQUARE test with Yates correction) in relation with distance from base station and sex, show significant ($p < 0.05$) increase as compared to people living > 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, discomfort, etc. 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men ($p < 0.05$) complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual perturbations. This first study on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, minimal distance of people from cellular phone base stations should not be < 300 m.

Santini R, Santini P, Le Ruz P, Danze JM, Seigne M, Survey study of people living in the vicinity of cellular phone base stations. Electromag Biol Med 22:41-49, 2003.

A survey study was conducted, using a questionnaire, on 530 people (270 men, 260 women) living or not in proximity to cellular phone base stations. Eighteen different symptoms (Non Specific Health Symptoms-NSHS), described as radiofrequency sickness, were studied by means of the chi-square test with Yates correction. The results that were obtained underline that certain complaints are experienced only in the immediate vicinity of base stations (up to 10 m for nausea, loss of appetite, visual disturbances), and other at greater distances from base stations (up to 100 m for irritability, depressive tendencies, lowering of libido, and up to 200 m for headaches, sleep disturbance, feeling of discomfort). In the 200 m to 300 m zone, only the complaint of fatigue is experienced significantly more often when compared with subjects residing at more than 300 m or not exposed (reference group). For seven of the studied symptoms and for the distance up to 300 m, the frequency of reported complaints is significantly higher ($P < 0.05$) for women in comparison to men. Significant differences are also observed in relation to the ages of subjects, and for the location of subjects in relation to the antennas and to other electromagnetic factors.

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Navarro EA, Sequera J, Portoles M, Gomez-Perretta de Mateo C. The Microwave Syndrome: A Preliminary Study in Spain. Electromag Biol Med 22:161-169, 2003.

A health survey was carried out in Murcia, Spain, in the vicinity of a Cellular Phone Base Station working in DCS-1800 MHz. This survey contained health items related to "microwave sickness" or "RF syndrome." The microwave power density was measured at the respondents' homes. Statistical analysis showed significant correlation between the declared severity of the symptoms and the measured power density. The separation of respondents into two different exposure groups also showed an increase of the declared severity in the group with the higher exposure.

Lerchl A, Krüger H, Niehaus M, Streckert JR, Bitz AK, Hansen V. Effects of mobile phone electromagnetic fields at nonthermal SAR values on melatonin and body weight of Djungarian hamsters (Phodopus sungorus). J Pineal Res. 44(3):267-272, 2008.

In three experiments, adult male Djungarian hamsters (Phodopus sungorus) were exposed 24 hr/day for 60 days to radio frequency electromagnetic fields (RF-EMF) at 383, 900, and 1800 MHz, modulated according to the TETRA (383 MHz) and GSM standards (900 and 1800 MHz), respectively. A radial waveguide system ensured a well defined and uniform exposure at whole-body averaged specific absorption rates of 80 mW/kg, which is equal to the upper limit of whole-body exposure of the general population in Germany and other countries. For each experiment, using two identical waveguides, hamsters were exposed (n = 120) and sham-exposed (n = 120) in a blind fashion. In all experiments, pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected. At 383 MHz, exposure resulted in a significant transient increase in body weight up to 4%, while at 900 MHz this body weight increase was more pronounced (up to 6%) and not transient. At 1800 MHz, no effect on body weight was seen. The results corroborate earlier findings which have shown no effects of RF-EMF on melatonin levels in vivo and in vitro. The data are in accordance with the hypothesis that absorbed RF energy may result in metabolic changes which eventually cause body weight increases in exposed animals. The data support the notion that metabolic effects of RF-EMFs need to be investigated in more detail in future studies.

Kato Y, Johansson O. Reported functional impairments of electrosensitive Japanese: A questionnaire survey. Pathophysiology.19(2) 95-100, 2012.

An increasing number of people worldwide complain that they have become electromagnetic hypersensitive (EHS). We conducted a questionnaire survey of EHS persons in Japan. The aim was to identify electromagnetic fields (EMF) and plausible EMF sources that caused their symptoms. Postal questionnaires were distributed via a self-help group, and 75 participants (95% women) responded. Reported major complaints were "fatigue/tiredness" (85%), "headache", "concentration, memory, and thinking" difficulty (81%, respectively). Seventy-two per cent used some form of complementary/alternative therapy. The most plausible trigger of EHS onset was a mobile phone base station or personal handy-phone system (37%). Sixty-five percent experienced health problems to be due to the radiation from other passengers' mobile

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phones in trains or buses, and 12% reported that they could not use public transportation at all. Fifty-three percent had a job before the onset, but most had lost their work and/or experienced a decrease in income. Moreover, 85.3% had to take measures to protect themselves from EMF, such as moving to low EMF areas, or buying low EMF electric appliances. EHS persons were suffering not only from their symptoms, but also from economical and social problems.

Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med.* 63(5):307-313, 2006.

BACKGROUND: The erection of mobile telephone base stations in inhabited areas has raised concerns about possible health effects caused by emitted microwaves.

METHODS: In a cross-sectional study of randomly selected inhabitants living in urban and rural areas for more than one year near to 10 selected base stations, 365 subjects were investigated. Several cognitive tests were performed, and wellbeing and sleep quality were assessed. Field strength of high-frequency electromagnetic fields (HF-EMF) was measured in the bedrooms of 336 households. RESULTS: Total HF-EMF and exposure related to mobile telecommunication were far below recommended levels (max. 4.1 mW/m²). Distance from antennae was 24-600 m in the rural area and 20-250 m in the urban area. Average power density was slightly higher in the rural area (0.05 mW/m²) than in the urban area (0.02 mW/m²). Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality. CONCLUSION: Despite very low exposure to HF-EMF, effects on wellbeing and performance cannot be ruled out, as shown by recently obtained experimental results; however, mechanisms of action at these low levels are unknown.

Bortkiewicz A, Zmyslony M, Szyjowska A, Gadzicka E. [Subjective symptoms reported by people living in the vicinity of cellular phone base stations: a review of the studies] *Med Pr.* 55(4):345-351, 2004. [Article in Polish]

The problem of health effects of electromagnetic fields (EMF) emitted by cellular phone base stations evokes much interest in view of the fact that people living in their vicinity are fated to continuous exposure to EMF. None of the studies carried out throughout the world have revealed excessive values of standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). A questionnaire was used as a study tool. The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo. The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints

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with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

Bortkiewicz A, Gadzicka E, Szykowska A, Politański P, Mamrot P, Szymczak W, Zmyślony M. Subjective complaints of people living near mobile phone base stations in Poland. *Int J Occup Med Environ Health*. 25(1):31-40, 2012.

OBJECTIVES: The aim of our study was to assess the health conditions and subjective symptoms of the inhabitants living in the base stations vicinity and to analyse the relationship between the complaints and level of exposure to electromagnetic fields (EMF). MATERIALS AND METHODS: Our study was performed in housing estates located in five regions of Łódź. The electric field measurements were performed in the buildings located closest to the azimuth of the antennas. Respondents were selected by trained interviewers using an uniform procedure. The number of the households to be examined was set at a minimum of 420. The questionnaire contained: demographic data, occupational and environmental exposure to EMF, health condition, subjective complaints. Results were adjusted for confounders (age, gender, EMF at the workplace and EMF emitted by household equipment) using multiple regression model. RESULTS: 181 men and 319 women from 500 households were examined. Electric field above 0.8 V/m was recorded in 12% of flats. There was no significant correlation between electric field strength and the distance of examined flats from the base stations. To make possible comparison with relevant literature, we analysed also the frequency of the reported symptoms vs. the distance. Headache was declared by 57% people, most frequently (36.4%) living 100-150 m away from the base station compared to people living at longer distances ($p = 0.013$). 24.4% subjects, mostly living at a distance above 150 m, declared impaired memory. Difference was statistically significant in comparison with people living at other distances ($p = 0.004$). CONCLUSIONS: The explanation why we did not find any correlation between the electric field strength and frequency of subjective symptoms but found a correlation between subjective symptoms and distance from base station needs further studies. Maybe new metrics of exposure assessment should be adopted for this purpose.

Augner C, Florian M, Pauser G, Oberfeld G, Hacker GW. GSM base stations: Short-term effects on well-being. *Bioelectromagnetics*. 30:73-80, 2009.

The purpose of this study was to examine the effects of short-term GSM (Global System for Mobile Communications) cellular phone base station RF-EMF (radiofrequency electromagnetic fields) exposure on psychological symptoms (good mood, alertness, calmness) as measured by a standardized well-being questionnaire. Fifty-seven participants were selected and randomly assigned to one of three different exposure scenarios. Each of those scenarios subjected participants to five 50-min exposure sessions, with only the first four relevant for the study of psychological symptoms. Three exposure levels were created by shielding devices in a field laboratory, which could be installed or removed during the breaks between sessions such that double-blinded conditions prevailed. The overall median power flux densities were 5.2 microW/m(2) during "low," 153.6 microW/m(2) during "medium," and 2126.8 microW/m(2) during

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"high" exposure sessions. For scenario HM and MH, the first and third sessions were "low" exposure. The second session was "high" and the fourth was "medium" in scenario HM; and vice versa for scenario MH. Scenario LL had four successive "low" exposure sessions constituting the reference condition. Participants in scenarios HM and MH (high and medium exposure) were significantly calmer during those sessions than participants in scenario LL (low exposure throughout) ($P = 0.042$). However, no significant differences between exposure scenarios in the "good mood" or "alertness" factors were obtained. We conclude that short-term exposure to GSM base station signals may have an impact on well-being by reducing psychological arousal.

Augner C, Hacker GW. Are people living next to mobile phone base stations more strained? Relationship of health concerns, self-estimated distance to base station, and psychological parameters. *Indian J Occup Environ Med.* 13(3):141-145, 2009.

BACKGROUND AND AIMS: Coeval with the expansion of mobile phone technology and the associated obvious presence of mobile phone base stations, some people living close to these masts reported symptoms they attributed to electromagnetic fields (EMF). Public and scientific discussions arose with regard to whether these symptoms were due to EMF or were nocebo effects. The aim of this study was to find out if people who believe that they live close to base stations show psychological or psychobiological differences that would indicate more strain or stress. Furthermore, we wanted to detect the relevant connections linking self-estimated distance between home and the next mobile phone base station (DBS), daily use of mobile phone (MPU), EMF-health concerns, electromagnetic hypersensitivity, and psychological strain parameters. DESIGN, MATERIALS AND METHODS: Fifty-seven participants completed standardized and non-standardized questionnaires that focused on the relevant parameters. In addition, saliva samples were used as an indication to determine the psychobiological strain by concentration of alpha-amylase, cortisol, immunoglobulin A (IgA), and substance P. RESULTS: Self-declared base station neighbors (DBS $\leq$ 100 meters) had significantly higher concentrations of alpha-amylase in their saliva, higher rates in symptom checklist subscales (SCL) somatization, obsessive-compulsive, anxiety, phobic anxiety, and global strain index PST (Positive Symptom Total). There were no differences in EMF-related health concern scales. CONCLUSIONS: We conclude that self-declared base station neighbors are more strained than others. EMF-related health concerns cannot explain these findings. Further research should identify if actual EMF exposure or other factors are responsible for these results.

Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schuez J, Berg-Beckhoff G. Mobile phone base stations and adverse health effects: Phase 1: A population-based cross-sectional study in Germany. *Occup Environ Med.* 66(2):118-123. 2009.

Abstract OBJECTIVE: The aim of this first phase of a cross-sectional study from Germany was to investigate whether proximity of residence to mobile phone base stations as well as risk perception is associated with health complaints. METHODS: We conducted a population-based multi-phase cross-sectional study within the context of a large panel

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survey regularly carried out by a private research institute in Germany. In the initial phase, which we will report on in this paper, 30,047 persons from a total of 51,444 who took part in the nationwide survey also answered questions on how mobile phone base stations affect their health. A list of 38 health complaints was used. A multiple linear regression model was used to identify predictors of health complaints including proximity of residence to mobile phone base stations and risk perception. RESULTS: Of the 30,047 participants (response rate 58.6%), 18.7% of participants were concerned about adverse health effects of mobile phone base stations, while an additional 10.3% attributed their personal adverse health effects to the exposure from them. Participants who are concerned about or attribute adverse health effects to mobile phone base stations and those living in the vicinity of a mobile phone base station (500 m) reported slightly more health complaints than others. CONCLUSIONS: A substantial proportion of the German population is concerned about adverse health effects caused by exposure from mobile phone base stations. The observed slightly higher prevalence of health complaints near base stations can however not be fully explained by attributions or concerns.

Effects on Sleep

Mohammed HS, Fahmy HM, Radwah NM, Elsayed AA. Non-thermal continuous and modulated electromagnetic radiation fields effects on sleep EEG of rats. J Adv Res 4(2) 181-187, 2013.

In the present study, the alteration in the sleep EEG in rats due to chronic exposure to low-level non-thermal electromagnetic radiation was investigated. Two types of radiation fields were used; 900 MHz unmodulated wave and 900 MHz modulated at 8 and 16 Hz waves. Animals has exposed to radiation fields for 1 month (1 h/day). EEG power spectral analyses of exposed and control animals during slow wave sleep (SWS) and rapid eye movement sleep (REM sleep) revealed that the REM sleep is more susceptible to modulated radiofrequency radiation fields (RFR) than the SWS. The latency of REM sleep increased due to radiation exposure indicating a change in the ultradian rhythm of normal sleep cycles. The cumulative and irreversible effect of radiation exposure was proposed and the interaction of the extremely low frequency radiation with the similar EEG frequencies was suggested.

Liu H, Chen G, Pan Y, Chen Z, Jin W, Sun C, Chen C, Dong X, Chen K, Xu Z, Zhang S, Yu Y. (2014) Occupational Electromagnetic Field Exposures Associated with Sleep Quality: A Cross-Sectional Study. PLoS ONE 9(10): e110825. doi:10.1371/journal.pone.0110825.

BACKGROUND: Exposure to electromagnetic field (EMF) emitted by mobile phone and other machineries concerns half the world's population and raises the problem of their impact on human health. The present study aims to explore the effects of electromagnetic field exposures on sleep quality and sleep duration among workers from electric power plant. METHODS: A cross-sectional study was conducted in an

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electric power plant of Zhejiang Province, China. A total of 854 participants were included in the final analysis. The detailed information of participants was obtained by trained investigators using a structured questionnaire, which including socio-demographic characteristics, lifestyle variables, sleep variables and electromagnetic exposures. Physical examination and venous blood collection were also carried out for every study subject. **RESULTS:** After grouping daily occupational electromagnetic exposure into three categories, subjects with long daily exposure time had a significantly higher risk of poor sleep quality in comparison to those with short daily exposure time. The adjusted odds ratios were 1.68 (95%CI: 1.18, 2.39) and 1.57 (95%CI: 1.10, 2.24) across tertiles. Additionally, among the subjects with long-term occupational exposure, the longer daily occupational time apparently increased the risk of poor sleep quality (OR (95%CI): 2.12 (1.23~3.66) in the second tertile; 1.83 (1.07~3.15) in the third tertile). There was no significant association of long-term occupational exposure duration, monthly electric fee or years of mobile-phone use with sleep quality or sleep duration. **CONCLUSIONS:** The findings showed that daily occupational EMF exposure was positively associated with poor sleep quality. It implies EMF exposure may damage human sleep quality rather than sleep duration.

Hung CS, Anderson C, Horne JA, McEvoy P. Mobile phone 'talk-mode' signal delays EEG-determined sleep onset. *Neurosci Lett.* 421: 82-86, 2007.

Mobile phones signals are pulse-modulated microwaves, and EEG studies suggest that the extremely low-frequency (ELF) pulse modulation has sleep effects. However, 'talk', 'listen' and 'standby' modes differ in the ELF (2, 8, and 217Hz) spectral components and specific absorption rates, but no sleep study has differentiated these modes. We used a GSM900 mobile phone controlled by a base-station simulator and a test SIM card to simulate these three specific modes, transmitted at 12.5% (23dBm) of maximum power. At weekly intervals, 10 healthy young adults, sleep restricted to 6h, were randomly and single-blind exposed to one of: talk, listen, standby and sham (nil signal) modes, for 30min, at 13:30h, whilst lying in a sound-proof, lit bedroom, with a thermally insulated silent phone beside the right ear. Bipolar EEGs were recorded continuously, and subjective ratings of sleepiness obtained every 3min (before, during and after exposure). After exposure the phone and base-station were switched off, the bedroom darkened, and a 90min sleep opportunity followed. We report on sleep onset using: (i) visually scored latency to onset of stage 2 sleep, (ii) EEG power spectral analysis. There was no condition effect for subjective sleepiness. Post-exposure, sleep latency after talk mode was markedly and significantly delayed beyond listen and sham modes. This condition effect over time was also quite evident in 1-4Hz EEG frontal power, which is a frequency range particularly sensitive to sleep onset. It is possible that 2, 8, 217Hz modulation may differentially affect sleep onset.

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Effects on Cells

Neshev NN, Kirilova EI, Environmental-health aspects of pulse-modulated microwaves. Rev Environ Health 11(1-2):85-88, 1996.

Our theoretical model describes the potential influence of irradiation with pulse-modulated microwaves on the conformational oscillations of enzymes in living organisms. Certain values of pulse-repetition time, determined by the period of conformational oscillations of the corresponding type of enzyme, can produce the effect at extremely low power levels. Synchronized oscillations in identical enzyme molecules produce in turn large-scale oscillations within living cells. Thus, short periods of exposure to pulse-modulated microwaves could be beneficial to cellular function, whereas maintaining the amplitude of such oscillations at a maximum for long periods may have a stressful effect on biochemical processes. The model discloses the possible environmental-health risks of long-term exposure in ambient fields that are created by radar, navigation, and communication systems.

Kwee S, Raskmark P, Changes in cell proliferation due to environmental non-ionizing radiation 2. Microwave radiation. Bioelectrochem Bioenerg 44(2) 251-255, 1998.

Due to the use of mobile telephones, there is an increased exposure of the environment to weak radiofrequency (RF) electromagnetic fields, emitted by these devices. This study was undertaken to investigate if the microwave radiation from these fields will have a similar effect on cell proliferation as weak electromagnetic (ELF) fields. The field was generated by signal simulation of the Global System for Mobile communications (GSM) of 960 MHz. Cell cultures, growing in microtiter plates, were exposed in a specially constructed chamber, a Transverse Electromagnetic (TEM) cell. The Specific Absorption Rate (SAR) values for each cell well were calculated for this exposure system. Experiments were performed on cell cultures of transformed human epithelial amnion cells (AMA), which were exposed to 960 MHz microwave fields at three different power levels and three different exposure times, respectively. It was found that cell growth in the exposed cells was decreased in comparison to that in the control and sham exposed cells. Cell proliferation during the period following exposure varied not only with the various SAR levels, but also with the length of exposure time. On the other hand, repeated periods of exposure did not seem to change the effects. There was a general linear correlation between power level and growth change. However, the exposure time required to obtain the maximum effect was not the same for the various power levels. It turned out that at low power level, a maximum effect was first reached after a longer exposure time than at higher power level. A similar phenomenon was registered in the studies on ELF electromagnetic fields. Here, it was found that there was a linear correlation between the length of exposure time to obtain maximum effect and field strength.

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Effects on Eyes

Lu L, Xu H, Wang X, Guo G. Increased nitric oxide synthase activity is essential for electromagnetic-pulse-induced blood-retinal barrier breakdown in vivo. *Brain Res.* 1264:104-10, 2009.

PURPOSE: To examine whether electromagnetic pulses (EMPs) affected the permeability of the **blood-retinal barrier (BRB)**, gene expression of occludin and activity of nitric oxide synthase (NOS). **METHODS:** Sprague-Dawley (SD) rats were used and randomized into EMP and control groups. Retinas were removed immediately, and 2 h or 24 h after EMP radiation. BRB permeability was analyzed by transmission electron microscopy and Evans Blue staining. Retinal NOS activity and concentrations of nitrite and nitrate were measured. Occludin mRNA and protein levels were detected by RT-PCR and Western blotting. **RESULTS:** Exposure of SD rats to EMP resulted in increased BRB permeability, with the greatest decrease in occludin at 24 h. Moreover, this permeability defect was also correlated with significant increases in the formation of NO and induction of NOS activity in SD rats. Furthermore, we found that treatment with NOS inhibitor N-nitro-L-arginine methyl ester (L-NAME) blocked BRB breakdown and prevented the increase in NO formation and induction of NOS activity, as well as the decrease in occluding expression. **CONCLUSION:** Taken together, these results support the view that NOS-dependent NO production is an important factor that contributes to EMP-induced BRB dysfunction, and suggests that NOS induction may play an important role in BRB breakdown.

Hässig M, Jud F, Naegeli H, Kupper J, Spiess B. Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. *Schweiz Arch Tierheilkd.* 151(10):471-478, 2009.

The purpose of this study was to valuate the prevalence of nuclear cataract in veal calves and to elucidate a possible impact by mobile phone base stations (MPBS). For this experiment a cohort study was conducted. A follow-up of the geographical location of each dam and its calf from conception through the fetal period up to slaughter was performed. The first trimester of gestation (organogenesis) was particularly emphasized. The activities of selected protective antioxidants (superoxide dismutase, catalase, glutathione peroxidase [GPx]) were assessed in aqueous humor of the eye to evaluate the redox status. Of 253 calves, 79 (32 %) had various degrees of nuclear cataract, but only 9 (3.6 %) calves had severe nuclear cataract. Results demonstrate a relation between the location of veal calves with nuclear cataracts in the first trimester of gestation and the strength of antennas. The number of antennas within 100 to 199 meters was associated with oxidative stress and there was an association between oxidative stress and the distance to the nearest MPBS. Oxidative stress was increased in eyes with cataract (OR per kilometer: 0.80, confidence interval 95 % 0.62,0.93). It has not been shown that the antennas actually affected stress. Hosmer-Lemeshow statistics showed an accuracy of 100 % in negative cases with low radiation, and only 11.11 % accuracy in positive cases with high radiation. This reflects, that there are a lot of other

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possibilities for nuclear cataract beside MPBS. Further studies on the influence of electromagnetic fields during embryonic development animal or person at risk are indicated.

Hässig M, Jud F, Spiess B. [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd. 154(2):82-86, 2012.[Article in German]

We examined and monitored a dairy farm in which a large number of calves were born with nuclear cataracts after a mobile phone base station had been erected in the vicinity of the barn. Calves showed a 3.5 times higher risk for heavy cataract if born there compared to Swiss average. All usual causes such as infection or poisoning, common in Switzerland, could be excluded. The real cause of the increased incidence of cataracts remains unknown.

Jelodar G, Akbari A, Nazifi S. The prophylactic Effect of Vitamin C on Oxidative Stress Indexes in Rat Eyes Following Exposure to Radiofrequency Wave Generated by a BTS Antenna Model. Int J Radiat Biol. 89(2):128-131, 2013.

Purpose: This study was conducted to evaluate the effect of radiofrequency wave (RFW)-induced oxidative stress in the eye and the prophylactic effect of vitamin C on this organ by measuring the antioxidant enzymes activity including: glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase (CAT), and malondialdehyde (MDA). Materials and methods: Thirty-two adult male Sprague-Dawley rats were randomly divided into four experimental groups and treated daily for 45 days as follows: control, vitamin C (L-ascorbic acid 200 mg/kg of body weight/day by gavage), test (exposed to 900 MHz RFW) and the treated group (received vitamin C in addition to exposure to RFW). At the end of the experiment all animals were killed, their eyes were removed and were used for measurement of antioxidant enzymes and MDA activity. Results: The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased MDA compared with the control groups (P<0.05). In the treated group vitamin C improved antioxidant enzymes activity and reduced MDA compared to the test group (P<0.05). Conclusions: It can be concluded that RFW causes oxidative stress in the eyes and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Oxidative Stress

Achudume A, Onibere B, Aina F, Tchokossa P. Induction of oxidative stress in male rats subchronically exposed to electromagnetic fields at non-thermal intensities. J Electromagnetic Analysis and Applications 2(8), 482-487, 2010.

To investigate the oxidative stress-inducing potential of non-thermal electromagnetic fields in rats. Male Wister rats were exposed to electrical field intensity of $2.3 \pm 0.82 \mu\text{V/m}$. Exposure was in three forms: continuous waves, or modulated at 900 MHz or modulated GSM-nonDTX. The radio frequency radiation (RFR) was 1800 MHz, specific

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absorption radiation (SAR) (0.95-3.9 W/kg) for 40 and/or 60 days continuously. Control animals were located > 300 m from base station, while sham control animals were located in a similar environmental conditions, but in the vicinity of a non-functional base station. The rats were assessed for thiobarbituric and reactive species (TBARS), reduced glutathione (GSH) content, catalase activity, glutathione reductase (GR) and glucose residue after 40 and 60 days of exposure. At 40 days, electromagnetic radiation failed to induce any significant alterations. However, at 60 days of exposure various attributes evaluated decreased. The respective decreases in both nicotinamide adenine dinucleotide phosphate (NADPH) and Ascorbate- linked lipid peroxidation (LPO) with concomitant diminution in enzymatic antioxidative defense systems resulted in decreased glucose residue. The present studies showed some biochemical changes that may be associated with a prolong exposure to electromagnetic fields and its relationship to the activity of antioxidant system in rat Regular assessment and early detection of antioxidative defense system among people working around the base stations are recommended.

Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J, Pauser G. Effects of Exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and Immunoglobulin A. *Biomed Environ Sci.* 23(3):199-207, 2010.

OBJECTIVE: The present study aimed to test whether exposure to radiofrequency electromagnetic fields (RF-EMF) emitted by mobile phone base stations may have effects on salivary alpha-amylase, immunoglobulin A (IgA), and cortisol levels. METHODS: Fifty seven participants were randomly allocated to one of three different experimental scenarios (22 participants to scenario 1, 26 to scenario 2, and 9 to scenario 3). Each participant went through five 50-minute exposure sessions. The main RF-EMF source was a GSM-900-MHz antenna located at the outer wall of the building. In scenarios 1 and 2, the first, third, and fifth sessions were "low" (median power flux density 5.2 $\mu\text{W}/\text{m}^2$) exposure. The second session was "high" (2126.8 $\mu\text{W}/\text{m}^2$), and the fourth session was "medium" (153.6 $\mu\text{W}/\text{m}^2$) in scenario 1, and vice versa in scenario 2. Scenario 3 had four "low" exposure conditions, followed by a "high" exposure condition. Biomedical parameters were collected by saliva samples three times a session. Exposure levels were created by shielding curtains. RESULTS: In scenario 3 from session 4 to session 5 (from "low" to "high" exposure), an increase of cortisol was detected, while in scenarios 1 and 2, a higher concentration of alpha-amylase related to the baseline was identified as compared to that in scenario 3. IgA concentration was not significantly related to the exposure. CONCLUSIONS: RF-EMF in considerably lower field densities than ICNIRP-guidelines may influence certain psychobiological stress markers.

Marzook EA, Abd El Moneim AE, Elhadary AA. Prootective role of seame oil against mobile phone base station-induced oxidative stress. *J Rad Res Appl Sci* 7(1):1-6, 2014.

The present study was undertaken to shed the light on the environmental threats associated with the wireless revolution and the health hazards associated with exposure to mobile base station (MBS). Besides, studying the possible protective role of sesame oil (SO) as an antioxidant against oxidative stress. Therefore, the present work was

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designed to study the effect of chronic exposure to electromagnetic radiations (EMR), produced by a cellular tower for mobile phone and the possible protective role of sesame oil on glutathione reductase (GSH-Rx), superoxide dismutase (SOD), catalase (CAT), total testosterone and lipid profile (total cholesterol (Tch), triglycerides (TG), low density lipoprotein cholesterol (LDL-c) and high density lipoprotein cholesterol (HDL-c) in male albino rats. Rats were arranged into four groups: the control unexposed, the exposed untreated and the exposed treated groups (1.5 and 3 ml oil). Exposed groups were subjected to electromagnetic field at frequency of 900 MHz, for 24 h/day for 8 weeks, at the same time both treated groups were supplied with oral injection of sesame oil three times per week. At the end of the experiment, blood samples were obtained for determination of the above mentioned variables in serum. The results obtained revealed that TG and testosterone were raised significantly over control in all groups and the significant increase in oil groups occurred in dose dependent manner. SOD and CAT activities were reduced significantly in exposed rats than control and increased significantly in sesame oil groups as the dose of oil increased. Total cholesterol only showed remarkable reduction in the group treated with 3 ml sesame oil. Also, in this latter group, significant elevation of GSH-Rx was recorded. Changes in serum HDL-c and LDL-c followed an opposite trend in exposed and sesame oil groups reflecting their affectation by EMR or sesame oil. In conclusion, all results of the current study proved that sesame oil can be used as an edible oil to attenuate the oxidative stress which could be yielded as a result of chronic exposure to EMR.

Effects on Blood

Kismali G, Ozgur E, Guler G, Akcay A, Sel T, Seyhan N. The influence of 1800 MHz GSM-like signals on blood chemistry and oxidative stress in non-pregnant and pregnant rabbits. Int J Radiat Biol. 88(5):414-419, 2012.

PURPOSE: Environmental electromagnetic fields originate from man-made sources, such as mobile phones and base stations, and have led to increasing public concern about their possible adverse health effects. We aimed to investigate the possible effects of radiofrequency radiation (RFR) generated from these devices on oversensitive animals, such as pregnant rabbits. **MATERIALS AND METHODS:** In the present study, the effects of whole body 1800 MHz Global System for Mobile Communications (GSM)-like RFR exposure for 15 min/day for seven days on blood chemistry and lipid peroxidation levels in both non-pregnant and pregnant New Zealand White rabbits were investigated. Thirteen-month-old rabbits were studied in the following four groups: Non-pregnant control, non-pregnant RFR-exposed, pregnant control and pregnant RFR-exposed. **RESULTS:** Lipid peroxidation, namely malondialdehyde (MDA) levels, did not change after RFR exposure. However, blood chemistry parameters, such as cholesterol (CHO), total protein (TP), albumin (ALB), uric acid, creatinin and **creatine kinase (CK)** and **creatine kinase-myocardial band isoenzyme (CK-MB)** changed due to both pregnancy and RFR exposure. **CONCLUSION:** Our investigations have been shown that no indication for oxidative stress was detected in the blood of pregnant rabbits upon RF exposure at specific conditions employed in the present study. Minor

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changes in some blood chemistry parameters were detected but CK-MB and CK increases were found remarkable. Studies on RFR exposure during pregnancy will help establish international standards for the protection of pregnant women from environmental RFR.

Yurekli AI, Ozkan M, Kalkan T, Saybasili H, Tuncel H, Atukeren P, Gumustas K, Seker S. GSM Base Station Electromagnetic Radiation and Oxidative Stress in Rats. *Electromagn Biol Med.* 2006;25(3):177-188, 2006.

The ever increasing use of cellular phones and the increasing number of associated base stations are becoming a widespread source of nonionizing electromagnetic radiation. Some biological effects are likely to occur even at low-level EM fields. In this study, a gigahertz transverse electromagnetic (GTEM) cell was used as an exposure environment for plane wave conditions of far-field free space EM field propagation at the GSM base transceiver station (BTS) frequency of 945 MHz, and effects on oxidative stress in rats were investigated. When EM fields at a power density of 3.67 W/m² (specific absorption rate = 11.3 mW/kg), which is well below current exposure limits, were applied, MDA (malondialdehyde) level was found to increase and GSH (reduced glutathione) concentration was found to decrease significantly (p < 0.0001). Additionally, there was a less significant (p = 0.0190) increase in SOD (superoxide dismutase) activity under EM exposure.

Jin YB, Lee HJ, Seon Lee J, Pack JK, Kim N, Lee YS. One-year, simultaneous combined exposure of CDMA and WCDMA radiofrequency electromagnetic fields to rats. *Int J Radiat Biol.* 87(4):416-423, 2011.

PURPOSE: We investigated whether one-year, long-term, simultaneous exposure to code division multiple access (CDMA; 849 MHz) and wideband code division multiple access (WCDMA; 1.95 GHz) radiofrequencies (RF) would induce chronic illness in Sprague-Dawley (SD) rats. **MATERIALS AND METHODS:** Two groups of 40 SD rats (50% males and females in sham and exposed groups) were exposed to CDMA and WCDMA RF simultaneously at 2.0 W/kg for 45 min/day (total 4.0 W/kg), 5 days per week for a total of one year. Body and organ weight measurements, urinalysis, haematological and blood biochemical analysis, and histopathological evaluations were performed.

RESULTS: The mortality patterns in male and female rats exposed to RF were compared with those found in gender-matched sham control animals. No significant alteration in body weight was observed with the simultaneous combined RF exposure. Most RF-exposed rats showed no significant alteration, based on urinalysis, haematology, blood biochemistry, or histopathology. However, some altered parameters of the complete blood count and serum chemistry were seen in RF-exposed rats. The total tumour incidence was not different between sham-exposed and RF-exposed animals.

CONCLUSIONS: Our results suggest that one-year chronic exposure to CDMA (849 MHz) and WCDMA (1.95 GHz) RF simultaneously at 2.0 W/kg for 45-min RF exposure periods (total, 4 W/kg) did not increase chronic illness in rats, although there were some altered parameters in the complete blood count and serum chemistry.

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Death

Dode AC, Leão MM, Tejo Fde A, Gomes AC, Dode DC, Dode MC, Moreira CW, Condessa VA, Albinatti C, Caiaffa WT. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. Sci Total Environ. 409(19):3649-3665, 2011.

Pollution caused by the electromagnetic fields (EMFs) of radio frequencies (RF) generated by the telecommunication system is one of the greatest environmental problems of the twentieth century. The purpose of this research was to verify the existence of a spatial correlation between **base station (BS)** clusters and cases of deaths by neoplasia in the Belo Horizonte municipality, Minas Gerais state, Brazil, from 1996 to 2006 and to measure the human exposure levels to EMF where there is a major concentration of cellular telephone transmitter antennas. A descriptive spatial analysis of the BSs and the cases of death by neoplasia identified in the municipality was performed through an ecological-epidemiological approach, using georeferencing. The database employed in the survey was composed of three data banks: 1. death by neoplasia documented by the Health Municipal Department; 2. BSs documented in ANATEL ("Agência Nacional de Telecomunicações": 'Telecommunications National Agency'); and 3. census and demographic city population data obtained from official archives provided by IBGE ("Instituto Brasileiro de Geografia e Estatística": 'Brazilian Institute of Geography and Statistics'). The results show that approximately 856 BSs were installed through December 2006. Most (39.60%) of the BSs were located in the "Centro-Sul" ('Central-Southern') region of the municipality. Between 1996 and 2006, 7191 deaths by neoplasia occurred and within an area of 500 m from the BS, the mortality rate was 34.76 per 10,000 inhabitants. Outside of this area, a decrease in the number of deaths by neoplasia occurred. The greatest accumulated incidence was 5.83 per 1000 in the Central-Southern region and the lowest incidence was 2.05 per 1000 in the Barreiro region. During the environmental monitoring, the largest accumulated electric field measured was 12.4 V/m and the smallest was 0.4 V/m. The largest density power was 40.78 $\mu\text{W}/\text{cm}^2$, and the smallest was 0.04 $\mu\text{W}/\text{cm}^2$.

Adang D, Remacle C, Vorst AV Results of a long-term low-level microwave exposure of rats. IEEE Trans Microwave Theor Tech 57: 2488-2497, 2009.

This paper summarizes the results of experimental research on biological effects induced by electromagnetic exposure to low-level microwaves. We exposed four-month-old Wistar albino rats during 21 months to two different microwave frequencies and exposure modes, 2 h a day, seven days a week. In order to assess possible biological effects of microwaves, we selected among others the following parameters: leucocytes, erythrocytes, monocytes, neutrophils, lymphocytes, hemoglobin, mean corpuscular hemoglobin concentration, and mortality rate. After three and eight months of exposure, we found a statistically significant difference of about 20% between the 970-MHz continuous wave group and sham-exposed group regarding the monocytes in both considered periods. After 14 and 18 months of exposure, we observed a significant

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increase in white blood cells and neutrophils of about 15% and 25%, respectively. Lymphocytes fell down after 18 months of exposure with about 15% compared to the sham-exposed group. No other statistically significant differences were found, except for minor changes with little biological significance. The most obvious effect we detected is the increase in mortality rate of the exposed groups with respect to the sham-exposed group after 21 months of exposure at the age of 25 months. This increase even increases when observing rats until the age of 28 months: mortality in exposed groups then reaches almost twice the value observed in the sham-exposed group.

Effects on Hormones

Eskander EF, Estefan SF, Abd-Rabou AA. How does long term exposure to base stations and mobile phones affect human hormone profiles? Clin Biochem. 45(1-2):157-161, 2012

OBJECTIVES: This study is concerned with assessing the role of exposure to radio frequency radiation (RFR) emitted either from mobiles or base stations and its relations with human's hormone profiles. **DESIGN AND METHODS:** All volunteers' samples were collected for hormonal analysis. **RESULTS:** This study showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels. **CONCLUSION:** The present study revealed that high RFR effects on pituitary-adrenal axis.

Eşmekaya MA, Seyhan N, Omeroğlu S. Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: A light, electron microscopy and immunohistochemical study. Int J Radiat Biol. 86(12):1106-1116, 2010.

Purpose: In the present study we investigated the possible histopathological effects of pulse modulated Radiofrequency (RF) fields on the thyroid gland using light microscopy, electron microscopy and immunohistochemical methods. Materials and methods: Two months old male Wistar rats were exposed to a 900 MHz pulse-modulated RF radiation at a specific absorption rate (SAR) of 1.35 Watt/kg for 20 min/day for three weeks. The RF signals were pulse modulated by rectangular pulses with a repetition frequency of 217 Hz and a duty cycle of 1:8 (pulse width 0.576 ms). To assess thyroid endocrine disruption and estimate the degree of the pathology of the gland, we analysed structural alterations in follicular and colloidal diameters and areas, colloid content of the follicles, and height of the follicular epithelium. Apoptosis was confirmed by Transmission Electron Microscopy and assessing the activities of an initiator (caspase-9) and an effector (caspase-3) caspases that are important markers of cells undergoing apoptosis. Results: Morphological analyses revealed hypothyrophy of the gland in the 900 MHz RF exposure group. The results indicated that thyroid hormone secretion was inhibited by the RF radiation. In addition, we also observed formation of apoptotic bodies and increased caspase-3 and caspase-9 activities in thyroid cells of the rats that were exposed to modulated RF fields. Conclusion: The overall findings indicated that whole body exposure to pulse-modulated RF radiation that is similar to that emitted by

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global system for mobile communications (GSM) mobile phones can cause pathological changes in the thyroid gland by altering the gland structure and enhancing caspase-dependent pathways of apoptosis.

Genetic Effects

Gandhi G, Kaur G, Nisar U. A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. Electromagn Biol Med. 2014 Jul 9:1-11. [Epub ahead of print]

Mobile phone base stations facilitate good communication, but the continuously emitting radiations from these stations have raised health concerns. Hence in this study, genetic damage using the single cell gel electrophoresis (comet) assay was assessed in peripheral blood leukocytes of individuals residing in the vicinity of a mobile phone base station and comparing it to that in healthy controls. The power density in the area within 300 m from the base station exceeded the permissive limits and was significantly ($p = 0.000$) higher compared to the area from where control samples were collected. The study participants comprised 63 persons with residences near a mobile phone tower, and 28 healthy controls matched for gender, age, alcohol drinking and occupational sub-groups. Genetic damage parameters of DNA migration length, damage frequency (DF) and damage index were significantly ($p = 0.000$) elevated in the sample group compared to respective values in healthy controls. The female residents ($n = 25$) of the sample group had significantly ($p = 0.004$) elevated DF than the male residents ($n = 38$). The linear regression analysis further revealed daily mobile phone usage, location of residence and power density as significant predictors of genetic damage. 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.

Fucic A, Garaj-Vrhovac V, Skara M, Dimitrovic B, X-rays, microwaves and vinyl chloride monomer: their clastogenic and aneugenic activity, using the micronucleus assay on human lymphocytes. Mutat Res 282(4):265-271, 1992.

Chromosome aberration assays, sister-chromatid exchange techniques and micronucleus assays are commonly used methods for biomonitoring genetic material damaged by chemical or physical agents. On the other hand, their aneugenic activity, which can lead to hypoploidy and may also be associated with carcinogenesis, has not been thoroughly investigated. In our study we chose the micronucleus assay with a new mathematical approach to separate clastogenic from aneugenic activity of three well-known mutagens (vinyl chloride monomer, X-rays and microwaves) on the genome of human somatic cells. The comparison of frequencies of size distribution of micronuclei in the lymphocytes of humans exposed to each of these three mutagens showed that X-rays and microwaves were preferentially clastogens while vinyl chloride monomer showed aneugenic activity as well. Microwaves possess some mutagenic characteristics typical of chemical mutagens.

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Esmekaya MA, Aytekin E, Ozgur E, Güler G, Ergun MA, Omeroğlu S, Seyhan N. Mutagenic and morphologic impacts of 1.8GHz radiofrequency radiation on human peripheral blood lymphocytes (hPBLs) and possible protective role of pre-treatment with Ginkgo biloba (EGb 761). Sci Total Environ. 410-411:59-64, 2011.

The mutagenic and morphologic effects of 1.8GHz Global System for Mobile Communications (GSM) modulated RF (radiofrequency) radiation alone and in combination with Ginkgo biloba (EGb 761) pre-treatment in human peripheral blood lymphocytes (hPBLs) were investigated in this study using Sister Chromatid Exchange (SCE) and electron microscopy. Cell viability was assessed with 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) reduction assay. The lymphocyte cultures were exposed to GSM modulated RF radiation at 1.8GHz for 6, 8, 24 and 48h with and without EGb 761. We observed morphological changes in pulse-modulated RF radiated lymphocytes. Longer exposure periods led to destruction of organelle and nucleus structures. Chromatin change and the loss of mitochondrial crista occurred in cells exposed to RF for 8h and 24h and were more pronounced in cells exposed for 48h. Cytoplasmic lysis and destruction of membrane integrity of cells and nuclei were also seen in 48h RF exposed cells. There was a significant increase ($p < 0.05$) in SCE frequency in RF exposed lymphocytes compared to sham controls. EGb 761 pre-treatment significantly decreased SCE from RF radiation. RF radiation also inhibited cell viability in a time dependent manner. The inhibitory effects of RF radiation on the growth of lymphocytes were marked in longer exposure periods. EGb 761 pre-treatment significantly increased cell viability in RF+EGb 761 treated groups at 8 and 24h when compared to RF exposed groups alone. The results of our study showed that RF radiation affects cell morphology, increases SCE and inhibits cell proliferation. However, EGb 761 has a protective role against RF induced mutagenity. We concluded that RF radiation induces chromosomal damage in hPBLs but this damage may be reduced by EGb 761 pre-treatment.

Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M. In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol. 23(3):319-327, 2008.

Recently we demonstrated that 835-MHz radiofrequency radiation electromagnetic fields (RF-EMF) neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro. Here, two kinds of cytogenetic endpoints were further investigated on mammalian cells exposed to 835-MHz RF-EMF (the most widely used communication frequency band in Korean CDMA mobile phone networks) alone and in combination with model clastogens: in vitro alkaline comet assay and in vitro chromosome aberration (CA) test. No direct cytogenetic effect of 835-MHz RF-EMF was found in the in vitro CA test. The combined exposure of the cells to RF-EMF in the presence of ethylmethanesulfonate (EMS) revealed a weak and insignificant cytogenetic effect when compared to cells exposed to EMS alone in CA test. Also, the comet assay results to evaluate the ability of RF-EMF alone to damage DNA were nearly negative, although showing a small increase in tail moment. However, the applied RF-EMF had potentiation

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effect in comet assay when administered in combination with model clastogens (cyclophosphamide or 4-nitroquinoline 1-oxide). Thus, our results imply that we cannot confidently exclude any possibility of an increased risk of genetic damage, with important implications for the possible health effects of exposure to 835-MHz electromagnetic fields.

Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J. 19(12):1686-1688, 2005.

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and posttranslational level.

Maes A, Collier M, Slaets D, Verschaeve L, 954 MHz microwaves enhance the mutagenic properties of mitomycin C. Environ Mol Mutagen 28(1):26-30, 1996.

This paper focuses on the combined effects of microwaves from mobile communication frequencies and a chemical DNA damaging agent mitomycin C (MMC). The investigation was performed in vitro by exposing whole blood samples to a 954 MHz emitting antenna from a GSM (Global System for Mobile Communication) base station, followed by lymphocyte cultivation in the presence of MMC. A highly reproducible synergistic effect was observed as based on the frequencies of sister chromatid exchanges in metaphase figures.

Fritze K, Wiessner C, Kuster N, Sommer C, Gass P, Hermann DM, Kiessling M, Hossmann KA, Effect of global system for mobile communication microwave exposure on the genomic response of the rat brain. Neuroscience 81(3):627-639, 1997.

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The acute effect of global system for mobile communication (GSM) microwave exposure on the genomic response of the central nervous system was studied in rats by measuring changes in the messenger RNAs of hsp70, the transcription factor genes c-fos and c-jun and the glial structural gene GFAP using in situ hybridization histochemistry. Protein products of transcription factors, stress proteins and marker proteins of astroglial and microglial activation were assessed by immunocytochemistry. Cell proliferation was evaluated by bromodeoxyuridine incorporation. A special GSM radiofrequency test set, connected to a commercial cellular phone operating in the discontinuous transmission mode, was used to simulate GSM exposure. The study was conducted at time averaged and brain averaged specific absorption rates of 0.3 W/kg (GSM exposure), 1.5 W/kg (GSM exposure) and 7.5 W/kg (continuous wave exposure), respectively. Immediately after exposure, in situ hybridization revealed slight induction of hsp70 messenger RNA in the cerebellum and hippocampus after 7.5 W/kg exposure, but not at lower intensities. A slightly increased expression of c-fos messenger RNA was observed in the cerebellum, neocortex and piriform cortex of all groups subjected to immobilization, but no differences were found amongst different exposure conditions. C-jun and GFAP messenger RNAs did not increase in any of the experimental groups. 24 h after exposure, immunocytochemical analysis of FOS and JUN proteins (c-FOS, FOS B, c-JUN JUN B, JUN D), of HSP70 or of KROX-20 and -24 did not reveal any alterations. Seven days after exposure, neither increased cell proliferation nor altered expression of astroglial and microglial marker proteins were observed. In conclusion, acute high intensity microwave exposure of immobilized rats may induce some minor stress response but does not result in lasting adaptive or reactive changes of the brain.

Baohong Wang, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D. Studying the synergistic damage effects induced by 1.8GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay in vitro. *Mutat Res.* 578(1-2):149-157, 2005.

The aim of this investigation was to study the synergistic DNA damage effects in human lymphocytes induced by 1.8GHz radiofrequency field radiation (RFR, SAR of 3W/kg) with four chemical mutagens, i.e. mitomycin C (MMC, DNA crosslinker), bleomycin (BLM, radiomimetic agent), methyl methanesulfonate (MMS, alkylating agent), and 4-nitroquinoline-1-oxide (4NQO, UV-mimetic agent). The DNA damage of lymphocytes exposed to RFR and/or with chemical mutagens was detected at two incubation time (0 or 21h) after treatment with comet assay in vitro. Three combinative exposure ways were used. Cells were exposed to RFR and chemical mutagens for 2 and 3h, respectively. Tail length (TL) and tail moment (TM) were utilized as DNA damage indexes. The results showed no difference of DNA damage indexes between RFR group and control group at 0 and 21h incubation after exposure ($P>0.05$). There were significant difference of DNA damage indexes between MMC group and RFR+MMC co-exposure group at 0 and 21h incubation after treatment ($P<0.01$). Also the significant difference of DNA damage indexes between 4NQO group and RFR+4NQO co-exposure group at 0 and 21h incubation after treatment was observed ($P<0.05$ or $P<0.01$). The DNA damage in RFR+BLM co-exposure groups and RFR+MMS co-exposure groups was not significantly

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increased, as compared with corresponding BLM and MMS groups ($P > 0.05$). The experimental results indicated 1.8GHz RFR (SAR, 3W/kg) for 2h did not induce the human lymphocyte DNA damage effects in vitro, but could enhance the human lymphocyte DNA damage effects induced by MMC and 4NQO. The synergistic DNA damage effects of 1.8GHz RFR with BLM or MMS were not obvious.

Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H. Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8GHz microwaves using comet assay in vitro. *Toxicology*. 232(3):311-316, 2007.

The objective of this study was to observe whether 1.8GHz microwaves (MW) (SAR, 3 W/kg) exposure can influence human lymphocyte DNA damage induced by ultraviolet ray C (UVC). The lymphocytes, which were from three young healthy donors, were exposed to 254 nm UVC at the doses of 0.25, 0.5, 0.75, 1.0, 1.5 and 2.0 J m⁻², respectively. The lymphocytes were irradiated by 1.8GHz MW (SAR, 3 W/kg) for 0, 1.5 and 4 h. The combinative exposure of UVC plus MW was conducted. The treated cells were incubated for 0, 1.5 and 4 h. Finally, comet assay was used to measure DNA damage of above treated lymphocytes. The results indicated that the difference of DNA damage induced between MW group and control group was not significant ($P > 0.05$). The MTLs induced by UVC were 1.71 $\pm$ 0.09, 2.02 $\pm$ 0.08, 2.27 $\pm$ 0.17, 2.27 $\pm$ 0.06, 2.25 $\pm$ 0.12, 2.24 $\pm$ 0.11 microm, respectively, which were significantly higher than that (0.96 $\pm$ 0.05 microm) of control ($P < 0.01$). MTLs of some sub-groups in combinative exposure groups at 1.5-h incubation were significantly lower than those of corresponding UVC sub-groups ($P < 0.01$ or $P < 0.05$). However, MTLs of some sub-groups in combinative exposure groups at 4-h incubation were significantly higher than those of corresponding UVC sub-groups ($P < 0.01$ or $P < 0.05$). In this experiment it was found that 1.8GHz (SAR, 3 W/kg) MW exposure for 1.5 and 4 h did not enhance significantly human lymphocyte DNA damage, but could reduce and increase DNA damage of human lymphocytes induced by UVC at 1.5-h and 4-h incubation, respectively.

Canseven AG, Esmekaya MA, Kayhan H, Tuysuz MZ, Seyhan N. Effects of microwave exposure and Gemcitabine treatment on apoptotic activity in Burkitt's lymphoma (Raji) cells. *Electromagn Biol Med*. 2014 Jun 5:1-5. [Epub ahead of print]

We investigated the effects of 1.8 MHz Global System for Mobile Communications (GSM)-modulated microwave (MW) radiation on apoptotic level and cell viability of Burkitt's lymphoma (Raji) cells with or without Gemcitabine, which exhibits cell phase specificity, primarily killing cells undergoing DNA synthesis (S-phase). Raji cells were exposed to 1.8 GHz GSM-modulated MW radiation at a specific absorption rate (SAR) of 0.350 W/kg in a CO₂ incubator. The duration of the exposure was 24 h. The amount of apoptotic cells was analyzed using Annexin V-FITC and propidium iodide (PI) staining with flow cytometer. The apoptotic activity of MW exposed Raji cells was increased significantly. In addition, cell viability of exposed samples was significantly decreased. Combined exposure of MW and Gemcitabine increased the amount of apoptotic cells than MW radiation alone. Moreover, viability of MW + Gemcitabine exposed cells was lower than that of cells exposed only to MW. These results demonstrated that MW

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radiation exposure and Gemcitabine treatment have a synergistic effect on apoptotic activity of Raji cells.

Effects on Glands

Aydogan F, Unlu I, Aydin E, Yumusak N, Devrim E, Samim EE, Ozgur E, Unsal V, Tomruk A, Ozturk GG, Seyhan N. The effect of 2100 MHz radiofrequency radiation of a 3G mobile phone on the parotid gland of rats. Am J Otolaryngol. 2014 Oct 5. pii: S0196-0709(14)00207-5. doi: 10.1016/j.amjoto.2014.10.001. [Epub ahead of print]

PURPOSE: We aimed to evaluate the effect of 2100 MHz radiofrequency radiation on the parotid gland of rats in short and relatively long terms. **MATERIAL AND METHODS:** Thirty Wistar albino rats were divided into four groups. Groups A and B served as the control groups (for 10 days and 40 days, respectively), and each group included six rats. Groups C and D were composed of nine rats each, and they were the exposure groups. The rats were exposed to 2100 MHz radiofrequency radiation emitted by a generator, simulating a third generation mobile phone for 6 hours/day, 5 days/week, for 10 or 40 days. Following exposure, the rats were sacrificed and parotid glands were removed. Histopathological and biochemical examinations were performed. **RESULTS:** Although there were no histopathological changes in the control groups except for two animals in group A and three animals in group B, the exposure groups C (10 days) and D (40 days) showed numerous histopathological changes regarding salivary gland damage including acinar epithelial cells, interstitial space, ductal system, vascular system, nucleus, amount of cytoplasm and variations in cell size. The histopathological changes were more prominent in group D compared to group C. There was statistically significant different parameter regarding variation in cell size between the groups B and D ($p=0.036$). **CONCLUSION:** The parotid gland of rats showed numerous histopathological changes after exposure to 2100 MHz radiofrequency radiation, both in the short and relatively long terms. Increased exposure duration led to an increase in the histopathological changes.

Effects on Animals and Environment

Panagopoulos DJ, Chavdoula ED, Margaritis LH. Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna. Int J Radiat Biol. 86(5):345-357, 2010.

PURPOSE: To examine the bioactivity of GSM 900 and 1800 (Global System for Mobile Telecommunications) radiations, in relation to the distance from the antenna or to the radiation-field intensities. **MATERIALS AND METHODS:** *Drosophila melanogaster* adult insects were exposed to the radiation of a GSM 900/1800 mobile phone antenna at different distances ranging from 0 to 100 cm, and the effect on their reproductive capacity and cell death induction in the gonads by the use of TUNEL (Terminal

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deoxynucleotide transferase dUTP Nick End Labeling) assay, was studied. RESULTS: These radiations/fields decreased the reproductive capacity by cell death induction, at all the different distances tested. The effect diminished with the distance/decreasing intensities. An increased bioactivity 'window' was revealed at distances of 20-30 cm from the mobile phone antenna, (radiation intensity around 10 microW/cm(2)) where the effect became highest, in relation to smaller or longer distances. The effect diminished considerably for distances longer than 40-50 cm and became not evident for distances longer than 1 m or radiation intensities smaller than 1 microW/cm(2). CONCLUSIONS: GSM bioactivity is highest for intensities down to less than 10 microW/cm(2) and still evident until 1 microW/cm(2) exhibiting 'window' effects

Loscher W, Kas G, Extraordinary behavior disorders in cows in proximity to transmission stations. Der Praktische Tierarz 79:437-444, 1998. (Article in German) In addition to reduction of milk yield and increased health problems, behavioral abnormalities were observed over a period of two years in a herd of dairy cows maintained in close proximity to a TV and cell phone transmitting antenna. Evaluation of possible factors which could explain the abnormalities in the live stock did not disclose any factors other than the high-frequency electromagnetic fields. An experiment in which a cow with abnormal behavior was brought to a stable 20 km away from the antenna resulted in a complete normalization of the cow within five days, whereas symptoms returned when the cow was brought back to the stable nearby the antenna. In view of the previous described effects of electromagnetic fields, it might be possible that the observed abnormalities in cows are related to electromagnetic field exposure. (power densities measured 0.02-7 mW/m2).

Koldayev VM, Shchepin YV, Effects of electromagnetic radiation on embryos of sea-urchins. Bioelectrochem Bioenerg 43:161-164, 1997. Electromagnetic radiation (EMR) causes a decrease in the number of fertilized eggs and an increase in the number of zygotes with abnormal fertilization envelopes in sea-urchins. The microstructural impairments of the cellular surface, the increase of lipid peroxidation and the changes of amino acid metabolism show that the impairments of the development of embryos exposed to EMR are caused by the damages of the membrane structures.

Cammaerts MC, De Doncker P, Patris X, Bellens F, Rachidi Z, Cammaerts D. GSM 900 MHz radiation inhibits ants' association between food sites and encountered cues. Electromagn Biol Med. 31(2):151-165, 2012.

The kinetics of the acquisition and loss of the use of olfactory and visual cues were previously obtained in six experimental colonies of the ant *Myrmica sabuleti* meinert 1861, under normal conditions. In the present work, the same experiments were conducted on six other naive identical colonies of *M. sabuleti*, under electromagnetic radiation similar to those surrounding GSM and communication masts. In this situation, no association between food and either olfactory or visual cues occurred. After a recovery period, the ants were able to make such an association but never reached the

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expected score. Such ants having acquired a weaker olfactory or visual score and still undergoing olfactory or visual training were again submitted to electromagnetic waves. Not only did they lose all that they had memorized, but also they lost it in a few hours instead of in a few days (as under normal conditions when no longer trained). They kept no visual memory at all (instead of keeping 10% of it as they normally do). The impact of GSM 900 MHz radiation was greater on the visual memory than on the olfactory one. These communication waves may have such a disastrous impact on a wide range of insects using olfactory and/or visual memory, i.e., on bees.

Senavirathna MD, Asaeda T, Thilakarathne BL, Kadono H. Nanometer-scale elongation rate fluctuations in the *Myriophyllum aquaticum* (Parrot feather) stem were altered by radio-frequency electromagnetic radiation. *Plant Signal Behav.* 2014 Mar 26;9(3). pii: e28590. [Epub ahead of print]

The emission of radio-frequency electromagnetic radiation (EMR) by various wireless communication base stations has increased in recent years. While there is wide concern about the effects of EMR on humans and animals, the influence of EMR on plants is not well understood. In this study, we investigated the effect of EMR on the growth dynamics of *Myriophyllum aquaticum* (Parrot feather) by measuring the nanometric elongation rate fluctuation (NERF) using a statistical interferometry technique. Plants were exposed to 2 GHz EMR at a maximum of 1.42 Wm⁻² for 1 h. After continuous exposure to EMR, *M. aquaticum* plants exhibited a statistically significant 51 ± 16% reduction in NERF standard deviation. Temperature observations revealed that EMR exposure did not cause dielectric heating of the plants. Therefore, the reduced NERF was due to a non-thermal effect caused by EMR exposure. The alteration in NERF continued for at least 2.5 h after EMR exposure and no significant recovery was found in post-EMR NERF during the experimental period.

Balmori A. Mobile Phone Mast Effects on Common Frog (*Rana temporaria*) Tadpoles: The City Turned into a Laboratory. *Electromagn Biol Med.* 29(1-2):31-35, 2010.

An experiment has been made exposing eggs and tadpoles of the common frog (*Rana temporaria*) to electromagnetic radiation from several mobile (cell) phone antennae located at a distance of 140 meters. The experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. Measurements of electric field intensity (radiofrequencies and microwaves) in V/m obtained with three different devices were 1.8 to 3.5 V/m. In the exposed group (n = 70), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Regarding the control group (n = 70) under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. These results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.

Studies that show **Cell Tower** Health Effects

Balode, Z, Assessment of radio-frequency electromagnetic radiation by the micronucleus test in bovine peripheral erythrocytes. Sci Total Environ 180(1):81-85, 1996.

Previous bioindicative studies in the Skrunda Radio Location Station area have focused on the somatic influence of electromagnetic radiation on plants, but it is also important to study genetic effects. We have chosen cows as test animals for cytogenetical evaluation because they live in the same general exposure area as humans, are confined to specific locations and are chronically exposed to radiation. Blood samples were obtained from female Latvian Brown cows from a farm close to and in front of the Skrunda Radar and from cows in a control area. A simplified alternative to the Schiff method of DNA staining for identification of micronuclei in peripheral erythrocytes was applied. Microscopically, micronuclei in peripheral blood erythrocytes were round in shape and exhibited a strong red colour. They are easily detectable as the only coloured bodies in the uncoloured erythrocytes. From each individual animal 2000 erythrocytes were examined at a magnification of x 1000 for the presence of micronuclei. The counting of micronuclei in peripheral erythrocytes gave low average incidences, 0.6 per 1000 in the exposed group and 0.1 per 1000 in the control, but statistically significant ($P < 0.01$) differences were found in the frequency distribution between the control and exposed groups.

Effects on Skin

Cam ST, Seyhan N, Kavaklı C, Celikbıçak O. Effects of 900 MHz Radiofrequency Radiation on Skin Hydroxyproline Contents. Cell Biochem Biophys. 2014 Apr 24. [Epub ahead of print]

The present study aimed to investigate the possible effect of pulse-modulated radiofrequency radiation (RFR) on rat skin hydroxyproline content, since skin is the first target of external electromagnetic fields. Skin hydroxyproline content was measured using liquid chromatography mass spectrometer method. Two months old male wistar rats were exposed to a 900 MHz pulse-modulated RFR at an average whole body specific absorption rate (SAR) of 1.35 W/kg for 20 min/day for 3 weeks. The radiofrequency (RF) signals were pulse modulated by rectangular pulses with a repetition frequency of 217 Hz and a duty cycle of 1:8 (pulse width 0.576 ms). A skin biopsy was taken at the upper part of the abdominal costa after the exposure. The data indicated that whole body exposure to a pulse-modulated RF radiation that is similar to that emitted by the global system for mobile communications (GSM) mobile phones caused a statistically significant increase in the skin hydroxyproline level ($p = 0.049$, Mann-Whitney U test). Under our experimental conditions, at a SAR less than the International Commission on Non-Ionizing Radiation Protection safety limit recommendation, there was evidence that GSM signals could alter hydroxyproline concentration in the rat skin.

Studies that show **Cell Tower** Health Effects

Effects on Protein

Hässig M, Wullschleger M, Naegeli HP, Kupper J, Spiess B, Kuster N, Capstick M, Murbach M. Influence of non ionizing radiation of base stations on the activity of redox proteins in bovines. BMC Vet Res. 2014 Jun 19;10(1):136. [Epub ahead of print]

BACKGROUND: The influence of electromagnetic fields on the health of humans and animals is still an intensively discussed and scientifically investigated issue (Prakt Tierarzt 11:15-20, 2003; Umwelt Medizin Gesellschaft 17:326-332, 2004; J Toxicol Environment Health, Part B 12:572-597, 2009). We are surrounded by numerous electromagnetic fields of variable strength, coming from electronic equipment and its power cords, from high-voltage power lines and from antennas for radio, television and mobile communication. Particularly the latter cause's controversy, as everyone likes to have good mobile reception at anytime and anywhere, whereas nobody wants to have such a base station antenna in their proximity. **RESULTS:** In this experiment, the **non-ionizing radiation (NIR)** has resulted in changes in the enzyme activities. Certain enzymes were disabled, others enabled by NIR. Furthermore, individual behavior patterns were observed. While certain cows reacted to NIR, others did not react at all, or even inversely. **CONCLUSION:** The present results coincide with the information from the literature, according to which NIR leads to changes in redox proteins, and that there are individuals who are sensitive to radiation and others that are not. However, the latter could not be distinctly attributed - there are cows that react clearly with one enzyme while they do not react with another enzyme at all, or even the inverse. The study approach of testing ten cows each ten times during three phases has proven to be appropriate. Future studies should however set the post-exposure phase later on.

Effects on Immune Function

Li CY, Liao MH, Lin CW, Tsai WS, Huang CC, Tang TK. Inhibitory Effects of Microwave Radiation on LPS-Induced NFκB Expression in THP-1 Monocytes. Chin J Physiol. 55(6):421-427, 2012.

Microwave radiations can be encountered regularly in daily lives. When WHO announced that microwave radiations were a kind of environmental energy which interfere with the physiological functions of the human body, great concerns have been raised over the damages microwave frequencies can do to human physiology. The immunological performance and the activities of the cellular inflammatory factor NFκB have been closely related in monocyte. Due to the effect of phorbol 12-myristate 13-acetate (PMA) on THP-1 monocytes, THP-1 monocytes would differentiate into macrophages and would then react with lipopolysaccharides (LPS), and the amount of NFκB increased in the THP-1 monocytes. Expression of cytokine is affected when cells are exposed to a frequency of 2450 MHz and at 900 W. Thus, in our experiments, an observation was made when THP-1 monocytes were stimulated with PMA and LPS to differentiate into macrophage, the amount of NFκB in cells increased exponentially, and

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the levels of NFkB expression were decreased by the exposure of microwave radiation. In conclusion, microwave radiations were found to inhibit the activity functions of THP-1 monocytes stimulated with PMA and LPS.

Electro Hypersensitivity

Nordin S, Neely G, Olsson D, Sandström M. Odor and Noise Intolerance in Persons with Self-Reported Electromagnetic Hypersensitivity. Int J Environ Res Public Health. 11(9):8794-8805, 2014.

Lack of confirmation of symptoms attributed to electromagnetic fields (EMF) and triggered by EMF exposure has highlighted the role of individual factors. Prior observations indicate intolerance to other types of environmental exposures among persons with electromagnetic hypersensitivity (EHS). This study assessed differences in odor and noise intolerance between persons with EHS and healthy controls by use of subscales and global measures of the Chemical Sensitivity Scale (CSS) and the Noise Sensitivity Scale (NSS). The EHS group scored significantly higher than the controls on all CSS and NSS scales. Correlation coefficients between CSS and NSS scores ranged from 0.60 to 0.65 across measures. The findings suggest an association between EHS and odor and noise intolerance, encouraging further investigation of individual factors for understanding EMF-related symptoms.

RF Levels in Cities

Urbiniello D, Huss A, Beekhuizen J, Vermeulen R, Rösli M. Use of portable exposure meters for comparing mobile phone base station radiation in different types of areas in the cities of Basel and Amsterdam. Sci Total Environ. 468-469:1028-1033, 2014.

BACKGROUND: Radiofrequency electromagnetic fields (RF-EMF) are highly variable and differ considerably within as well as between areas. Exposure assessment studies characterizing spatial and temporal variation are limited so far. Our objective was to evaluate sources of data variability and the repeatability of daily measurements using portable exposure meters (PEMs). METHODS: Data were collected at 12 days between November 2010 and January 2011 with PEMs in four different types of urban areas in the cities of Basel (BSL) and Amsterdam (AMS). RESULTS: Exposure from mobile phone base stations ranged from 0.30 to 0.53 V/m in downtown and business areas and in residential areas from 0.09 to 0.41 V/m. Analysis of variance (ANOVA) demonstrated that measurements from various days were highly reproducible (measurement duration of approximately 30 min) with only 0.6% of the variance of all measurements from mobile phone base station radiation being explained by the measurement day and only 0.2% by the measurement time (morning, noon, afternoon), whereas type of area (30%) and city (50%) explained most of the data variability. CONCLUSIONS: We conclude that mobile monitoring of exposure from mobile phone base station radiation with PEMs is

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useful due to the high repeatability of mobile phone base station exposure levels, despite the high spatial variation.

Urbiniello D, Joseph W, Verloock L, Martens L, Rösli M. Temporal trends of radio-frequency electromagnetic field (RF-EMF) exposure in everyday environments across European cities. Environ Res. 2014 Aug 12;134C:134-142. doi: 10.1016/j.envres.2014.07.003. [Epub ahead of print]

BACKGROUND: The rapid development and increased use of wireless telecommunication technologies led to a substantial change of radio-frequency electromagnetic field (RF-EMF) exposure in the general population but little is known about temporal trends of RF-EMF in our everyday environment. **OBJECTIVES:** The objective of our study is to evaluate temporal trends of RF-EMF exposure levels in different microenvironments of three European cities using a common measurement protocol. **METHODS:** We performed measurements in the cities of Basel (Switzerland), Ghent and Brussels (Belgium) during one year, between April 2011 and March 2012. RF-EMF exposure in 11 different frequency bands ranging from FM (Frequency Modulation, 88MHz) to WLAN (Wireless Local Area Network, 2.5GHz) was quantified with portable measurement devices (exposimeters) in various microenvironments: outdoor areas (residential areas, downtown and suburb), public transports (train, bus and tram or metro rides) and indoor places (airport, railway station and shopping centers). Measurements were collected every 4s during 10-50min per environment and measurement day. Linear temporal trends were analyzed by mixed linear regression models. **RESULTS:** Highest total RF-EMF exposure levels occurred in public transports (all public transports combined) with arithmetic mean values of 0.84V/m in Brussels, 0.72V/m in Ghent, and 0.59V/m in Basel. In all outdoor areas combined, mean exposure levels were 0.41V/m in Brussels, 0.31V/m in Ghent and 0.26V/m in Basel. Within one year, total RF-EMF exposure levels in all outdoor areas in combination increased by 57.1% (p<0.001) in Basel by 20.1% in Ghent (p=0.053) and by 38.2% (p=0.012) in Brussels. Exposure increase was most consistently observed in outdoor areas due to emissions from mobile phone base stations. In public transports RF-EMF levels tended also to increase but mostly without statistical significance. **DISCUSSION:** An increase of RF-EMF exposure levels has been observed between April 2011 and March 2012 in various microenvironments of three European cities. Nevertheless, exposure levels were still far below regulatory limits of each country. A continuous monitoring is needed to identify high exposure areas and to anticipate critical development of RF-EMF exposure at public places.

Estenberg J, Augustsson T. Extensive frequency selective measurements of radiofrequency fields in outdoor environments performed with a novel mobile monitoring system. Bioelectromagnetics. 2013 Dec 27. doi: 10.1002/bem.21830. [Epub ahead of print]

A novel, car based, measuring system for estimation of general public outdoor exposure to radiofrequency fields (RF) has been developed. The system enables fast, large area, isotropic spectral measurements with a bandwidth covering the frequency range of

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30 MHz to 3 GHz. Measurements have shown that complete mapping of a town with 15000 inhabitants and a path length of 115 km is possible to perform within 1 day. The measured areas were chosen to represent typical rural, urban and city areas of Sweden. The data sets consist of more than 70000 measurements. All measurements were performed during the daytime. The median power density was $16 \mu\text{W}/\text{m}^2$ in rural areas, $270 \mu\text{W}/\text{m}^2$ in urban areas, and $2400 \mu\text{W}/\text{m}^2$ in city areas. In urban and city areas, base stations for mobile phones were clearly the dominating sources of exposure.

Effects on Water

Hinrikus H, Lass J, Karai D, Pilt K, Bachmann M. Microwave effect on diffusion: a possible mechanism for non-thermal effect. Electromagn Biol Med. 23:1-7, 2014.

In this study, we assume that microwave radiation affects hydrogen bonding between dipolar water molecules and through that diffusion in water at constant temperature. The experimental study was performed on the setup of two identical reservoirs filled with pure water and 0.9% NaCl solution and connected by a thin tube. Alterations of NaCl concentration in the reservoir initially filled with pure water were measured using the resistance of the solution as an indicator. The applied 450 MHz continuous-wave microwave field had the maximal specific absorption rate of 0.4 W/kg on the connecting tube. The standard deviation of water temperature in the setup was 0.02 °C during an experiment. Our experimental data demonstrated that microwave exposure makes faster the process of diffusion in water. The time required for reduction of initial resistance of the solution by 10% was 1.7 times shorter with microwave. This result is consistent with the proposed mechanism of low-level microwave effect: microwave radiation, rotating dipolar water molecules, causes high-frequency alterations of hydrogen bonds between water molecules, thereby affects its viscosity and makes faster diffusion.

RF Levels From Cell Towers

Martinez-Burdalo M, Martin A, Anguiano M, Villar R. On the safety assessment of human exposure in the proximity of cellular communications base-station antennas at 900, 1800 and 2170 MHz. Phys Med Biol. 50(17):4125-4137, 2005.

In this work, the procedures for safety assessment in the close proximity of cellular communications base-station antennas at three different frequencies (900, 1800 and 2170 MHz) are analysed. For each operating frequency, we have obtained and compared the distances to the antenna from the exposure places where electromagnetic fields are below reference levels and the distances where the specific absorption rate (SAR) values in an exposed person are below the basic restrictions, according to the European safety guidelines. A high-resolution human body model has been located, in front of each base-station antenna as a worst case, at different distances, to compute whole body averaged SAR and maximum 10 g averaged SAR

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inside the exposed body. The finite-difference time-domain method has been used for both electromagnetic fields and SAR calculations. This paper shows that, for antenna-body distances in the near zone of the antenna, the fact that averaged field values be below the reference levels could, at certain frequencies, not guarantee guidelines compliance based on basic restrictions.

Hu J, Lu Y, Zhang H, Xie H, Yang X. [Level of microwave radiation from mobile phone base stations built in residential districts] Wei Sheng Yan Jiu. 38(6):712-716, 2009.

[Article in Chinese]

OBJECTIVE: To investigate the condition of microwave radiation pollution from mobile phone base station built in populated area. METHODS: Random selected 18 residential districts where had base station and 10 residential districts where had no base stations. A TES-92 electromagnetic radiation monitor were used to measure the intensity of microwave radiation in external and internal living environment. RESULTS: The intensities of microwave radiation in the exposure residential districts were more higher than those of the control residential districts ($p < 0.05$). There was a intensity peak at about 10 m from the station, it would gradually weaken with the increase of the distance. The level of microwave radiation in antenna main lobe region is not certainly more higher than the side lobe direction, and the side lobe direction also is not more lower. At the same district, where there were two base stations, the electromagnetic field nestification would take place in someplace. The intensities of microwave radiation outside the exposure windows in the resident room not only changed with distance but also with the height of the floor. The intensities of microwave radiation inside the aluminum alloys security net were more lower than those of outside the aluminum alloys security net ($p < 0.05$), but the inside or outside of glass-window appears almost no change ($p > 0.05$). CONCLUSIONS: Although all the measure dates on the ground around the base station could be below the primary standard in "environment electromagnetic wave hygienic standard" (GB9175-88), there were still a minorities of windows which exposed to the base station were higher, and the outside or inside of a few window was even higher beyond the primary safe level defined standard. The aluminum alloys security net can partly shield the microwave radiation from the mobile phone base station.

Danger Perception and Symptoms

Hutter HP, Moshammer H, Wallner P, Kundi M. Public perception of risk concerning cell towers and mobile phones. Soz Praventivmed. 49(1):62-66, 2004.

OBJECTIVE: The controversy about health risks of electromagnetic fields (EMF) has contributed in raising fears concerning emissions from celltowers. The study was to examine whether or not neighbours of celltowers are particularly concerned about adverse health effects of mobile phones and their base stations. METHODS: Prior to information delivered by medical doctors of the Institute of Environmental Health at public hearings a questionnaire was handed out to participants asking for their personal

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rating of several environmental health risks including those of mobile telecommunication (n = 123, response rate approx. 48%). Medical students (n = 366) served as a contrast group. RESULTS: Participants rated health risk for both, mobile phones and celltowers higher as students. A trend for higher ratings was also seen with older subjects and female sex. The risk ratings of both exposures correlated well with each other. The magnitude of the perceived risks, however, resembled that of other ubiquitous exposures like traffic noise and air pollution. CONCLUSION: Contrary to the claims of the telecommunication industry, opponents of celltowers generally do not express unusual fears concerning electromagnetic field exposure. The outcome of our study indicates that the risk rating is comparable with other perceived common hazards of the civilised world. It is hypothesised that offering information and participation to the concerned population will be efficient in reducing exaggerated fears.

Reason Why Not A Lot Of Studies on Cell Towers

Kundi M, Hutter HP. Mobile phone base stations-Effects on wellbeing and health. Pathophysiology. 16(2-3):123-135, 2009.

Studying effects of mobile phone base station signals on health have been discouraged by authoritative bodies like WHO International EMF Project and COST 281. WHO recommended studies around base stations in 2003 but again stated in 2006 that studies on cancer in relation to base station exposure are of low priority. As a result only few investigations of effects of base station exposure on health and wellbeing exist. Cross-sectional investigations of subjective health as a function of distance or measured field strength, despite differences in methods and robustness of study design, found indications for an effect of exposure that is likely independent of concerns and attributions. Experimental studies applying short-term exposure to base station signals gave various results, but there is weak evidence that UMTS and to a lesser degree GSM signals reduce wellbeing in persons that report to be sensitive to such exposures. Two ecological studies of cancer in the vicinity of base stations report both a strong increase of incidence within a radius of 350 and 400m respectively. Due to the limitations inherent in this design no firm conclusions can be drawn, but the results underline the urgent need for a comprehensive investigation of this issue. Animal and in vitro studies are inconclusive to date. An increased incidence of DMBA induced mammary tumors in rats at a SAR of 1.4W/kg in one experiment could not be replicated in a second trial. Indications of oxidative stress after low-level in vivo exposure of rats could not be supported by in vitro studies of human fibroblasts and glioblastoma cells. From available evidence it is impossible to delineate a threshold below which no effect occurs, however, given the fact that studies reporting low exposure were invariably negative it is suggested that power densities around 0.5-1mW/m² must be exceeded in order to observe an effect. The meager data base must be extended in the coming years. The difficulties of investigating long-term effects of base station exposure have been exaggerated, considering that base station and handset exposure have almost nothing

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in common both needs to be studied independently. It cannot be accepted that studying base stations is postponed until there is firm evidence for mobile phones.

Miscellaneous Effects

Panagopoulos, D. J., Johansson O. & Carlo G.L. Polarization: A Key Difference between Man-made and Natural Electromagnetic Fields, in regard to Biological Activity. *Sci. Rep.* 5, 14914; doi: 10.1038/srep14914 (2015). Published online Oct 12, 2015.

In the present study we analyze the role of polarization in the biological activity of Electromagnetic Fields (EMFs)/Electromagnetic Radiation (EMR). All types of man-made EMFs/EMR - in contrast to natural EMFs/EMR - are polarized. Polarized EMFs/EMR can have increased biological activity, due to: 1) Ability to produce constructive interference effects and amplify their intensities at many locations. 2) Ability to force all charged/polar molecules and especially free ions within and around all living cells to oscillate on parallel planes and in phase with the applied polarized field. Such ionic forced-oscillations exert additive electrostatic forces on the sensors of cell membrane electro-sensitive ion channels, resulting in their irregular gating and consequent disruption of the cell's electrochemical balance. These features render man-made EMFs/EMR more bioactive than natural non-ionizing EMFs/EMR. This explains the increasing number of biological effects discovered during the past few decades to be induced by man-made EMFs, in contrast to natural EMFs in the terrestrial environment which have always been present throughout evolution, although human exposure to the latter ones is normally of significantly higher intensities/energy and longer durations. Thus, polarization seems to be a trigger that significantly increases the probability for the initiation of biological/health effects.

Dhami AK. Study of electromagnetic radiation pollution in an Indian city. *Environ Monit Assess.*184(11):6507-6512, 2012.

Abstract. Electromagnetic radiation emitted by cell phone towers is a form of environmental pollution and is a new health hazard, especially to children and patients. The present studies were taken to estimate the microwave/RF pollution by measuring radiation power densities near schools and hospitals of Chandigarh city in India. The cell phone radiations were measured using a handheld portable power density meter TES 593 and specific absorption rates were estimated from the measured values. These values of electromagnetic radiation in the environment were compared with the levels at which biological system of humans and animals starts getting affected. The values were also compared with the international exposure limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The highest measured power density was 11.48 mW/m(2) which is 1,148% of the biological limit. The results indicated that the exposure levels in the city were below the ICNIRP limit, but much above the biological limit.

Cell Towers; Consequences of Chronic Microwave RF Exposure,
Dr. Paul Dart MD. (Petitioner)

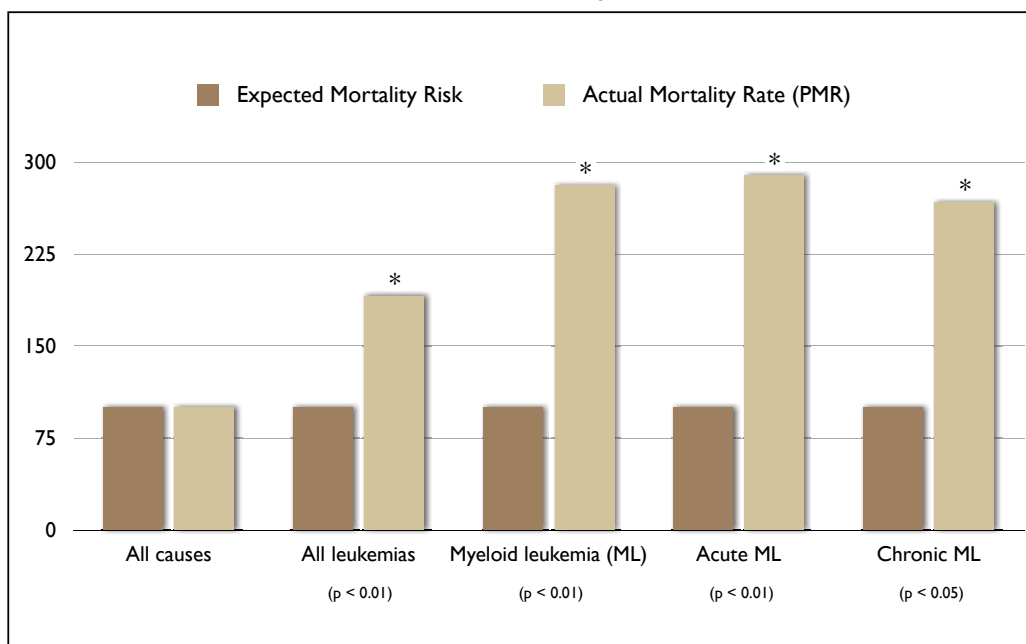
Consequences of Chronic Microwave RF Exposure



Fig. 2. Geographical location of BS Site BH 20 at 1373 Rua do Ouro Street, in the Serra neighborhood, Belo Horizonte municipality

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

Amateur Radio Operators

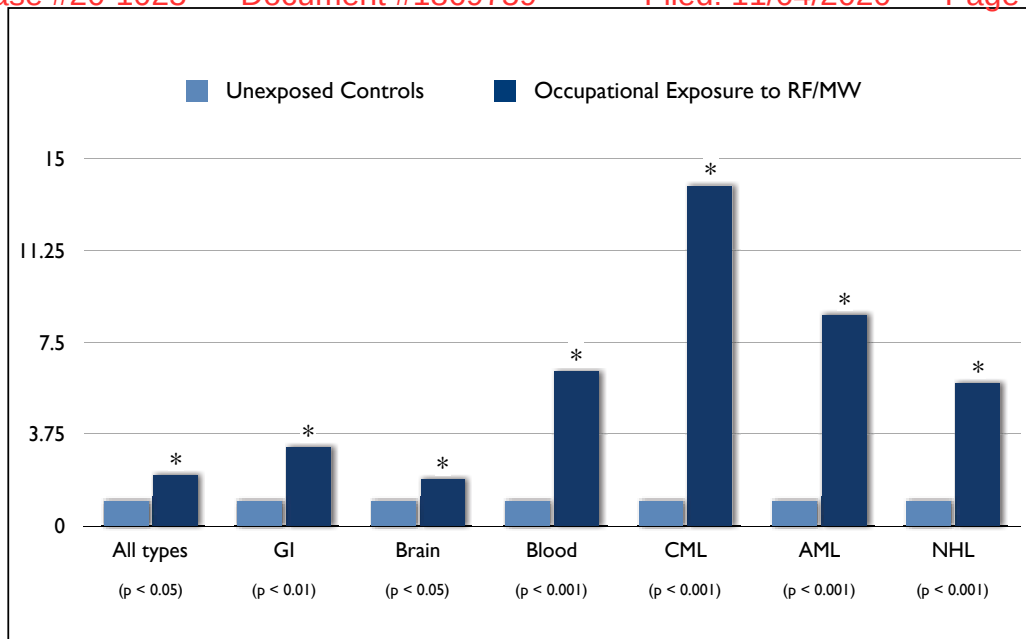


Analysis of leukemia deaths in male members of the American Radio Relay League resident in Washington and California, 1971-1983

Milham SJ. Silent keys: leukaemia mortality in amateur radio operators. *Lancet* (1985); 1(8432):812.

Cherry N. Evidence in support of the a priori hypothesis that Electromagnetic Radiation across the spectrum is a Ubiquitous Universal Genotoxic Carcinogen. (2002):1-52. <http://www.neilcherry.com/documents.php>

Polish Military (1971-1985)



Polish military personnel with occupational exposure to radio and microwave frequency radiation.

Odds ratio of cancer incidence (1971-1985)

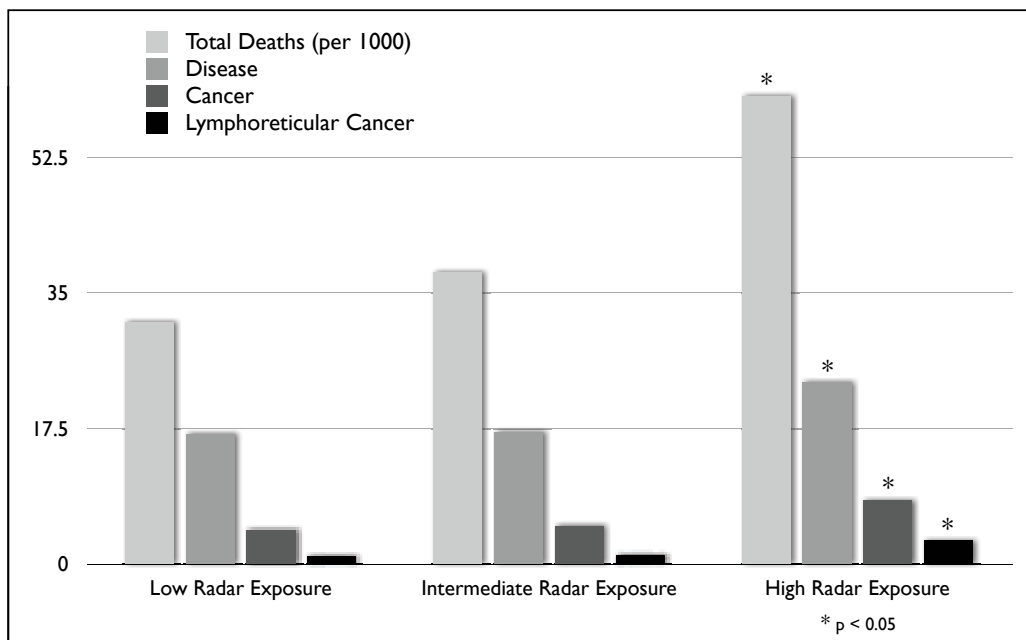
CML = chronic myelocytic leukemia

AML = acute myeloblastic leukemia

NHL = non-Hodgkin lymphoma

Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. *Sci Total Environ* (1996); 180(1):9-17.

U.S. Navy Korean War Veterans (1950-1974)



Mortality in U.S. Navy Korean War Veterans (1950-1974) stratified by levels of occupational radar exposure.

Mortality 1950-1974. (Y axis = crude mortality per 1000) Stratified by level of radar exposure.

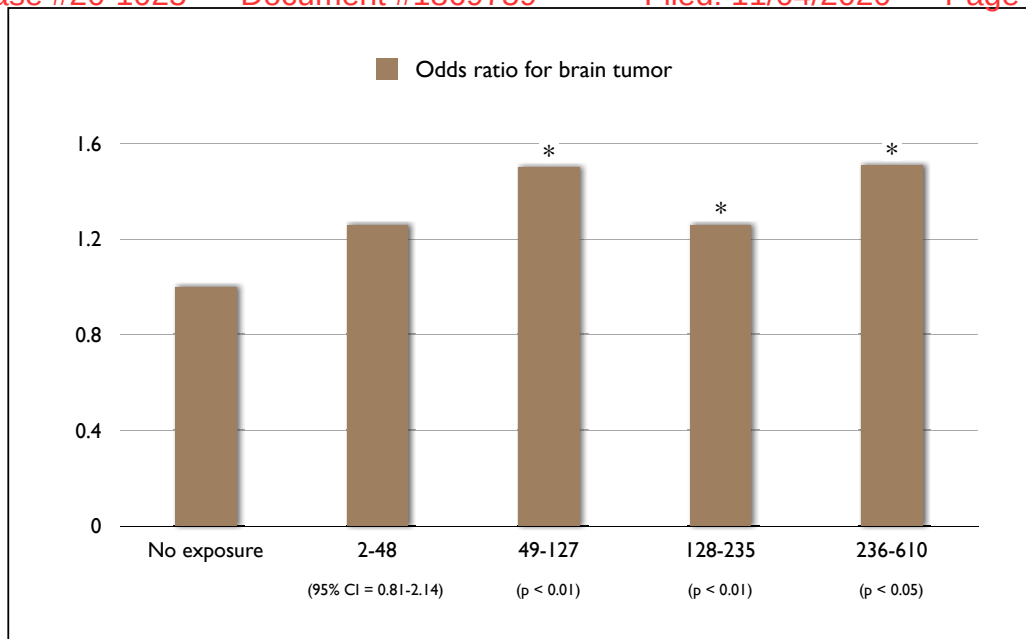
In the original paper, Robinette et al evaluated job exposure hazard levels of 6 categories of navy personnel and grouped them into two groups, low exposure and high exposure. The electronic technicians (ET) had a significantly lower hazard rating and lower levels of pathology than the other two job categories in the high risk group, so this classification diluted out the high exposure risk pool.

Dr. Cherry took Robinette et al's published data and divided the workers into three exposure levels. The above chart is the result of Dr. Cherry's analysis of the data set.

Robinette CD, Silverman C, Jablon S. Effects upon health of occupational exposure to microwave radiation (radar). *Am J Epidemiol* (1980); 112(1):39-53.

Cherry N. Health Effects in the vicinity of Radio/TV towers and mobile phone base stations. (2002): 1-40. <http://www.neilcherry.com/documents.php>

US Air Force (1970-1989)



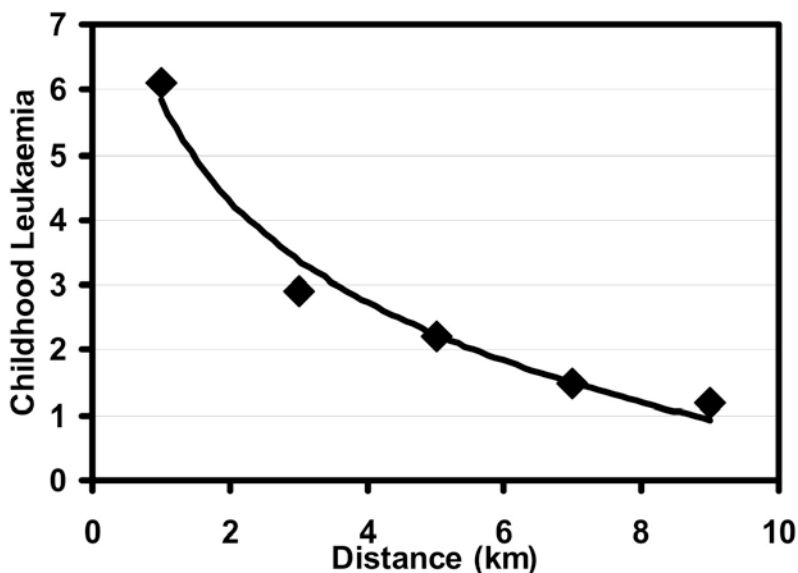
US Air Force Workers with occupational exposure to microwave RF (1970-1989)

Y axis: Odds ratio for brain tumor

X axis: Exposure intensity score x months exposed)

 Grayson JK. Radiation exposure, socioeconomic status, and brain tumor risk in the US Air Force: a nested case-control study. *Am J Epidemiol* (1996); 143(5):480-486.

Vatican Radio Tower (1987-1999).



Cumulative childhood leukaemia near the Vatican Radio Transmitters in Rome, 1987-1999.

Multiple powerful transmitters on site.

10 km radius around towers contains a population of >49,650 (1990 census).

exponential fitted trend line, $R^2=0.9756$, $p = 0.002$

Cherry N. Health Effects in the vicinity of Radio/TV towers and mobile phone base stations. (2002): 1-40.
<http://www.neilcherry.com/documents.php>

Michelozzi P, Capon A, Kirchmayer U et al. Adult and childhood leukemia near a high-power radio station in Rome, Italy. *Am J Epidemiol* (2002); 155(12):1096-1103.

Netanya, Israel (1997-1998)



New cell phone tower set up in city of Netanya, Israel, in July, 1996.

1500 watt, 850 MHz.

Power density in the whole exposed area was far below $0.53 \mu\text{W}/\text{cm}^2$.

This is 1000 times less than the FCC Guidelines of $600 \mu\text{W}/\text{cm}^2$ for 850 MHz exposure.

Comparison of cancer rates during the second year of exposure, in 677 long-term residents near the tower, compared to 1,222 matched controls living in another area of the city.

Wolf R, Wolf D. Increased Incidence of Cancer Near a Cell-Phone Transmitter Station. *International Journal of Cancer Prevention* (2004); 1(2):1-19.

Netanya, Israel - Relative Cancer Risk



Relative risk of cancer in residents near a new cell phone tower in Netanya, Israel, during the second year of exposure.

Overall risk of cancer in Area A was 4.15 times higher than in the town as a whole.

For men in area A, the cancer rate was 1.4 times higher.

For women in area A, the cancer rate was 10.5 times higher (p < 0.0001)

[the probability of this being a random finding is one hundredth of 1%]

Wolf R, Wolf D. Increased Incidence of Cancer Near a Cell-Phone Transmitter Station. *International Journal of Cancer Prevention* (2004); 1(2):1-19.

Naila, Germany (1999-2004)



Town of ~ 1100 residents.

Cell tower installed in 1993.

Medical of 1000 residents reviewed for the years 1994–2004.

Comparison of cancer incidents in residents living within 400 meters of the cell phone tower,
compared to residents living farther away,
and compared to the death rates for the province as a whole.

Eger H, Hagen K, Lucas B, Vogel P, Voit H. The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer. *Umwelt-Medizin-Gesellschaft* (2004); 17(4):1-7.

Cancer Incidence in Naila (1999-2004)

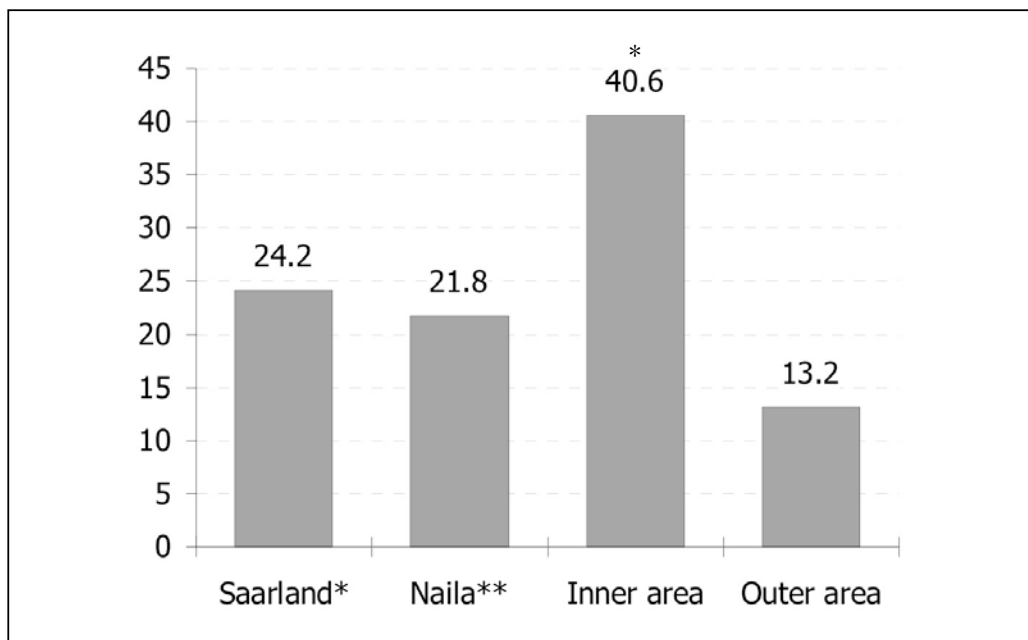


Fig. 3 : Number of new cancer cases 1999 to 2004, adjusted for age and gender, calculated for the 5,000 patient years

Y axis: Cancer incidence 1994 – 2004 (new cases per 5000 patient years).

* Saarland = predicted rate based on the cancer registry for the federal state of Saarland.

** Naila = incidence for the town as a whole.

Inner area = residence within 400 meters of the tower.

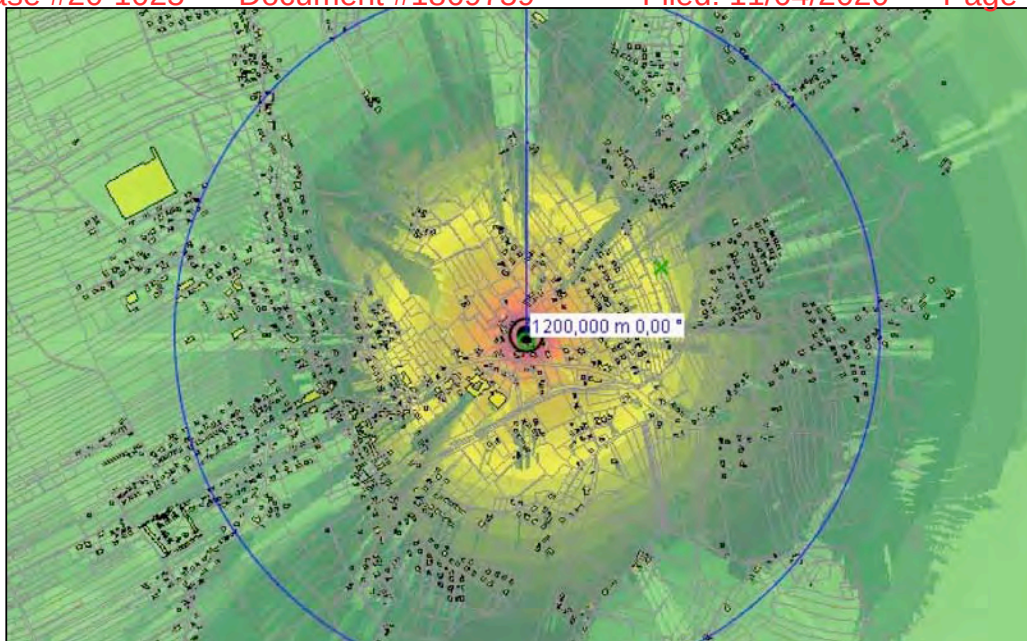
Outer area = remainder of community.

In the inner area, the risk of cancer incidence was three times as high after five or more years of exposure.

In addition, the patients that live within 400 metres tend to develop the cancers at a younger age.

Hausmannstätten & Vasoldsberg, Austria (1984-1997)

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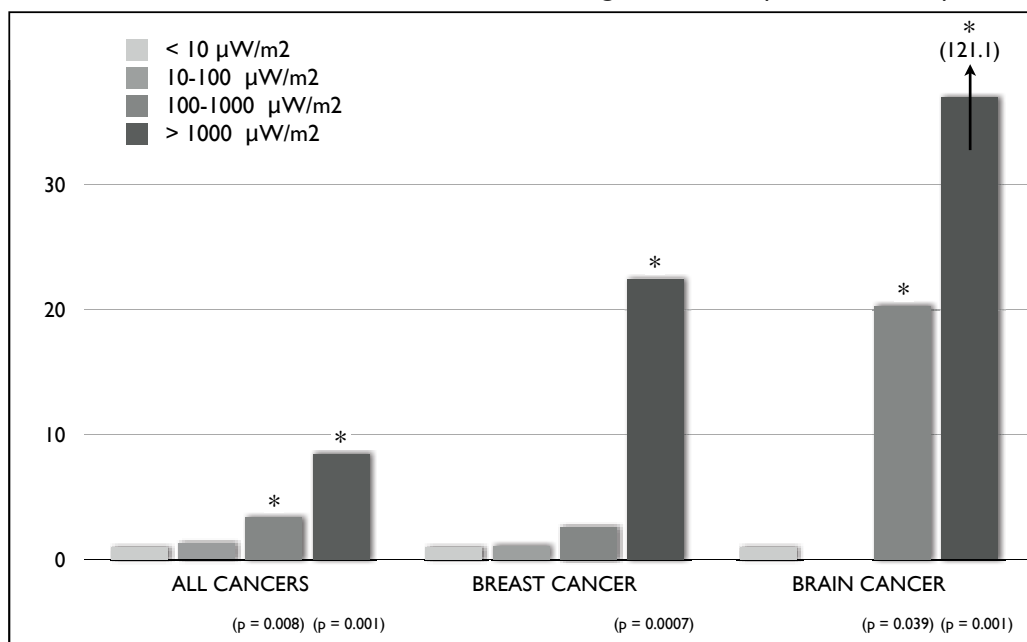


NMT 450 cell tower, operational from 1984–1997.

Case/control study of cancer patients living within 1200 meter radius of the tower.

Oberfeld G. Environmental Epidemiological Study of Cancer Incidence in the Municipalities of Hausmannstätten & Vasoldsberg (Austria). Provincial Government of Styria, Department 8B, Provincial Public Health Office, Graz, Austria (2008):1-10. <http://www.emf-health.com/PDFreports/Austrianstudy.pdf>

Hausmannstätten & Vasoldsberg, Austria (1984-1997)



Odds ratio of cancer incidence — stratified by exposure levels (exterior to dwelling) in $\mu\text{W}/\text{m}^2$.

Note: FCC thermal safety guidelines ~ $6,000,000 \mu\text{W}/\text{m}^2$

In the highest exposure category:

Breast cancer risk was 23 times higher,

Brain cancer risk was 121 times higher.

Oberfeld G. Environmental Epidemiological Study of Cancer Incidence in the Municipalities of Hausmannstätten & Vasoldsberg (Austria). Provincial Government of Styria, Department 8B, Provincial Public Health Office, Graz, Austria (2008):1-10. <http://www.emf-health.com/PDFreports/Austrianstudy.pdf>

Belo Horizonte, Brazil (2011)

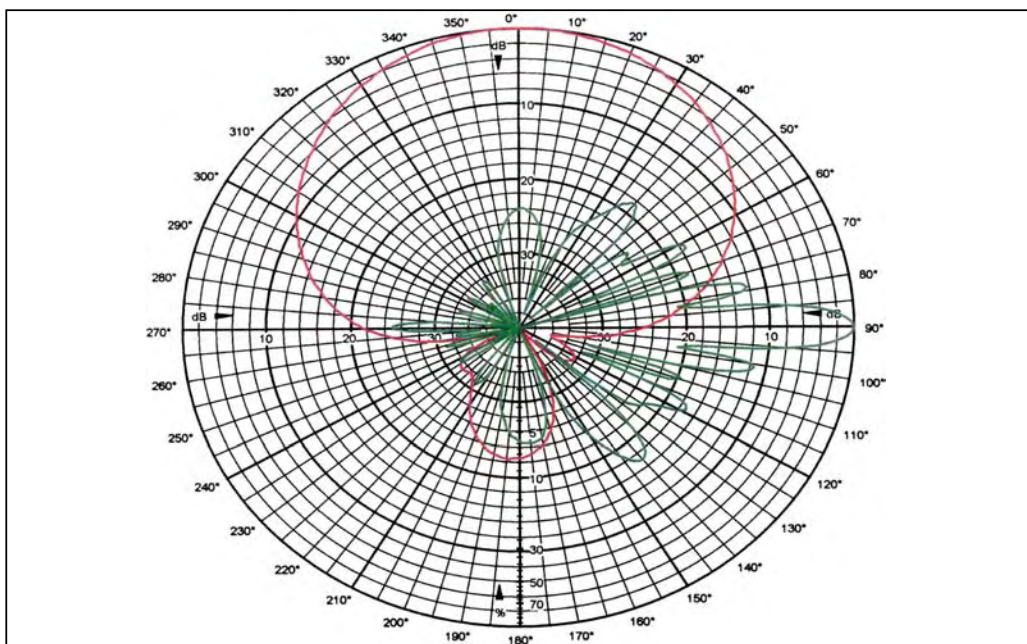


Belo Horizonte is the capital of Minas Gerais state in Brazil, population 2,258,096 in 2010.

Rated by the U.N. in 2007 as having the best quality of life in Latin America.

By 2006, 856 cell phone towers had been installed in the city.

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.



Environmental monitoring of RF power densities in the city was performed.

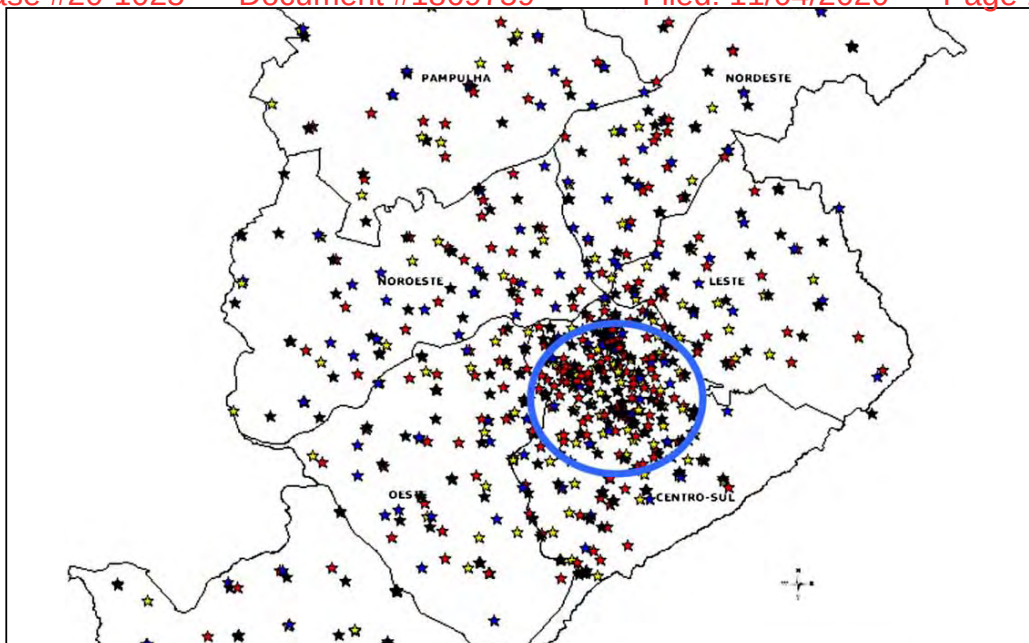
In 2003, the highest recorded power density in the city was $3.06 \mu\text{W}/\text{cm}^2$.

In 2008, the largest recorded power density was $40.78 \mu\text{W}/\text{cm}^2$, 13 times higher than in 2003.

$40 \mu\text{W}/\text{cm}^2$ is 15 times less than the FCC Exposure Guidelines.

Fig. 3. Horizontal and vertical radiation patterns per sector of BS site BH 20

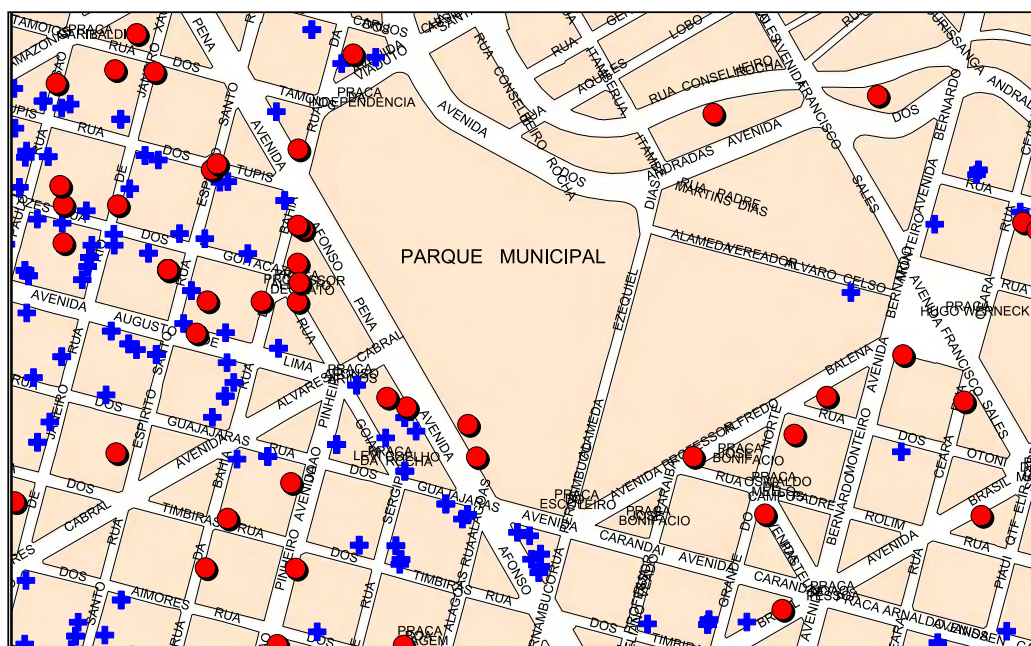
From: Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.



The authors used the Telecommunications National Agency database to map the locations of the 856 cell phone towers that existed in the city as of December 2006.

Fig. 8. Installed BSs in the Belo Horizonte municipality until 2006. Total amount = 856.

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

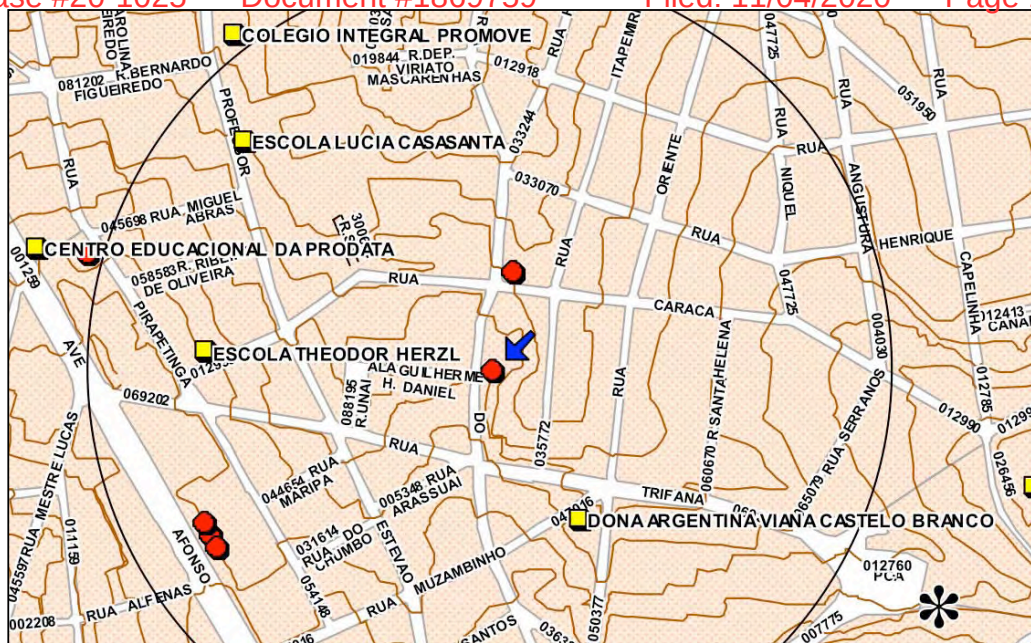


They then cross-referenced health department records of death by neoplasia with census and demographic city population data to **locate the residence** of all individuals who had died of cancer in the city between 1996 and 2006.

Fig. 10. Sample of geocoded deaths and BS locations in downtown Belo Horizonte City located in Central-Southern region.

From: Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

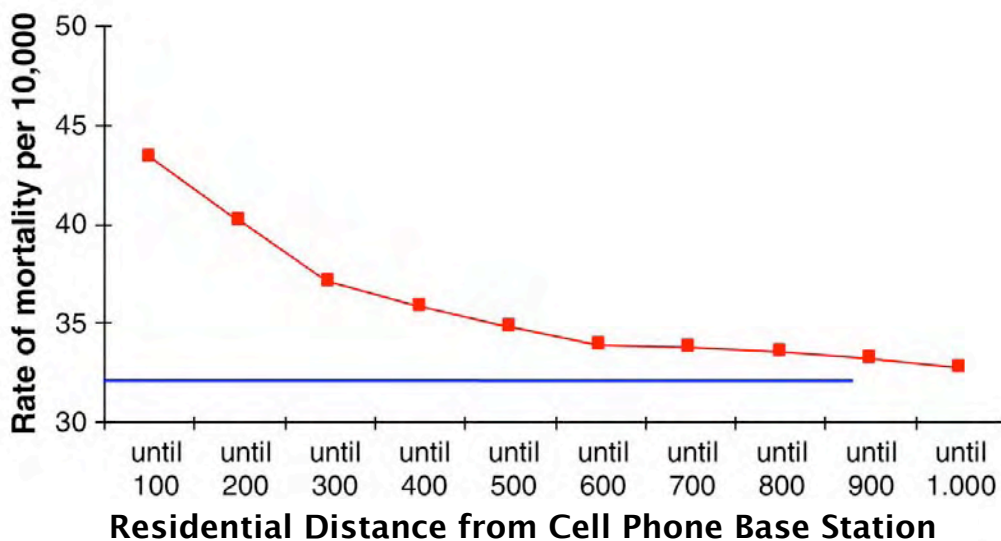
Belo Horizonte, Brazil (2011)



This allowed them to calculate the distance between the deceased individuals' residences and the closest cell phone tower, in meters.

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

Belo Horizonte, Brazil (2011)

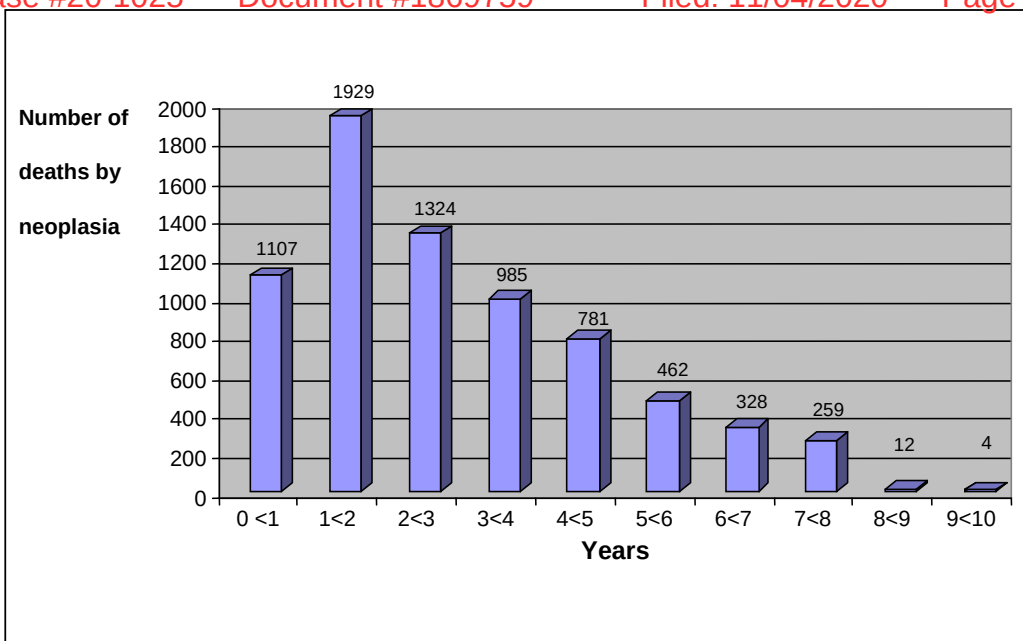


Analysis of this data showed that the cancer death rate was significantly elevated at proximities closer than 500 meters to cell phone towers.

Fig. 15. Rate of mortality by neoplasia, according to the distance from the BS in Belo Horizonte municipality, from 1996 to 2006, and the null hypothesis (blue line).

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

Belo Horizonte, Brazil (2011)



Death rates peaked during the second year of exposure.

Fig. 16. Distribution of the number of deaths by neoplasia versus duration of exposure since the date that the first antenna in each analyzed CT came into operation.

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.

Effects of Microwave RF Exposure on Fertility



Cell Towers - Cancer; Meta-Analysis, Long-Term Exposure To
Microwave Radiation Provokes Cancer Growth: Evidences From Radars
And Mobile Communication Systems. (Yakymenko et al); 2011

LONG-TERM EXPOSURE TO MICROWAVE RADIATION PROVOKES CANCER GROWTH: EVIDENCES FROM RADARS AND MOBILE COMMUNICATION SYSTEMS

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In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17–24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

Key Words: non-ionizing radiation, radiofrequency, tumor, risk assessment, safety limits, precautionary principle.

INTRODUCTION

Electromagnetic radiation (EMR) became one of the most significant and fastest growing environmental factors due to intensive development of communication technologies during the last decades. Currently, according to expert estimations, the level of electromagnetic radiation from artificial sources exceeds the level of natural electromagnetic fields by thousand folds. The active development of mobile communication technologies over the world will only raise this level further. In this connection the problem of possible adverse effects of anthropogenic EMR on human health and particularly strictest assessment of possible carcinogenic effects of EMR is extremely important.

In August 2007 an international working group of renowned scientists and public health experts released a report on electromagnetic fields (EMF) and human

health [1]. It raised a serious concern about safety limits for public electromagnetic irradiation from power lines, cell phones, radars, and other sources of EMF exposure in daily life. The authors concluded that the existing public safety limits were inadequate to protect public health. Moreover, very recently a vast number of new extremely important studies in this field have been published. Importantly, nowadays the problem is discussed on highest political level over the world. It appears that the most sound political document in Europe is a European Parliament Resolution from April 2, 2009 (www.europarl.europa.eu), where the direct appeals to activate the research and business strategy for effective solving of the problem over the member states were indicated.

In this review we would like to analyze the results of studies on specific biological effects of microwaves (MW), both epidemiological and experimental that deal with cancer promotion by long term low intensity microwave irradiation of human/animal beings. We will concentrate on unequivocal studies and will not analyze ambiguous data. For additional analysis of microwave risks we can recommend recently published reviews [2–10].

MICROWAVES OF RADARS AND MOBILE COMMUNICATION SYSTEMS

Microwaves are non-ionizing electromagnetic radiation. That means MW is a type of electromagnetic radiation which does not carry enough energy

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Abbreviations used: 8-OH-dG — 8-hydroxi-2-deoxyguanosine; EGF — epidermal growth factor; EMF — electromagnetic field; EMR — electromagnetic radiation; ERK — extracellular-signal-regulated kinase; GSM — Global System for Mobile communication; ICNIRP — International Commission on Non-Ionizing Radiation Protection; MW — microwaves; NHL — Non-Hodgkin lymphoma; ODC — ornithine decarboxylase; OER — observed expected ratio; OR — odds ratio; ROS — reactive oxygen species; SAR — specific absorption rate; SIR — standardized incidence ratio; SMR — standardized mortality ratio; WHO — the World Health Organization.

for ionization of atoms and molecules under normal conditions and unlike the ionizing radiation this kind of radiation generally has not enough energy for breaking the intermolecular bonds or for breakaway of electrons from atoms or molecules. MW comprise a part of radiofrequency range. Radiofrequency radiation (RF) refers to electromagnetic waves with a rate of oscillation of electromagnetic fields in the range from 30 kHz to 300 GHz. As any other electromagnetic waves, the radio waves are pulses of electric and magnetic fields. These fields regenerate each other as they move through the space at the speed of light. MW have frequencies from 300 MHz to 300 GHz. As MW have the highest frequency among other RF, it carries the highest energy and produce most thermal effect upon interaction with the matter.

The main sources of radiofrequency radiation during a long period in previous century were broadcasting systems. In some cases, for example, in military and aviation the most powerful local sources of radiofrequency radiation were and still are radars (RADIo De-tectioN And Ranging). However, the situation changed dramatically for general population during recent decades; and currently the most prevailing sources of RF in nearest human environment are mobile communication systems. It is important that both radars and systems for mobile communication use the same microwave part of radiofrequency spectrum.

Radar systems are type of powerful sources of pulsed MW which generally effect only certain groups of military or service staff or population living nearby. Radars are detection systems which use MW to determine both moving and fixed objects like aircraft, ships, missiles, etc. Depending on the tasks they use different frequencies of MW, from 1GHz to 12 GHz.

Mobile communication systems are undoubtedly the most source of MW in human environment over the world nowadays. Starting from the first commercial mobile phone networks in Japan, Europe and USA since 1979–1983 the number of active users of mobile telephony increased globally to over five billion. In developed countries the number of cellular phone users today is over the point of saturation. It means that many people use more than one cell phone. The initial age of youngest users of cell phone is estimated as three years old [5].

Mobile communication technology utilizes MW for connection of cell phones and base transmitting stations. Phone refers to as mobile because it is free from wire connection and it refers to as cellular/cell because technology utilizes cellular network principle. All area is covered by many base transmitting stations, each station operates in one cell (part of area) and cell phone automatically changes the station when moves from one cell to another. In GSM (Global System for Mobile communication) standard, which covers about 80% of all services over the world the frequencies of electromagnetic waves used are about 850; 900; 1850; or 1900 MHz, which belongs to the microwave range. The useful information (sounds or images)

is transferred by modulation of electromagnetic wave frequency. In GSM standard TDMA (Time Division Multiple Access) principle is realized. This means a part-time access of each consumer to the logical channel with frequency of channel rotation about 217 Hz. Thus, both base transmitting stations and cell phones emit MW modulated according to the digital standard.

SAFETY LIMITS FOR MICROWAVE RADIATION

The main international recommendations on safety levels of non-ionizing electromagnetic radiation is *Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)* of International Commission on Non-ionizing Radiation Protection [11]. The document gives recommended safety limits in all ranges of EMR both for occupational and general public exposure. “Basis for limitation exposure” is dramatically important for understanding the imperfection of this document. Accordingly, the document directly states that “Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF.” However, the basic assumption of that is questioned nowadays by numerous data sources.

According to that document a few parameters of EMR energy are recommended to be restricted. Among them the two parameters are used the most often: 1) Specific Absorption Rate (SAR) in W/kg, which indicates the EMR energy absorbed per mass unit of human tissue per second; and 2) power density or intensity of incident radiation in W/m^2 (or $\mu W/cm^2$) which indicates the amount of electromagnetic energy which falls on a unit of surface (under the right angle) per second. SAR safety limit for general public exposure indicated in Guidelines as 2 W/kg (for head and trunk) for the microwave range. To that, this limit is accepted by industry as mandatory for every commercial cell phone over the world, and real value of SAR of each cell phone model must be indicated in technical specification of the model. Unfortunately, SAR is rather sophisticated index for measurement. Moreover, only models of adult human head are currently used by industry for calculation of SAR, while real SAR values depend on a geometry and structure of tissues and, for example, was shown to be much higher for a child head than for the adult one [12–14].

Power density, or intensity of radiation, is much more direct and simple index as compared to SAR, although it does not estimate the specificity of interaction of EMR and the matter. Occupational exposure limits in microwave range according to ICNIRP are 10–50 W/m^2 . Public exposure limits for microwaves according to ICNIRP recommendation were set to 2–10 W/m^2 (or 200–1000 $\mu W/cm^2$) depending on fre-

quency. For example, for GSM–900 MHz standard IC-NIRP safety limit will be calculated as $450 \mu\text{W}/\text{cm}^2$ [11].

It is important to note that ICNIRP recommendations have no legal validity, as it is only a recommendation. Each country has their own national legislation in the field of electromagnetic safety, and national limits are rather different in different countries. Some countries such as the USA and Germany conformed national EMR limits to ICNIRP recommendation. Other countries have much tougher national limits as compared with ICNIRP guidelines. For example, for GSM-900 MHz standard MW safety limits are: in Italy, Russia and China — $10 \mu\text{W}/\text{cm}^2$, in Switzerland — $4 \mu\text{W}/\text{cm}^2$, in Ukraine — $2.5 \mu\text{W}/\text{cm}^2$ [1]. As we can see, some countries, including Ukraine, have extremely strict national safety limits. Such national positions are explained first of all by long-term national research traditions in a field of electromagnetic biology, and on experience in studying the non-thermal biological effects of this kind of radiation. On the other hand, some countries like Switzerland follow a strict precautionary principle (Better protect than sorry).

RADAR RADIATION AND CANCER PROMOTION

Substantial military and occupational data indicate a significant effect of pulse microwaves on cancer development and other pathological conditions in human. Accordingly, a statistically significant increase in immature red blood cells among workers exposed to a radar was reported [15]. In addition, radar-exposed workers had significantly lower levels of leukocytes and thrombocytes than workers distant from MW sources.

Among Polish soldiers (128 thousand personnel subjects aged from 20 to 59 years), soldiers of 20–29 years old exposed to radar microwaves during 1970–1979 had cancer incidence rates 5.5 folds higher than non-exposed soldiers [16]. The greatest rise of cancer cases was detected in blood-forming organs and lymphatic tissues: by 13.9 folds for chronic myelocytic leukemia and 8.6 folds for myeloblastic leukemia. The level of mortality among all exposed personnel was significantly higher than in unexposed: for colorectal cancer (observed-expected ratio, OER 3.2; 95 %), for cancer of esophagus and stomach (OER 3.2; 95 %), cancer of blood-forming system and lymphatic tissues (OER 6.3; 95 %) [17].

Almost two times more cases of cancer were indicated in the high-exposed American naval personnel served during the Korean War (1950–1954) as compared with the low-exposed subjects among 40 thousands of personnel [18]. Death rates for aviation electronic technicians, the group with the highest exposure rate, were significantly higher than those for the other personnel during the following years up to 1974 [15].

A very substantial increase in cancer incidence was also detected in commercial airline pilots. Thus, the standardized incidence ratio (SIR) for malignant melanoma cases was 10.2; 95.5 % for pilots of com-

mercial airlines in Iceland [19]. Significantly increased risks of acute myeloid leukemia (SIR 5.1), skin cancer, excluding melanoma (SIR 3.0) and total cancer (SIR 1.2) were observed also among Danish male jet pilots [20]. These data have been explained as a result of excess cosmic ionizing radiation or even excessive sun radiation during a leisure time. However, analysis of brain cancers among US Air Force personnel has revealed that non-ionizing radiation and particularly MW had significant effect on cancer development (odds ratio, OR 1.38; 95%), whereas ionizing radiation had negative association with cancer cases (OR 0.58; 95 %) [21]. To that, standardizing mortality ratio (SMR) for brain tumors was 2.1; 95 % among German male cockpit crew members (6,017 people) [22]. Cancer risk was significantly raised (risk ratio 2.2; 95%) among cockpit crew members employed for 30 years as compared to those employed for less than 10 years. In addition, Non-Hodgkin's lymphoma (NHL) was also increased (SMR 4.2; 95%) among male cabin crew members (20,757 people). Importantly, any increase in cancers associated with ionizing (cosmic) radiation was not detected in this cohort study.

In another report, six incident cases of testicular cancer occurred within a cohort of 340 police officers between 1979 and 1991 in Seattle, Washington, observed/expected ratio was 6.9; $p < 0.001$ [23]. Occupational use of hand-held radar was the only shared risk factor among all six officers, and all had a routine habit of keeping the radar gun directly in close proximity to their testicles. Similarly, in Ontario, Canada risk assessment among police officers exposed to radar devices for speed measurement (1,596 females and 20,601 males) revealed an increased risk among men for testicular cancer (SIR 1.3) and for melanoma (SIR 1.45; 95 %) [24].

In another study, eighty seven persons working with radars (and 150 matched control) were divided into risk groups according to frequencies of MW (200 KHz to 26 GHz) and power density ($8 \mu\text{W}/\text{cm}^2$ to $300 \mu\text{W}/\text{cm}^2$) [15]. Three specific radiation cataracts in persons working with extremely high MW exposure were identified. Lens changes were associated with level of exposure in different risk groups.

Other occupational studies revealed the highest risk ratio (2.6) for acute myelogenous leukemia in radio and radar operators among all occupational groups studied [25]. In addition, excessive risk for breast cancer was detected (SIR 1.5) among Norwegian female radio and telegraph operators (2,619 women) with potential exposure to radio frequency (405 kHz — 25 MHz) [26].

RADIATION FROM MOBILE COMMUNICATION SYSTEMS AND CANCER PROMOTION

Cell phones. A significant increase of risk of particular brain tumors in long-term (10 years or more) users of cell phones and cordless phones has been detected in series of epidemiological studies of Swedish oncologist Prof. L. Hardell with colleagues [27–33].

It is important that for a short-term use of cell phones similar effects were absent or less evident [4].

The risk of development of high-grade glioma has increased in more than 3 times (OR 3.1; 95 %) for bilateral users of cell phones and in more than 5 times (OR 5.4; 95%) for ipsilateral users after 10 years of using [34].

The risk of development of acoustic neuroma for bilateral users of cell phones was OR 2.9; 95% and OR 3.5; 95 % for ipsilateral users after 10 years of using [29].

Notably, the highest risk of brain tumors has been detected in the youngest users of cell phones (20–29-yr) among all analyzed age groups (20–80 years old), with OR 5.91; 95% for ipsilateral use of cell phones. The highest risk was associated with more than 5-year using period in the 20–29-yr age group for analog cell phones (OR 8.17; 95%) [28].

International multiyear Interphone project conducted under the management of the World Health Organization and substantially supported by industry, was an interview-based case-control study with 2708 glioma and 2409 meningioma cases and matched controls, conducted in 13 countries using a common protocol [35]. The results of study were rather controversial. For example, authors were forced to declare “a reduced odds ratio related to ever having been a regular mobile phone users was seen for glioma (OR 0.81; 95 %) and meningioma (OR 0.79; 95 %), possibly reflecting participation bias or other methodological limitations.” However, significantly increased risks of tumors development in “heavy” users of cell phones (with more than 1640 hours of using during less than four years) have been revealed in this study: for meningioma OR 4.8; 95 %, for glioma OR 3.77; 95% as compared with the matched controls [35]. One thousand and six hundred forty hours per four years means about one hour per day of a cell phone use. In this connection we can point to our data [36] that indicates amount of time which Ukrainian students (like students in other countries?) spend talking via cell phones every day. Our findings indicated that more than a half of them spend over one hour per day, and more than a quarter of them spend over two hours per day talking via cell phones every day.

Parotid gland, like a human brain, is another potential target for cell phone MW radiation during cell phone talks without hands-free devices. Thus, a study done by an Israeli team has indicated an association between a cell phone use and parotid gland tumors [37]. This study comprised 402 benign and 58 malignant cases of parotid gland tumors diagnosed in Israelis at age over 18 years in 2001–2003. The risk of parotid malignant tumors in intensive users of cell phones (for users with more than 5,479 hours of a use during less than five years) were OR 2.26; 95%. Recently new data have been published that totally a 4-fold increase of parotid malignant tumors in Israel during 1970–2006 took place, whereas other salivary glands tumors had been almost on a stable level

during that period of time [38]. Previously, a Finnish study has revealed the OR 5.0; 95% for salivary gland cancer among all Finland digital cell phone subscribers compared with control population after one-two years of a cell phone use [39].

The odds ratio for Non-Hodgkin’s lymphoma of T-cell, cutaneous and leukemia types has been found for analogue-cell-phone users as 3.4; 95%; for digital-phone users 6.1; 95 %; and for cordless-phone users 5.5; 95% by L. Hardell group [40]. An American study indicated OR 1.6; 95 % for NHL in users of cell phones with a period of use over eight years [41].

Uveal melanoma (in analysis of 118 cases with uveal melanoma and 475 controls in Germany) has been indicated to have odds ratio 4.2; 95% for people probable/certain exposed to cell phone radiation [42].

Testicular cancer (seminoma) risk had odds ratio 1.8; 95% for men keeping a cell phone during “stand by” in ipsilateral trousers pocket [43]. The results have been based on 542 cases of seminoma in Sweden.

Base transmitting stations. During the last decades more than one and half million base transmitting stations for mobile communication have been installed over the world. However, the World Health Organization suggested a priority to study effects mainly of cell phones, while discouraging studies on the effects of transmitting stations (with an exception of years 2003–2006 when WHO recommended studies of possible effects of radiation of transmitting stations as well) [44]. This is probably the main reason why only a few publications on this particular problem can be found to date [45–49].

The comparison of cancer cases among people living up to 400 m from base transmitting station and people living further than 400 m from station during 1994–2004 was carried out in Germany [48]. A total increase of cancer cases among people living nearby to transmitting station over the control population was 1.26 times during the first five-year period (1994–1998), and 3.11 times during the second five-year period (1999–2004) of operation of the station. Particularly, in the second period the increase of cancer cases was statistically significant both as compared with the population from more distant area and with the expected background incidence.

Population (n=622) living in the area nearby (up to 350 m) the cell phone base transmitting station (850 MHz, 1500 watt of full power) during one year of operation and matched individuals (n=1222) from other area have been compared in Israel [47]. There were 4.15 times more cases of cancer in transmitted station area than in the rest of a city. Relative cancer rates for females were 10.5 for close to station area, 0.6 for control area and 1 for the whole town. Cancer incidence of women in close to base station area was significantly higher ($p < 0.0001$) as compared with the control area and the whole city. Keeping in mind that very significant increase in a number of cancer cases took place during only one year period, the authors of the study suggested that MW could provoke latent

cases of cancer in inhabitants of the area nearby transmitting station.

French and Spanish researchers also revealed that inhabitants living near base station for mobile communication (up to 300 m) developed significantly higher rates of many subjective symptoms of health like headache, fatigue, sleep disorder, depression as compared with the matched control from distant area [49, 50].

RODENT MODEL OF CANCER PROMOTION BY MICROWAVES

A highly representative research has been carried out at the University of Washington, Seattle commissioned by US Air Force [51]. The experimental rats (100 animals) were exposed during 24 months at 21.5 hours per day to 2,450-MHz pulsed microwaves at 800 pps with a 10 μ s pulse width. The pulsed microwaves were square-wave modulated at 8 Hz. An average SAR was 0.4 W/kg for a 200-g rat. It was a model of long-term irradiation of Air Force pilots to pulsed microwaves of radar systems. Totally 155 indexes of metabolisms were checked out during the study. As a result, the most expressive effect of long-term MW irradiation of animals was a dramatic increase in a level of cancer cases. In total, 3.6 folds more cancer cases were detected in irradiated animals than in matched control. Lymphoma cases were diagnosed in the irradiated animals 4.5 times more often than in the control group. In addition, benign tumors of adrenal were detected seven folds more often in the irradiated animals than in the control.

In the next study under US Air Force contract, 200 female C3H/HeJ mice were exposed for 21 months (22 h/day, 7 days/week) to a horizontally polarized 435 MHz pulse-wave (1.0 ps pulse width, 1.0 kHz pulse rate) RF radiation environment with an incident power density of 1.0 mW/cm² (SAR 0.32 W/kg), while 200 mice were sham-exposed [52]. Although under the conditions of this study, an exposure of mice prone to mammary tumors did not affect the incidence of mammary tumors, when compared with the controls, some other tumor cases increased markedly. For example, bilateral cases of ovary epithelial stromal tumor raised by five folds; multiple cases of hepatocellular carcinoma, raised 3 folds, and adrenal gland tumor cases (total) raised 1.63 folds.

In the third published study of this series [53] the same prone-mammary tumor mice were irradiated during 20 months to continuous wave 2450 MHz MW radiation with SAR from 0.3 to 1 W/kg (20 h/day, 7 days/week). A hundred mice were exposed, while 100 mice were used as sham-exposed. As a result, the exposed mice had higher level of mammary tumors (1.27 folds), and higher total level of all types of tumor (1.38 folds) as compared with sham-exposed; the difference between groups was statistically insignificant. Meanwhile, multiple mammary tumor cases occurred in exposed mice twice more frequently than in sham exposed.

In other study mice with high incidence of spontaneous breast cancer and mice treated with 3,4-benzopyrene (BP) were irradiated to continuous wave 2,450 MHz microwaves in an anechoic chamber at 5 or 15 mW/cm² (2 hours daily, 6 sessions per week, 3 months) [54]. Irradiation with MW at either 5 or 15 mW/cm² resulted in acceleration of development of BP-induced skin cancer. Microwaves-exposed mice with high incidence of spontaneous breast cancer developed breast tumors earlier than control. Authors indicated that the promotion of cancer development and lowering of natural antineoplastic resistance was similar in mice exposed to MW at 5 mW/cm² and chronically stressed by confinement, but level of cancer cases in animals exposed to 15 mW/cm² was significantly higher as compared to chronically stressed by confinement control.

And in well-known study of M. Ripacholi *et al.* (1997) transgenic mice moderately predisposed to develop lymphoma spontaneously have been used for exposure to MW of 900 MHz, with pulse repetition frequency of 217 Hz, incident power densities of 2.6–13 W/m², and average SAR of 0.13–1.4 W/kg [55]. One group of mice (101 females) has been exposed for two 30-min periods per day during 18 months. Another group of mice (100 females) has been a sham-exposed control. Lymphoma risk was significantly higher, more than twice, in the exposed mice than in the matched control (OR 2.4; 95 %). In particular, follicular lymphoma was the major contributor to the increased tumor incidence.

MICROWAVES AND CELL METABOLISM

Free radical species, including reactive oxygen species (ROS), is an intrinsic feature of cell metabolism [56–58]. But disturbance of redox balance, uncontrolled activation of free radical processes, overproduction of ROS and/or suppression of antioxidant defense in cell often are the important signals of some hazardous changes in cell metabolism [59, 60]. That is why data indicated oxidative effect of some factor is extremely important in risk-assessment research.

A significant increase of ROS and nitrogen oxide generation in cells under non-thermal intensities of MW has been detected both *in vivo* [61–67] and *in vitro* [68–72]. Possibilities of mitochondrial and membrane NADH oxidase dependent ways of ROS generation in exposed cells have been suggested [71, 72]. Accordingly, it was found that the first step in MW (875 MHz, 0.07 mW/cm²) interaction with model cells (Rat1 and HeLa) was mediated in the plasma membrane by NADH oxidase, which can rapidly (during the minutes) generate ROS [72]. ROS directly stimulate matrix metalloproteinases and allow them to cleave and release heparin-binding epidermal growth factor (EGF). This secreted factor activates the EGF receptor, which in turn activates the extracellular-signal-regulated kinase (ERK) cascade and thereby induces transcription and other cellular pathways. On the other hand, on the model of purified human

spermatozoa exposed to MW (1.8 GHz, SAR from 0.4 W/kg to 27.5 W/kg) a significant overproduction of ROS in mitochondria was detected, along with a significant reduction in motility and vitality of spermatozoa [71]. All observed effects were significantly correlated with SAR levels, suggesting that significant effects of MW exposure occurred under non-thermal levels of MW.

Therefore, MW can induce cellular oxidative stress, which in turn can cause cancer stimulation [57, 59]. To that, it is known nowadays that in addition to damage via oxidative stress, ROS in cells can play a role of a secondary messenger for certain intracellular signaling cascades which can induce oncogenic transformation [60].

DNA damage in cells exposed to low-intensive microwaves both *in vivo* and *in vitro* was demonstrated during the last years in more than 50 independent studies [73]. The most often method used for detection of DNA damage after the MW exposure was alkaline Comet Assay. A statistically significant increase of both single strand and/or double strand breaks of DNA has been detected in humans [74, 75], animal models [76–79] and cell cultures [76, 80–83] exposed to low intensity microwaves.

Recently, an oxygen damage of DNA in human spermatozoa through formation of 8-hydroxi-2-deoxyguanosine (8-OH-dG) under non-thermal microwaves irradiation *in vitro* has been demonstrated [71].

Consequently, as DNA mutation is a critical step in carcinogenesis and increased level of 8-OH-dG takes place in many tumors [60], the possibility of MW to initiate oxidative damage of DNA is extremely dangerous signal for risk-assessment studies.

Ornithine decarboxylase (ODC) significantly changes its activity under conditions of non-thermal microwave exposure [84–88]. It was one of the first markers of carcinogenesis revealed to be activated under the low intensity microwaves exposure. ODC is involved in processes of cell growth and differentiation, and its activity is raised in tumor cells. Although overexpression of ODC is not sufficient for transformation of normal cells into tumorigenic ones, an increased activity of the enzyme was shown to promote the development of tumors from pre-tumor cells [89].

DISCUSSION AND CONCLUSIONS

In this review we presented evidences for carcinogenic effects of low intensity microwaves. Both epidemiological and experimental data led us to a conclusion that at least under certain conditions the exposure to long term low intensity MW can lead to tumorigenesis. Supporting evidences come from statistically significant epidemiological data based either on long-term analysis, e.g., on mortality of US Navy personnel in 20 years after expose during the Korean War [15], or on relatively short, one year exposure, e.g., by base transmitting station for mobile communication in Israel [47]. In the latter case we fully agree with the authors that MW exposure most likely results in acceleration

of pre-existed cancer development. It is of note here that the same conclusion was drawn in epidemiological research on fast increase cancer incidence among adult population in Colorado exposed to extremely low frequency radiation [90].

The main shortcoming of the most epidemiological data, both in military studies and in mobile communication risk assessment, is a lack of a strict dose measurement of exposure. We strongly suggest that in the forthcoming epidemiological studies the correct measurement of intensity and dosage of exposure should be obligatory. The example of a large-scale epidemiological research employing personal MW dosimeters can be found in recent studies in Germany [91–94]. On the other hand, we also realize that the levels of the MW exposure in contemporary epidemiological studies, at least in those which deal with mobile communication systems, were within the official “safety limits” set by appropriate national standards and ICNIRP recommendations. Therefore, taking into account the reviewed data, we conclude that the relatively long-term (e.g., 10 years) exposure to microwaves emitted from mobile communication devices operating within “safety limits” set by current regulating bodies can be considered as a potential factor for promotion of cancer growth. Indeed, in the most studies on rodents the intensity of MW exposure was appropriately measured, and in majority of them the MW intensity was below ICNIRP safety limits. Nevertheless, majority of these studies to a greater or lesser extent demonstrated obvious carcinogenic effects after long term exposure (up to 24 months). This further emphasizes that at least under certain conditions the exposure to both pulsed and continuous MW with intensities below the current official “safety limits” can indeed promote cancer development.

In addition, experimental evidences of involvement of typical markers of carcinogenesis like overproduction of reactive oxygen species or formation of 8-OH-dG under conditions of MW exposure further indicate potential danger of this type of radiation for human health. It is important to emphasize here that experimental data, especially obtained in studies *in vitro* often reveal significant biological effects even after short-term (e.g., only a few minutes) [72] and/or extremely weak intensity of exposure to MW (by several orders of magnitude lower than in ICNIRP recommendations) [95]. Taking these data into account we strongly suggest that currently used “thermal” assessment of potential hazards of MW exposure is far from being appropriate and safe.

Taken together, we state here that nowadays there is enough convincing data to appropriately assert that the long-term exposure to low intensity electromagnetic microwaves can indeed promote cancer development. To that, the official recommendations by ICNIRP and safety limits set by many national regulatory bodies for technical devices emitting microwave radiation, first of all for mobile communication systems, must be re-assessed according to the recent alarming

data; and additional studies for unprejudiced risk assessment must be carried out. At present, we strongly suggest for a wide implementation of precautionary principle for everyday microwave exposure that implies maximum restriction of excessive exposure.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Cell Towers - Neurological; Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields, A Long-term Study under Real-life Conditions; Umwelt-Medizin-Gesellschaft; (Buchner & Eger); 2011

Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields—A Long-term Study under Real-life Conditions

Klaus Buchner and Horst Eger

This follow-up of 60 participants over one and a half years shows a significant effect on the adrenergic system after the installation of a new cell phone base station in the village of Rimbach (Bavaria).

After the activation of the GSM base station, the levels of the stress hormones adrenaline and noradrenaline increased significantly during the first six months; the levels of the precursor dopamine decreased substantially. The initial levels were not restored even after one and a half years. As an indicator of the dysregulated chronic imbalance of the stress system, the phenylethylamine (PEA) levels dropped significantly until the end of the study period.

The effects showed a dose-response relationship and occurred well below current limits for technical RF radiation exposures. Chronic dysregulation of the catecholamine system has great relevance for health and is well known to damage human health in the long run.

Keywords: cell phone base station, long-term study, stress hormones, radiofrequency radiation, GSM transmitter, far-field radiation

----- Introduction

Despite the distribution of numerous wireless transmitters, especially those of cell phone networks, there are only very few real-life field studies about health effects available. In 2003, the Commission on Radiation Protection was still noticing that there are no reliable data available concerning the public's exposure to UMTS radiation near UMTS base stations (1).

Since the 1960s, occupational studies on workers with continuous microwave radiation exposures (radar, manufacturing, communications) in the Soviet Union have shown that RF radiation exposures below current limits represent a considerable risk potential. A comprehensive overview is given in the review of 878 scientific studies by

Prof. Hecht, which he conducted on behalf of the German Federal Institute of Telecommunications (contract no. 4231/630402) (2, 3).

As early as the 1980s, US research projects also demonstrated in long-term studies that rats raised under sterile conditions and exposed to "low-level" RF radiation showed signs of stress by increased incidences of endocrine tumors (4, 5).

Concerned by this "scientific uncertainty" about how radiofrequency "cell tower radiation" affects public health, 60 volunteers from Rimbach village in the Bavarian Forest decided to participate in a long-term, controlled study extending about one and a half years, which was carried out by INUS Medical Center GmbH and Lab4more GmbH in

Zusammenfassung**Veränderung klinisch bedeutsamer Neurotransmitter unter dem Einfluss modulierter hochfrequenter Felder - Eine Langzeiterhebung unter lebensnahen Bedingungen**

Die vorliegende Langzeitstudie über einen Zeitraum von eineinhalb Jahren zeigt bei den 60 Teilnehmern eine signifikante Aktivierung des adrenergen Systems nach Installation einer örtlichen Mobilfunksendeanlage in Rimbach (Bayern).

Die Werte der Stresshormone Adrenalin und Noradrenalin steigen in den ersten sechs Monaten nach dem Einschalten des GSM-Senders signifikant; die Werte der Vorläufersubstanz Dopamin sinken nach Beginn der Bestrahlung erheblich ab. Der Ausgangszustand wird auch nach eineinhalb Jahren nicht wieder hergestellt. Als Hinweis auf die nicht regulierbare chronische Schieflage des Stresshaushalts sinken die Werte des Phenylethylamins (PEA) bis zum Ende des Untersuchungszeitraums signifikant ab. Die Effekte unterliegen einem Dosis-Wirkungs-Zusammenhang und zeigen sich weit unterhalb gültiger Grenzwerte für technische Hochfrequenzbelastung. Chronische Dysregulationen des Katecholaminsystems sind von erheblicher gesundheitlicher Relevanz und führen erfahrungsgemäß langfristig zu Gesundheitsschäden.

Schlüsselwörter: Mobilfunk-Basisstationen, Langzeituntersuchung, Stresshormone, Mobilfunkstrahlung, Fernfeld

in cooperation with Dr. Kellermann from Neuroscience Inc.¹.

Common risk factors such as external toxic agents, parameters of the catecholamine system (6) were determined prior to the activation of the GSM transmitter and followed up in three additional tests for a period of more than 18 months. The informed consent of all participants included the condition that the data were to be published anonymously.

----- Materials and Methods

Study Setting and Selection of Study Subjects

In spring 2004, a combined GSMD1 and GSMD2 cell transmitter (900 MHz band) was installed on Buchberg mountain in D-93485 Rimbach (Lower Bavaria) with two sets of antenna groups each. The installation height of the antennas for both systems is 7.9 m; the horizontal safety distance along the main beam direction is 6.3 or 4.3 m, respectively. At the same tower, there is also a directional antenna at 7.2 m (7).

1) INUS Medical Center, Dr. Adam-Voll Str. 1, 93437 Furth im Wald, Tel.: 09973/500 5412, www.inus.de; Lab4more GmbH, Prof. Dr. W. Bieger, Paul-Heyse-Straße 6, 80336 München, Tel.: 089/54321 730, info@lab4more.de; NeuroScience Inc., Dr. Kellermann, 373 280th Street - Osceola, WI 54020 - USA, Tel.: +1/715/294-2144, www.neuroscienceinc.com.

Shortly after it had become known that the wireless transmitters were to be installed, all inhabitants of Rimbach had been asked to participate in a mass screening. The municipality has approximately 2,000 inhabitants. In 60 volunteers (27 male, 33 female) aged between 2 and 68, the levels of adrenaline, noradrenaline, dopamine, and PEA (phenylethylamine)—which cannot be consciously regulated—were determined in their urine at the end of January/beginning of February 2004 (shortly before the activation of the antennas and the RF emissions beginning) as well as in July 2004, in January 2005, and in July 2005.

Most of these study participants signed up immediately after an informational gathering in late January 2004, at which the course of action by the cell phone service providers was criticized. Others signed up following a call for participation in the local paper. Since Rimbach is a small municipality, mouth-to-mouth propaganda also played a role. Participation was made attractive to the volunteers because a lab test that usually would be very expensive was offered for a small fee. Since the study required to show the status of the biological parameters over a given time period, only those study subjects participating in all four tests are included.

The data presented below come primarily from volunteers who have a certain interest in the life of their community and their health. Other persons joined the stress hormone investigation because of the recommendation of, or request by, their fellow citizens. This does not meet the requirements for a random sample. The result of this study, however, is hardly affected because Rimbach is a very small municipality. Therefore, the social contacts that lead to participation are very important. Most probably they do not affect the blood parameters. Furthermore, numerous large families participated as a whole whereby the health status of the individual family members did not play any role. For this reason, but especially because of the population structure, the study includes many children but only a few adolescents and young adults: there are hardly any opportunities for occupational training in Rimbach. In contrast, the municipality is attractive to young families with many children.

Sample Collection

The second morning urine was collected at INUS Medical Center on Mondays between 9:00 and 11:00 a.m. We made sure that each participant's appointment was always scheduled for the same time and that the time of breakfast or the state of fasting was the same for each participant at all tests. On the same day, the samples were sent by express to *Labor Dr. Bieger* in Munich where they were processed. In addition, samples were also sent to a laboratory in Seattle for control analyses (8-11).

Medical History

Medical doctors of the INUS Medical Center took a thorough medical history of each participant. At the initial test, the following data were also gathered: exact address, average time spent at home, indoor toxins, stress due to heavy-traffic roads, and the number of amalgam fillings. The latter number also included fillings that had already been removed. A nine-year-old child was noted to be electro-

sensitive to the effects of household wiring and connected appliances. All other study participants declared themselves to be not electrosensitive.

When taking their medical history, participants were also questioned about subjective symptoms and chronic diseases at the start of the study and during its course; if overweight, this was also noted. In this study, overweight in adults is defined as a weight greater than the "body height in cm minus 100 plus 5 kg tolerance."

Consistency checks for the parameter "overweight," however, indicate that—especially with regard to children—different criteria have been applied during the taking of the medical history. These data, therefore, can only serve as a reference point. They are listed here anyhow since they can provide suggestions for further studies.

All atopic disorders such as:

1. Hay fever, neurodermatitis, allergies, asthma, eczema are referred to as "chronic disorders;" as well as
2. All chronic inflammations such as interleukin- or COX-2-mediated problems;
3. All autoimmune diseases such as rheumatism, multiple sclerosis (MS);
4. All chronic metabolic disorders such as diabetes, liver diseases, intestinal diseases, kidney diseases.

Out of the 16 chronically affected participants 12 had allergies.

It was also asked whether there were DECT, Wi-Fi, or Bluetooth devices in the house or apartment during the study period from late January 2004 until July 2005. Also included were those devices present only for part of the study period, but not those turned off at night.

Exposure Level Measurements

For the most part, Rimbach municipality is located at one side of a narrow V-shaped valley. The cell phone base station is situated almost right across from the village center on the other side. RF radiation levels were measured at the outside of the residences of all study participants, wherever possible with direct line of sight of the transmitter. Because the municipality is located on a slope, great differences were noted inside homes—depending on whether or not a line of sight to the transmitter existed. In three cases, it was possible to measure the exposure levels at the head end of the bed. In these cases, the peak value of the power density was lower by a factor of 3.5 to 14 compared to measurements in front of the house with direct line of sight to the transmitter. The exact location of DECT, Wi-Fi, and Bluetooth base stations (if present) as well as possible occupational exposures, etc. were not determined by most participants.

At first, the measurements were taken with a broadband RF meter HF38B of Gigahertz Solutions, for which the manufacturer guarantees an error margin of max. ± 6 dB (+ 7 decimal places; but this error can be mostly eliminated by selecting the appropriate measurement range). However, an inspection revealed that the error margin was less than ± 3 dB. In addition, the broadband RF meter

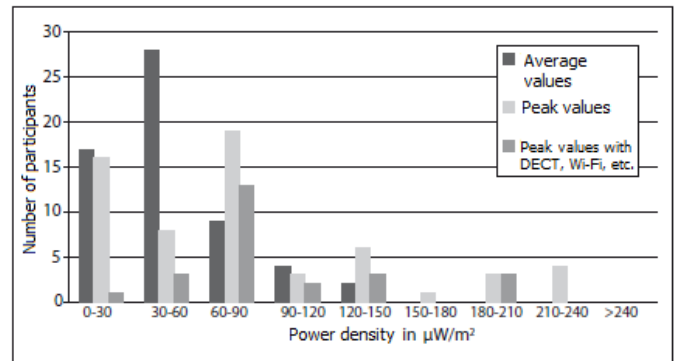


Fig. 1: Classification of participants based on average or peak value of the GSM power density level

HF59B (± 3 dB, ± 5 decimal places) was used at several points. With this RF meter, relevant frequencies can be analyzed with variable filters, the ELF modulation frequencies via fast Fourier analysis.

By using broadband RF meters, the testing effort and expense are reduced compared to spectrum analyzers. Thus, it was possible to take measurements at a greater number of points, and as a result, it was easier to determine the maxima and minima of the power density levels. Furthermore, the accuracy of high-quality broadband RF meters is similar to that of spectrum analyzers.

In this study, only cell phone signals are considered: not DECT, Wi-Fi, or Bluetooth devices inside homes or emissions from broadcast or TV stations at *Hohenbogen*, a mountain above Rimbach. For the most part, the emissions from the latter transmitters remained stable during the study period, whereas the focus of this study is on changes in exposure levels. For almost all sample measurements, the portion of the exposure due to the transmitter at *Hohenbogen* was at maximum $35 \mu\text{W}/\text{m}^2$ (peak value). It was higher in the residences of only two study participants: $270 \mu\text{W}/\text{m}^2$ (average) or $320 \mu\text{W}/\text{m}^2$ (peak), respectively. At these residences, the GSM exposure was approximately $10 \mu\text{W}/\text{m}^2$.

For the assessment, the peak values of the signals are used because, in the case of GSM radiation, they are less dependent on the usage level than average values. The peak value of the power density for all study participants from Rimbach was on average $76.9 \mu\text{W}/\text{m}^2$ (Tab. 1).

In Figure 1 the exposure of the participants is given as power density levels in increments of $30 \mu\text{W}/\text{m}^2$.

Classification of Participant Group and Exposure Levels

Sixty persons participated in the study; their age distribution is shown in Figure 2 according to year groups. In order to capture the effect of the cell phone base station, other environmental factors must be excluded as much as possible. It is vitally important to ensure that no major differences between high-exposure and low-exposure persons influenced the results.

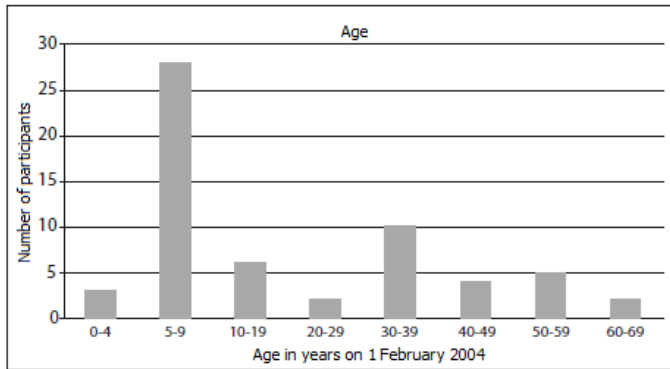


Fig. 2: Age distribution of study participants on 1 February 2004

	All	≤ 60 $\mu\text{W}/\text{m}^2$	60-100 $\mu\text{W}/\text{m}^2$	> 100 $\mu\text{W}/\text{m}^2$
Participants	60	24	20	16
Power density, avg ($\mu\text{W}/\text{m}^2$)	76.9	21.7	68.1	170.7
Healthy adults	20	9	5	6
Sick adults	9	6	2	1
Healthy children	24	9	7	8
Sick children	7	0	6	1
Overweight	14	7	3	4
Amalgam number	12	5	3	4
Evaluation of amalgam/person	120	76.4	32.7	240
Street	8	0	8	0
Indoor toxins	17	7	6	4
DECT, Wi-Fi, Bluetooth	25	4	14	7

Tab. 1: Data on the 60 study participants who are classified into exposure groups 0 - 60 $\mu\text{W}/\text{m}^2$, 60 - 100 $\mu\text{W}/\text{m}^2$, and above 100 $\mu\text{W}/\text{m}^2$, based on relevant peak values of GSM exposure in front of their residence.**Additional information:****Power density, avg ($\mu\text{W}/\text{m}^2$)** means: average peak value of GSM exposure level in the relevant category;**Healthy adults:** adults without chronic diseases. Participants who were born after 1 February 1994 are referred to as children, all others as adults;**Sick adults:** adults with chronic diseases;**Healthy children:** children without chronic diseases;**Sick children:** children with chronic diseases;**Overweight:** see text;**Amalgam number:** number of participants who had at least one amalgam filling (which may have been removed prior to the study period);**Evaluation of amalgam/person:** For each tooth with an amalgam filling of a participant, the size of the filling (values from 1 to 3) is multiplied with the number of years this filling has been placed prior to the date of the initial test of this study (rounded up to the nearest whole number). The value in the table is the sum of these numbers for all amalgam fillings of a person in the respective category divided by the number of participants with amalgam fillings (= "amalgam number");**Street:** number of participants who live at a busy street;**Indoor toxins:** number of participants who have had contact with toxins, varnishes, preservatives, etc. at home or at work;**DECT, Wi-Fi:** number of persons who had DECT, Wi-Fi, Bluetooth or the like at home at the end of January 2004 or later.

As shown in Table 1, the group with exposure levels greater than 100 $\mu\text{W}/\text{m}^2$ included fewer chronically ill persons and fewer residences at heavy-traffic roads, but considerably higher amalgam exposures by dental fillings compared to the average of the participants. These differences, however, cannot explain the observed development of the blood parameters as will be shown further below. It should also be noted that the number of children in the group of ≤ 60 $\mu\text{W}/\text{m}^2$ is considerably lower than in the other two groups.

Statistics

Because of the large individual differences in blood values, their asymmetrical distribution, and because of the many "outliers," the assessment presented here focuses on the following problem: "Did the level of a given substance predominantly increase (or decrease, respectively) in the test subjects?" For this problem, the so-called signed-rank paired Wilcoxon test (12) is applied. How to determine the confidence intervals of medians is described in an easy-to-understand form in (13).

Due to the rather large differences in individual values, we refrained from carrying out additional statistical analyses, especially those with parametric methods.

Results**1 Clinical Findings**

Adrenaline, noradrenaline, and dopamine as well as phenylethylamine (PEA) levels were determined at the time when the medical history was taken at INUS Medical Center. Out of the 60 participants, eleven had sleep problems until the end of 2004. During the study period (until July 2005), eight additional cases with these problems were reported. At the end of January 2004, only two participants complained about headaches; eight additional cases were reported thereafter. For allergies, there were eleven cases in the beginning and 16 later; for dizziness five and eight; and for concentration problems ten and fourteen. Due to the limited number of participants, no meaningful statements can be made about changes during the study period regarding the conditions tinnitus, depression, high blood pressure, autoimmune diseases, rheumatism, hyperkinetic syndrome, attention deficit hyperactivity disorder (ADHD), tachycardia, and malignant tumors. (Tab. 2)

Symptoms	Before activation of transmitter	After activation of transmitter
Sleep problems	11	19
Headache	2	10
Allergy	11	16
Dizziness	5	8
Concentration problems	10	14

Tab. 2: Clinical symptoms before and after activation of transmitter

2 Adrenaline

The adrenaline level trends are shown in Figure 3. After the activation of the transmitter from January until July 2004, a clear increase is followed by a decrease. In participants in the exposure category above $100 \mu\text{W}/\text{m}^2$, the decrease is delayed.

Since the distribution of the adrenaline levels is very asymmetrical as shown in Figure 4, the median values are better suited for evaluation than the average values. However, there is no significant difference between the trend of the median and the trend of the average values (Tab. 3). But it stands out that, in the lowest exposure group with a power density below $60 \mu\text{W}/\text{m}^2$, median values do not decrease between July 2004 and January 2005.

The statement "The adrenaline values of study subjects increased after the activation of the transmitter, i.e. between January and July 2004" is statistically confirmed ($p < 0.002$), as well as the statement "The adrenaline level of the study participants decreased from July 2004 to July 2005" ($p < 0.005$). In the lowest exposure group, the increase is the smallest. Until the end of the study period, these values do not drop.

A certain dose-response relationship can be observed for the increase in adrenaline levels from January 2004 until July 2004. The increase in medians was $2.3 \mu\text{g}/\text{g}$ creatinine for all subjects. At an RF radiation level up to $60 \mu\text{W}/\text{m}^2$, creatinine was $1.0 \mu\text{g}/\text{g}$, and by contrast, for power density levels between 60 - $100 \mu\text{W}/\text{m}^2$ it was $2.6 \mu\text{g}/\text{g}$.

For subjects in the exposure group above $100 \mu\text{W}/\text{m}^2$, creatinine levels were found to be $2.7 \mu\text{g}/\text{g}$, i.e. this value did not increase. We refrain from any additional statistical analysis because, as shown further below, the increase in adrenaline levels was mainly observed in children and chronically ill participants whose numbers were not sufficient to be broken down into further subgroups.

		January 2004	July 2004	January 2005	July 2005
All	Average	8.56	10.79	8.84	9.14
	Median	7.44	9.75	8.40	7.45
	CI	5.9 - 8.4	6.6 - 11.7	6.1 - 10.0	6.5 - 9.6
0-60 $\mu\text{W}/\text{m}^2$	Average	8.9	10.3	7.7	9.0
	Median	6.4	7.4	7.8	7.4
	CI	3.8 - 10.3	4.6 - 13.2	3.4 - 9.4	5.5 - 11.1
60-100 $\mu\text{W}/\text{m}^2$	Average	7.9	10.4	8.4	9.0
	Median	7.4	10.2	8.1	7.2
	CI	5.3 - 10.0	6.6 - 12.8	5.0 - 11.2	6.4 - 9.7
>100 $\mu\text{W}/\text{m}^2$	Average	8.9	12.0	11.1	9.6
	Median	8.2	10.9	10.6	8.6
	CI	5.3 - 10.9	5.7 - 19.6	5.8 - 15.2	4.9 - 13.4

Tab. 3: Results for adrenaline levels in $\mu\text{g}/\text{g}$ creatinine
CI = 95% confidence interval of median

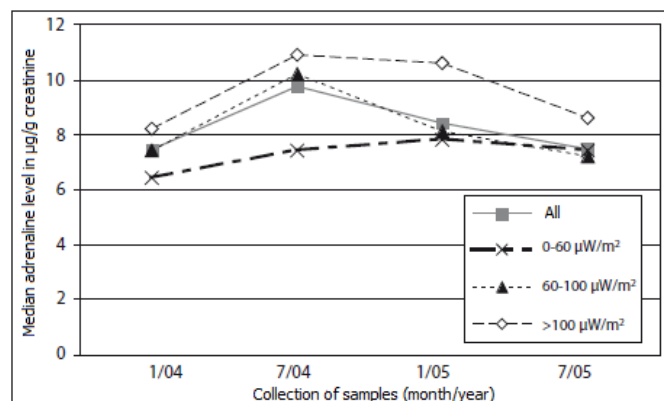


Fig. 3: Median adrenaline levels for all participating citizens of Rimbach whose cell phone base station exposure was above $100 \mu\text{W}/\text{m}^2$, between 60 and $100 \mu\text{W}/\text{m}^2$, or up to $60 \mu\text{W}/\text{m}^2$. The power density levels refer to peak values of the GSM radiation exposure in front of a given residence.

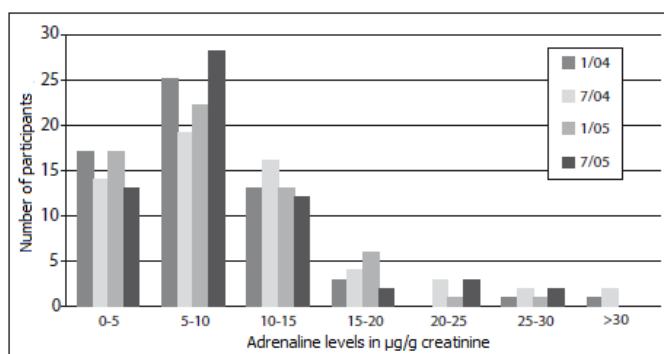


Fig. 4: Distribution of adrenaline levels in $\mu\text{g}/\text{g}$ creatinine

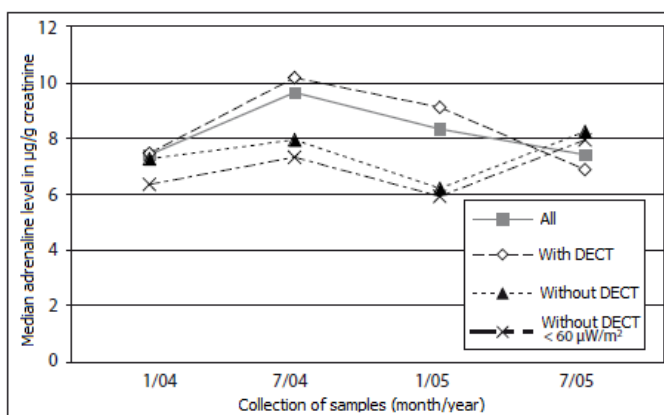


Fig. 5: Median adrenaline levels for all participating citizens of Rimbach who have a DECT phone, Wi-Fi, Bluetooth, or similar device, for those who do not have such wireless devices, and for the lowest exposure group without indoor wireless transmitters and with a GSM power density level up to $60 \mu\text{W}/\text{m}^2$.

The impact of indoor wireless devices such as DECT, Wi-Fi, and Bluetooth (the latter are not specifically mentioned in the graphs) are shown in Fig. 5. Within the first year after the activation of the GSM transmitter, i.e. until and including January 2005, the group with indoor wireless devices shows the strongest responses.

It is possible that in the less exposed subjects seasonal fluctuations or other factors such as "overshooting" of the values could have played a role.

It should be noted here that both the average as well as the median adrenaline values increased after the activation of the transmitter and decreased again after one year. This, however, only applies to exposure levels $>60 \mu\text{W}/\text{m}^2$. Chronically ill subjects and children showed especially strong responses; except for some "outliers," no effect was observed in healthy adults.

The adrenaline level of overweight subjects and those with an amalgam burden hardly changed during the study period (Fig. 6). In contrast, chronically ill subjects showed especially strong responses above average. In fact, the increase in the median values between January and July 2004 for all study subjects was predominantly caused by children and chronically ill subjects; adults without any chronic disease show a flat curve. During this period, an increased adrenaline level between 5 and 10.3 was measured in three healthy adults. Because of these "outliers," the average values for healthy adults clearly increased in contrast to the median values.

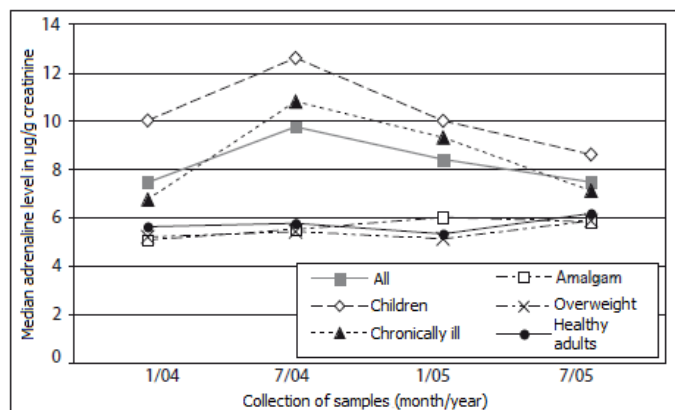


Fig. 6: Median adrenaline levels for participating children, for chronically ill subjects, for those with amalgam burden, and overweight subjects in Rimbach in comparison to the median levels of all study subjects and adults without chronic disease

The lower sensitivity of subjects with an amalgam burden can be explained by the fact that the effect occurs more often in children and that children according to our definition are younger than 10 years. They have hardly any fillings with amalgam.

3 Noradrenaline

The results for noradrenaline are similar to those for adrenaline (Tab. 4, Fig. 7). The statement that individual noradrenaline levels from January to July 2004 increased is statistically well supported with $p < 0.001$. The fact that the levels dropped between July 2004 and July 2005 is also well supported with $p < 0.0005$. Like in the case of adrenaline, the period under investigation is July 2004 to July 2005 to take the delayed decrease in the high exposure group into consideration. According to Table 4, the median of all noradrenaline levels increased from January to July 2004 for $11.2 \mu\text{g}/\text{g}$ creatinine; for exposures up to $60 \mu\text{W}/\text{m}^2$, there were $2.2 \mu\text{g}/\text{g}$ creatinine, at

$60\text{--}100 \mu\text{W}/\text{m}^2$ $12.4 \mu\text{g}/\text{g}$ creatinine, and above $100 \mu\text{W}/\text{m}^2$ $12.3 \mu\text{g}/\text{g}$ creatinine. As in the case of adrenaline, the increase for the last two groups is almost the same. Again, it is not possible to statistically verify a dose-response relationship. In Figure 7, a dose-response relationship

		January 2004	July 2004	January 2005	July 2005
All	Average	55.8	64.9	57.7	55.7
	Median	49.8	61.0	52.2	53.5
	CI	44.3-59.1	53.3-72.2	45.0-60.3	41.9-60.5
0-60 $\mu\text{W}/\text{m}^2$	Average	54.7	59.3	56.5	53.5
	Median	45.2	47.4	48.7	48.1
	CI	35.1-67.8	36.3-75.6	40.1-60.0	36.3-65.6
60-100 $\mu\text{W}/\text{m}^2$	Average	51.4	63.6	49.1	55.9
	Median	47.5	59.9	45.8	54.8
	CI	38.0-59.1	53.1-74.8	40.5-58.4	34.9-66.5
>100 $\mu\text{W}/\text{m}^2$	Average	62.9	74.9	70.1	58.8
	Median	58.8	71.1	71.6	56.3
	CI	49.9-87.3	54.9-91.6	48.7-89.1	36.9-81.6

Tab. 4: Results for the noradrenaline levels in $\mu\text{g}/\text{g}$ creatinine
CI = 95% confidence interval of the median

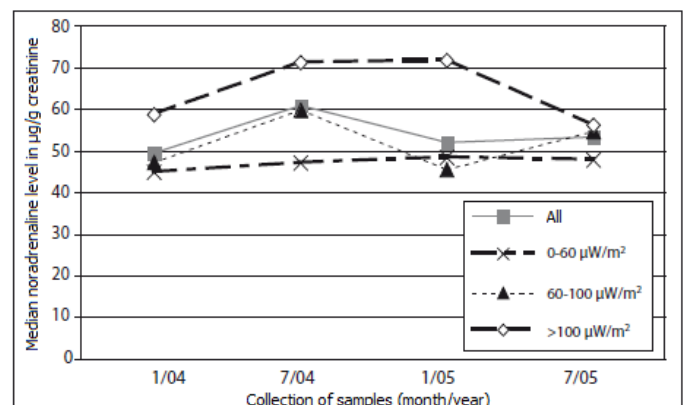


Fig. 7: Median noradrenaline levels in all participating citizens of Rimbach as a function of GSM power density levels (peak values)

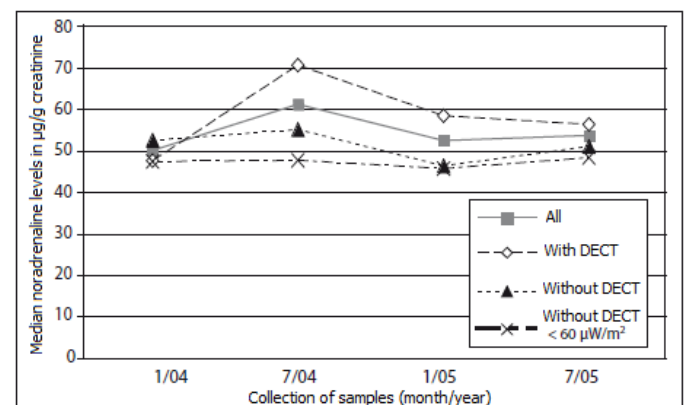


Fig. 8: Median noradrenaline values for subjects who had a DECT phone or other wireless devices at home, for those without indoor wireless devices, as well as for subjects without indoor wireless devices and with a GSM radiation exposure up to $60 \mu\text{W}/\text{m}^2$ (peak value measured in front of residence)

ELECTROMAGNETIC FIELDS

is seen, whereby the dot-dashed line serves as reference for persons with very low exposures. It stands out that the "recovery period," i.e. the decrease in values in 2005, drags on for longer in subjects in the exposure group with GSM radiation levels above 100 $\mu\text{W}/\text{m}^2$. This also corresponds with the behavior of the adrenaline levels.

In comparison with adrenaline, noradrenaline plays a somewhat greater role in residences where wireless devices existed before the beginning of this study (Fig. 8).

The trend in Figure 9 shows that children and chronically ill subjects in contrast to overweight subjects express strong responses to cell tower radiation. The ratios, however, are not as clearly visible as with adrenaline. Especially in overweight subjects, they indicate a slow response to GSM radiation.

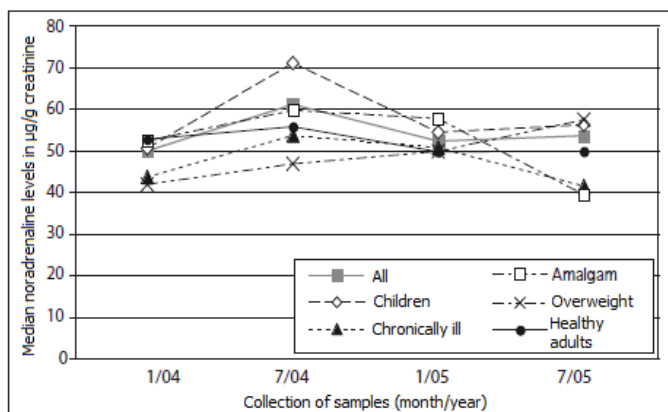


Fig. 9: Median noradrenaline levels of children, chronically ill subjects, those with amalgam burden and overweight subjects in Rimbach in comparison to the median values of all study subjects and healthy adults

Noradrenaline and adrenaline, however, responded very similarly.

4 Dopamine

For dopamine, inverse effects to those for adrenaline and noradrenaline were observed. The median dopamine levels decreased from 199 to 115 $\mu\text{g}/\text{g}$ creatinine between January and July 2004 (Tab. 5). The fact that the dopamine levels of the study subjects decreased during this period is highly significant ($p < 0.0002$). Thereafter, the median increased again: In January 2005, it was at 131 $\mu\text{g}/\text{g}$ creatinine, in July of this year 156. This increase is also significant (for increase between July 2004 and July 2005 $p < 0.05$).

This, too, is a dose-response relationship: from January to July 2004, the median for all subjects decreased for 84 $\mu\text{g}/\text{g}$ creatinine, in the exposure group up to 60 $\mu\text{W}/\text{m}^2$ for 81, in the exposure group above 100 $\mu\text{W}/\text{m}^2$ even 153 $\mu\text{g}/\text{g}$ (see Tab. 5 and Fig. 10). This dose-response relationship is statistically significant based on the signed-rank Wilcoxon test (12) with $p < 0.025$. The following statement applies: "The decrease in dopamine levels for exposure levels up to 100 $\mu\text{W}/\text{m}^2$ is smaller than at exposure levels above 125 $\mu\text{W}/\text{m}^2$."

In subsequent laboratory tests, the dopamine levels do not return to the same level as in January 2004. From Figure 11, it is obvious that the correlation with prior exposures to indoor wireless devices is small.

		January 2004	July 2004	January 2005	July 2005
All	Average	233	158	138	164
	Median	199	115	131	156
	CI	168-273	86-160	111-153	145-175
0-60 $\mu\text{W}/\text{m}^2$	Average	217	183	130	148
	Median	189	108	116	147
	CI	142-273	80-254	90-157	129-167
60-100 $\mu\text{W}/\text{m}^2$	Average	242	161	140	178
	Median	223	150	131	175
	CI	137-335	94-168	93-164	126-207
>100 $\mu\text{W}/\text{m}^2$	Average	244	115	147	170
	Median	244	91	151	156
	CI	139-316	48-202	117-169	138-209

Tab. 5: Results for dopamine levels in $\mu\text{g}/\text{g}$ creatinine
CI = 95% confidence interval of median

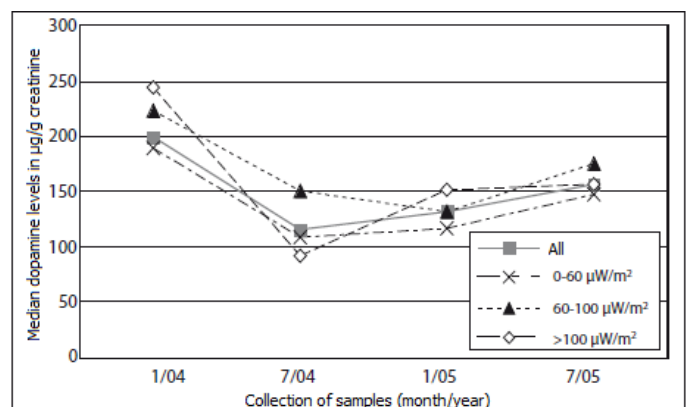


Fig. 10: Median dopamine levels for different GSM power density levels

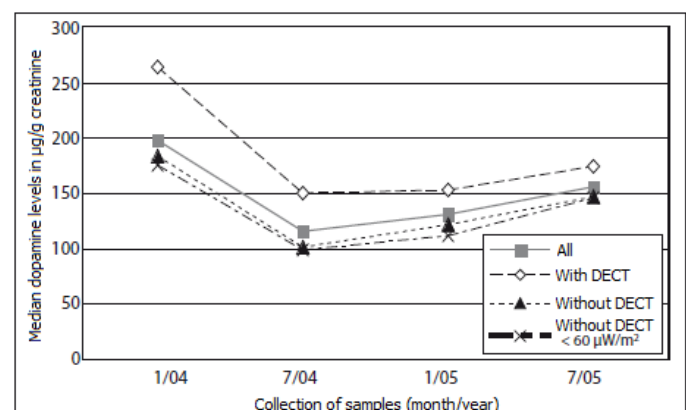


Fig. 11: Median dopamine levels for all participating citizens of Rimbach, for those with and without DECT phone, Wi-Fi, or Bluetooth, and for those without indoor wireless devices who had a GSM exposure level below 60 $\mu\text{W}/\text{m}^2$ (peak value).

It is to be emphasized that the lowest exposure group without such indoor wireless devices and with a GSM power density level $< 60 \mu\text{W}/\text{m}^2$ responds almost as strongly as all other study subjects. This is consistent with the data in Figure 10: the data suggest that the effect of the radiation on the dopamine levels can already be observed at very low power density levels; however, it still can increase at levels above $100 \mu\text{W}/\text{m}^2$.

Figure 12 shows that the radiation effect is somewhat more pronounced in children compared to the average, i.e. the gradient of the curves between the first two data points is somewhat greater. However, the difference is far too small to be statistically significant.

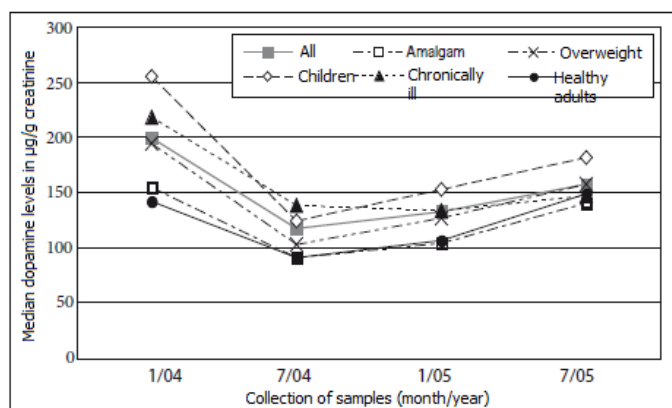


Fig. 12: Median dopamine levels of children, the chronically ill, with amalgam burden, overweight subjects, and healthy adults in Rimbach

In summary, dopamine levels decreased after the activation of the GSM transmitter and were not restored to the initial level over the following one and a half years. A significant dose-response relationship is observed. In children, the decrease is somewhat more pronounced than in adults.

5 Phenylethylamine (PEA)

Phenylethylamine (PEA) levels respond more slowly to the radiation compared to the substances investigated so far (Tab. 6, Fig. 13). Only in the exposure group above $100 \mu\text{W}/\text{m}^2$ GSM radiation do the PEA levels decrease within the first six months. Thereafter, hardly any differences can be discerned between PEA values of the various power density levels investigated here.

The decrease of PEA levels between July 2004 and July 2005 is highly significant ($p < 0.0001$)

Similar to adrenaline and noradrenaline, a previous exposure to indoor wireless devices intensifies the effect of the GSM radiation (see Fig. 14). The subjects of the low-exposure groups without indoor wireless devices do respond in a time-delayed fashion, but after six months they respond just as clearly as the subjects of the highest exposure group. In this regard, the PEA levels behave like those of dopamine in contrast to adrenaline and noradrenaline, which only respond to stronger fields.

		January 2004	July 2004	January 2005	July 2005
All	Average	725	701	525	381
	Median	638	671	432	305
	CI	535 - 749	569 - 745	348 - 603	244 - 349
0-60 $\mu\text{W}/\text{m}^2$	Average	655	678	523	329
	Median	604	653	484	243
	CI	477 - 835	445 - 835	279 - 675	184 - 380
60-100 $\mu\text{W}/\text{m}^2$	Average	714	699	535	451
	Median	641	678	426	330
	CI	492 - 746	569 - 790	310 - 804	293 - 438
>100 $\mu\text{W}/\text{m}^2$	Average	843	739	514	371
	Median	780	671	413	305
	CI	451 - 1144	334 - 822	338 - 748	157 - 513

Tab. 6: Results for phenylethylamine (PEA) levels in ng/g creatinine
CI = 95% confidence interval of median

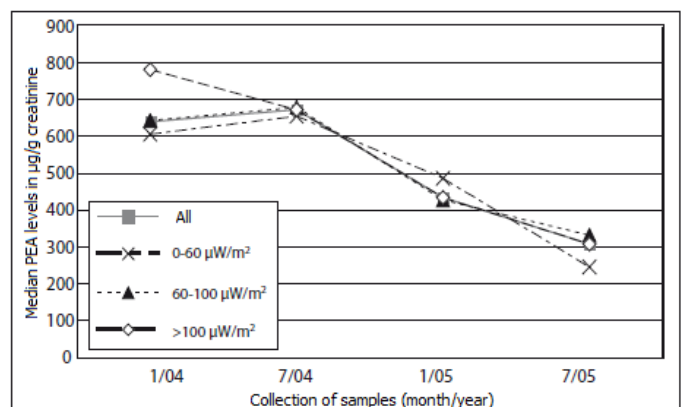


Fig. 13: Median phenylethylamine (PEA) levels for various GSM power density levels

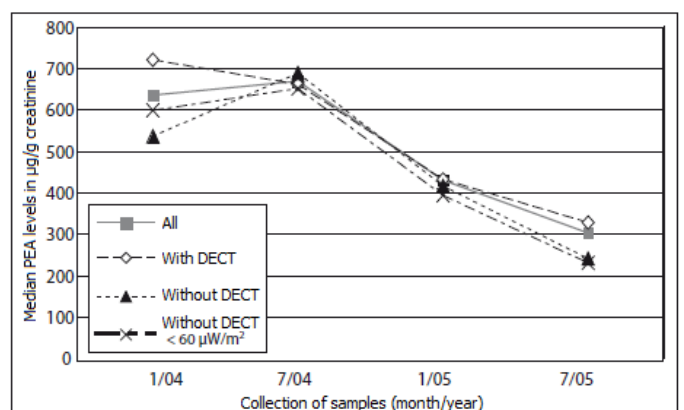


Fig. 14: Median phenylethylamine (PEA) concentrations in $\mu\text{g}/\text{g}$ creatinine of subjects with and without indoor wireless devices at home and subjects without indoor wireless devices with a GSM power density level below $60 \mu\text{W}/\text{m}^2$

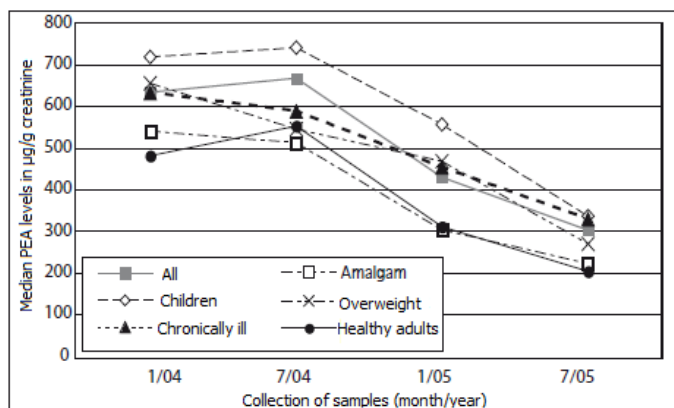


Fig. 15: Median phenylethylamine (PEA) concentrations in µg/g creatinine of children, the chronically ill, with amalgam burden, and overweight subjects, as well as health adults in Rimbach

In children, the effect of GSM radiation on their PEA levels is no greater than in the average of the study subjects; healthy adults also do not respond substantially differently. In contrast to the other substances looked at so far, the group of overweight subjects does respond particularly rapidly to PEA.

Summary of Results

Adrenaline and noradrenaline levels increase during the first six months after the GSM transmitter had been activated; thereafter, they decrease again. After an exposure period of one and a half years, the initial levels are almost restored. Only at power density levels above $100 \mu\text{W}/\text{m}^2$ is this decrease delayed for several months. In contrast, dopamine levels decrease substantially after the exposure begins. Even after one and a half years, the initial levels are not restored. Six months after the activation of the transmitter, PEA levels decrease continuously over the entire exposure period. Only in the exposure group above $100 \mu\text{W}/\text{m}^2$ is this effect observed immediately. All findings were observed well below current exposure limits (14).

Wireless devices used at home such as DECT, Wi-Fi, and Bluetooth amplify the effect of the GSM radiation. In the case of adrenaline and noradrenaline, almost exclusively children and chronically ill subjects (here mostly subjects with allergies) are affected. However, the response of chronically ill subjects to dopamine and the response of children to PEA are very similar to those found in the average of the study subjects. Except for PEA, overweight subjects show only very weak responses to GSM radiation.

Discussion

Catecholamine System and Phenylethylamine (PEA)

The survival of mammals depends on their ability to respond to external sources of stress. An established, well-researched axis of

the human stress system represents the catecholamine system (6, 15, 16). It can be activated by psychic or physical stressors. Impulses mediated by nerves are responsible for an induction of the catecholamine biosynthesis at the level of tyrosine hydroxylase as well as dopamine beta-hydroxylase, whereby the effect is based on an induction of both enzymes. Many biochemical regulatory mechanisms tightly control catecholamine synthesis (8, 15, 17). Chronic dysregulation always leads to health problems in the long run. The development of high blood pressure under continuous stress serves as a clinical example; so-called "beta blockers" directly block the action of adrenaline and noradrenaline on the target receptors, and it is impossible to imagine medication-based therapy without them (15).

PEA can be synthesized from the essential amino acid phenylalanine either via tyrosine, dopamine, noradrenaline, and adrenaline or via a direct biochemical path (15) (Fig. 16). The sympathetic-mimetic effect of PEA was first described by Barger in 1910 (18).

PEA is also synthesized from phenylalanine and is considered a superordinate neuromodulator for the regulation of catecholamine synthesis (19-22).

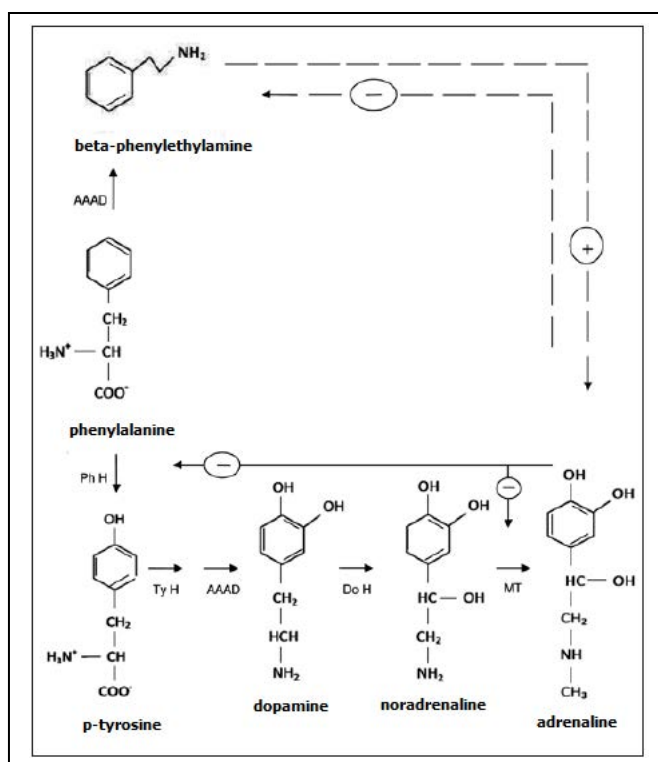


Fig. 16: Chemical structure of derivatives of the essential amino acid phenylalanine and the simplified synthesis pathways of catecholamines or phenylethylamine, respectively, simplified according to Löffler (15).

Abbreviations
AAAD: aromatic L-amino acid decarboxylase,
DoH: dopamine beta-hydroxylase,
PhH: phenylalanine hydroxylase,
MT: n-methyltransferase,
TyH: tyrosine hydroxylase
—(—) — postulated feedback loop, - - (---) - - postulated feedback loop

In 1976, Zeller described the physiological relationships (23) and points out that PEA is released by the brain via electrical stimulation (24).

The effect mechanism of PEA in the catecholamine system is the center of current pharmaceutical research efforts. In molecular biological terms, intracellular TAAR (trace amine-associated receptor) G-protein-coupled receptors that mediate modulatory effects of PEA are verified (20).

For high nanomolar to low micromolar PEA concentrations, in vivo studies have shown amphetamine-like effects. During an increase of PEA, an increased amount of noradrenaline and dopamine is also released and the reuptake of these substances is impaired (25, 26).

According to Burchett, the following effects of PEA amplifying the catecholamine effect are assumed to be known: Direct agonist action via increased release of transmitters, reuptake inhibition, and stimulation of transmitter synthesis as well as inhibition of monoamine oxidase (MAO) (19). PEA's high lipophilia—a prerequisite for the permeability of membrane barriers such as the blood-brain barrier—is of note here; PEA levels in the brain, serum, and urine correlate quite well (10, 21, 25, 27).

The clinical relevance of changed PEA levels is well documented for mental illnesses. Endogenous depression is associated with lowered PEA levels, whereby the transition from depression to manic episodes is accompanied by an increase in PEA levels (28-32).

The therapeutic increase in the PEA level has a positive impact on the course of the disease. Phenylalanine improves the effectiveness of antidepressants; PEA by itself is a good antidepressant—effective in 60% of the cases of depression.

In persons with ADD/ADHD (attention deficit hyperactivity disorder), PEA levels are substantially lower; the ADHD treatment with methylphenidate (Ritalin®) normalizes PEA excretion in the urine of responders (33, 34).

Contributing Factors

Laboratory tests of catecholamine have been established for years. Increased values are found in disorders such as pheochromocytoma, neuroblastoma, and arterial hypertension, whereby it is impossible for a subject to consciously regulate these values. Especially urine tests offer a sufficient level of sensitivity and specificity because urine contains 100 to 1000 times higher levels than blood plasma. The intraindividual variation coefficient ranges from 7% to 12% from one day to another; stored under appropriate conditions, the stability of the samples can be guaranteed without problems (8).

In Rimbach, urine samples were always collected at the same time of the day so that a circadian dependence could be ruled out. Other contributing factors such as increased physical activity as well as large meals were also ruled out by collecting the urine in the morning. Seasonal factors of the samples collected twice in winter and

summer should have been reflected as undulating levels in the testing results. Only in the adrenaline levels of the lower exposure groups (Fig. 5) can such a corresponding correlation be found. All other data did not indicate any seasonal influences.

In the study presented here, the selection of the participating citizens of Rimbach was not based on random assignment, but on self-selection. We can assume that the subjects, especially the adults, had informed themselves about the issue of cell tower radiation. However, because it is impossible to consciously regulate these levels, this self-selection should not make any difference in this study.

Especially in children below age ten, it is not thought possible to maintain a chronic state of anxiety for one and a half years due to an abstract term such as cell tower radiation.

This study limits itself to the following type of questions: "Did the level of a given substance predominantly increase or decrease during the study period?" Independent of each model, this question can be clearly answered with the Wilcoxon test and the indication of the confidence interval. The corresponding results are statistically very well supported. Any statements beyond this—e.g. the dependence of levels on certain parameters—cannot be made because with 60 study subjects the number of cases is too small to establish the same type of statistical significance.

The great advantage of the "Rimbach data" is that prior to January 2004 the exposure levels were very low because there was no cell phone tower and because only a few citizens had installed DECT, Wi-Fi and similar devices. In addition, due to the testing equipment with a measurement accuracy of less than ± 3 dB combined with repeated control measurements, the classification of the exposure groups can be considered to be verified.

For the stress hormones adrenaline and noradrenaline, the increase occurred only after the installation and activation of the transmitter, and thereafter, levels continued to decrease but did not fully normalize.

For dopamine, significant differences in the dose-response relationship according to exposure group could be shown after the activation of the new cell tower antenna. Also, the consistently decreasing levels of the hypothetically superordinate regulatory PEA do not support the hypothesis that the stress factor for the observed changes in the adrenergic system would exclusively be found in the realm of psychological factors.

Mode of Action of Microwave Radiation

There is a wide range of evidence to interpret the newly emerging microwave exposures as an invisible stressor.

Microwaves are absorbed by living tissue. The frequencies used for cell phone technologies have a half-life penetration depth of several centimeters, whereby cell membranes constitute no obstacle (35).

Microwaves cause enzymes to malfunction directly by, for example, monomerization (36). Thus, it is conceivable that enzymes of the catecholamine system could be affected directly.

Intracellular processes are changed, and cellular mitosis is disturbed by forces acting on the cellular spindle apparatus (37, 38). The human body is required to provide a higher level of repair services that is comparable to a chronic state of stress. A decrease in adenosine triphosphate (ATP) due to microwave exposure could be demonstrated by Sanders in intracerebral tissue already in 1980 (39).

Within current exposure limits, Friedman could show the stress caused by microwaves in the cell membranes of a cell model (40). The oxygen radicals formed by NADH have an activating effect on subsequent intracellular cascades that amplify the membrane effect by a factor of 10^7 , which in turn substantially change intracellular processes (17). Even reproductive impairments due to microwaves are mediated by the formation of free radicals (41).

In industry, more and more microwave devices are being used for chemical peptoid syntheses, which allow for a 100 times faster and more precise production even without any measurable heating (42). The toxic effects of free radicals formed by microwaves are used in such technical applications as water purification (43).

In several studies, the chronic symptoms of residents near cell tower antennas were described (44-48). Interestingly, the expansion of wireless networks corresponds with the increase in prescription expenses for methylphenidate, a drug whose chemical structure is related to PEA and which is indicated in cases of attention deficit disorder (ADD) (49).

Long-term studies over five years suggested an increased cancer incidence due to microwave exposure (50, 51). Since the catecholamine system is directly linked with the nervous system within the psychoneuroimmunological framework beside its organ-specific effects, the observed increase in cancer incidence can now also be understood from a pathophysiological perspective (6, 15, 52, 53).

Hypothesis of the Course of the Stress Response in Rimbach

Significant research on the stress-response axis was carried out in the 1950s. Selye established the nowadays generally accepted theory of the general adaptation syndrome of the human body to a stressor (16). He distinguished between three stages in the stress response, which can be found again in the description of the microwave syndrome according to Hecht (2, 3). Thus, after the stages of alarm and resistance, the last stage of exhaustion sets in (Fig. 17). The parameters investigated in the Rimbach study follow this pattern.

STAGE I—Activation Stage

The results of the long-term study presented here show an immediate activation of the adrenergic system. After the activation of the cell phone base station under investigation, the parameters adrenaline and noradrenaline increase significantly within a period of one and a half years. Because of the increased production of the final hormones noradrenaline/adrenaline, the use of dopamine increases, and as a result, the dopamine level decreases. The de-

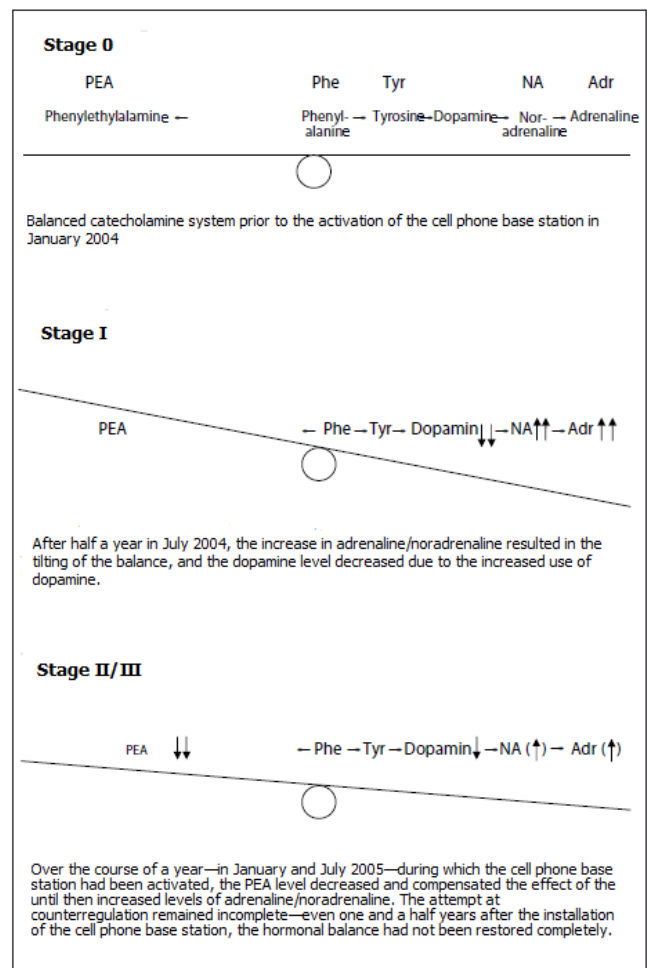


Fig. 17: Stage-like course of the stress response in Rimbach

crease in the dopamine level is the more pronounced, the higher the GSM radiation exposure level is at the residence of the individual participants.

STAGE II—Adaptation Stage

After this sympathicotonic activation stage, the body tries to compensate the increase in adrenaline and noradrenaline. In order to inhibit the overshooting catecholamine production and to ensure a stable regulation, the phenylethylamine level (PEA level) decreases. Here the decrease in PEA starts in the highest exposure group first.

STAGE III—Premorbid Stage

According to our hypothesis, the effects of adrenaline and noradrenaline are inhibited by feedback mechanisms at the expense of a chronically, over six continuous months, lowered PEA level. However, the attempt at counterregulation remains incomplete—even one and a half years after the installation of the cell phone base station; the hormonal balance had not been restored completely. The PEA level remains at a low level, which is to be interpreted as evidence for the beginning of exhaustion.

----- Conclusion

Thus, the following hypothesis is proposed: Although participants maintained their usual lifestyle, they developed chronic stress with a primary increase in adrenaline/noradrenaline and a subsequent decrease in dopamine in response to the microwave exposure from the newly installed cell phone base station. During the stage of counterregulation, the "trace amine" PEA decreases and remains decreased.

This is of considerable clinical relevance because psychiatric symptoms also exhibit altered PEA levels. In Rimbach, the increase in sleep problems, cephalgia, vertigo, concentration problems, and allergies could be clinically documented after the cell phone base station had been activated. The newly developed symptoms can be explained clinically with the help of disturbances in the humoral stress axis (53).

After having exhausted the biological feedback mechanisms, major health problems are to be expected. The possible long-term consequences of remaining caught in the exhaustion stage have already been described by Hecht and Selye (3, 16).

Thus, the significant results presented here not only provide clear evidence for health-relevant effects in the study subjects of Rimbach after a new GSM base station had been installed there, but they also offer the opportunity to carry out a causal analysis. This has already been successfully done in the "shut-down study" of Schwarzenburg, Switzerland (54). In Rimbach, the documented levels should return to normal once the relevant base station is shut down.

Epidemiological Evidence

There is current epidemiological evidence for the considerable clinical relevance of the dysfunction of the humoral stress axis with its endpoints of PEA decrease and adrenaline increase, as documented by us.

1. Decreased PEA levels can be found in a large portion of ADD/ADHD patients. As therapy methylphenidate is used, a substance that is structurally related to PEA. Between 1990 and 2004, the boom time of cell phones, prescription costs for this medication had increased by a factor of 86 (49, 55).

2. As part of the German Mobile Telecommunication Research Programme, approximately 3000 children and adolescents were studied in Bavaria for their individual cell phone radiation exposure levels in relation to health problems. Among the various data sets, the data set regarding behavioral problems showed a significant increased risk for both adolescents (OR: 3.7, 95%-CI: 1.6-8.4) and also children (OR: 2.9, 95%-CI: 1.4-5.9) in the highest exposure group (56). For the first time, the "Rimbach Study" provides a model of explanation in biochemical terms.

3. Pheochromocytomata are adrenaline- and noradrenaline-secreting tumors of the adrenal gland (57). This type of tumor due to microwave exposure has already been demonstrated in animal

experiments in 1985 (5). The increase of this disease in the US population is highly significant. Concurrent with the increase in local microwave exposures due to an increased number of base stations and use of wireless communication technologies, the number of cases have increased from 1,927 to 3,344 between 1997 and 2006 (58, 59).

It is a physician's responsibility—not bound by directives—to work toward the preservation of the natural basis of life regarding human health (60). Now it is the duty of the responsible agencies (public health department, Bavarian State Ministry of the Environment and Public Health as well as other federal ministries) to investigate the current situation.

Note

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Editor's Note

The above paper is identified as an original scientific paper and it was subject to a special peer-review process in cooperation with the Scientific Advisory Board.

The Editorial Team

Translation

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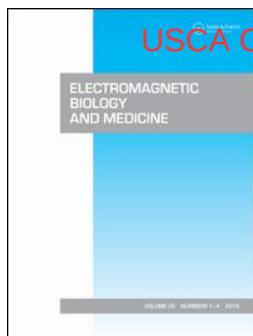
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Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations

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ABSTRACT

Radiofrequency radiations (RFRs) emitted by mobile phone base stations have raised concerns on its adverse impact on humans residing in the vicinity of mobile phone base stations. Therefore, the present study was envisaged to evaluate the effect of RFR on the DNA damage and antioxidant status in cultured human peripheral blood lymphocytes (HPBLs) of individuals residing in the vicinity of mobile phone base stations and comparing it with healthy controls. The study groups matched for various demographic data including age, gender, dietary pattern, smoking habit, alcohol consumption, duration of mobile phone use and average daily mobile phone use. The RF power density of the exposed individuals was significantly higher ($p < 0.0001$) when compared to the control group. The HPBLs were cultured and the DNA damage was assessed by cytokinesis blocked micronucleus (MN) assay in the binucleate lymphocytes. The analyses of data from the exposed group ($n = 40$), residing within a perimeter of 80 m of mobile base stations, showed significantly ($p < 0.0001$) higher frequency of micronuclei when compared to the control group, residing 300 m away from the mobile base station/s. The analysis of various antioxidants in the plasma of exposed individuals revealed a significant attrition in glutathione (GSH) concentration ($p < 0.01$), activities of catalase (CAT) ($p < 0.001$) and superoxide dismutase (SOD) ($p < 0.001$) and rise in lipid peroxidation (LOO) when compared to controls. Multiple linear regression analyses revealed a significant association among reduced GSH concentration ($p < 0.05$), CAT ($p < 0.001$) and SOD ($p < 0.001$) activities and elevated MN frequency ($p < 0.001$) and LOO ($p < 0.001$) with increasing RF power density.

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Antioxidants; genotoxicity; humans; micronucleus; power density

Introduction

The mobile phone base stations are one of the essential parts of mobile telecommunication as they transmit the signals in the form of radiofrequency radiations (RFRs) that are received by the mobile phones, acting as a two-way radio, i.e. transceiver (Kwan-Hoong, 2005), generally operating in the frequency range of 900 MHz to 1.9 GHz (Levitt and Lai, 2010). The ever-increasing subscription of mobile phones has led to a phenomenal increase in the mobile phone base stations required to cater to the needs of increasing demand of the mobile subscribers. For decades, there has been an increasing concern on the possible adverse effects of RFR on humans living near mobile phone base stations despite the fact that RFR spectrum are of low frequency (ARPANSA, 2011). There has been a link between the RFR exposures and several human health disorders including cancer, diabetes, cardiovascular and neurological diseases (Bortkiewicz et al., 2004; Eger et al., 2004; Havas, 2013; Lerchl et al., 2015; Wolf and Wolf, 2004). The International Agency for Research on Cancer (IARC, 2011) has classified RFR as a possible carcinogen

to humans (group 2B), based on the increased risk for glioma, a malignant type of brain cancer associated with wireless phone use (Hardell et al., 2013).

RFR may change the fidelity of DNA as the increased incidence of cancer has been reported among those residing near mobile phone base stations (Abdel-Rassoul et al., 2007; Bortkiewicz et al., 2004; Cherry, 2000; Eger et al., 2004; Hardell et al., 1999; Hutter et al., 2006; Wolf and Wolf, 2004). RFR emitted from mobile base stations is also reported to increase the DNA strand breaks in lymphocytes of mobile phone users and individuals residing in the vicinity of a mobile base station/s (Gandhi and Anita, 2005; Gandhi et al., 2014). Exposure of human fibroblasts and rat granulosa cells to RFR (1800 MHz, SAR 1.2 or 2 W/kg) has been reported to induce DNA single- and double-strands breaks (Diem et al., 2005). Irreversible DNA damage was also reported in cultured human lens epithelial cells exposed to microwave generated by mobile phones (Sun et al., 2006). The adverse health effects of RFR are still debatable as many studies indicated above have found a positive correlation between the DNA

damage and RFR exposure; however, several studies reported no significant effect of RFR on DNA strand breaks and micronuclei formation in different study systems (Li et al., 2001; Tice et al., 2002; McNamee et al., 2003; Maes et al., 2006). The potential genotoxicity of RFR emitted by mobile phone base stations can be determined by micronucleus (MN) assay, which is an effective tool to evaluate the genotoxic or clastogenic effects of physical and chemical agents. This technique has also been used to quantify the frequencies of radiation-induced MN in human peripheral blood lymphocytes (HPBLs) (Fenech and Morley, 1985; Jagetia and Venkatesha, 2005; Prosser et al., 1988; Yildirim et al., 2010).

Besides its effect on DNA damage and association of cancer in individuals living near mobile phone base station, the deep penetration of RFR within the living cells may cause overproduction of free radicals particularly reactive oxygen species (ROS), thereby inducing adverse effects in living cells (Yakymenko et al., 2015). ROS amount is also reported to increase during infections, exercise, exposure to pollutants, UV light, ionizing radiations, etc. (Kunwar and Priyadarsini, 2011). Uncontrolled generations of ROS can lead to their accumulation causing oxidative stress in the cells. Any chronic exposure to conditions that increase the oxidative stress leads to an increased risk of cancer, and elevated levels of cancer have been demonstrated in populations with increased residential exposure to RFR (Dart et al., 2013; IARC, 2011). The change in the activities of antioxidants such as glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) may be regarded as an indicator of increased oxidative stress (Kerman and Senol, 2012). Since lipid peroxidation (LOO) is a free-radical oxidation product of polysaturated fatty acids, detection and measurement of LOO is the evidence which is frequently cited to support the involvement of free-radical reactions in toxicity and disease progression (Gutteridge, 1995). The increasing use of mobile phones and installation of more mobile base stations stimulated us to obtain an insight into the genotoxic effects of RFR using MN assay and alteration in the antioxidant status in the PBLs of the individuals residing in the vicinity of the mobile phone base stations.

Methods

Chemicals

RPMI-1640 medium, phytohemagglutinin, acridine orange, bovine serum albumin (BSA), GSH reduced, nicotinamide adenosine dinucleotide (NADH), nitrobluete-trazolium (NBT) and *n*-butanol were purchased from HiMedia laboratories Pvt Ltd. (Mumbai, Maharashtra, India). Methanol, acetic acid, Folin-Ciocalteu reagent,

potassium tartarate, hydrogen peroxide (H₂O₂), trichloroacetic acid (TCA), hydrochloric acid (HCl) and potassium chloride (KCl) were purchased from MERCK (Mumbai, Maharashtra, India). Cytochalasin B, thiobarbaturic acid (TBA) and phenazinemetosulphate (PMS) were purchased from Sigma Aldrich Chemical Co (Bangalore, Karnataka, India) and 5,5'-dithio-2-nitrobenzoic acid (DTNB) was procured from Tokyo Chemical Industry (Tokyo, Japan).

Power density measurement from mobile phone base stations

Six mobile phone base stations, operating in the frequency range of 900 MHz (*N* = 2) and 1800 MHz (*N* = 4), erected in the thickly populated areas of Aizawl city were selected for the present study. Both dish and sectored antennas of each base station are arranged equilaterally that provide 360° network coverage. The power output of all the base stations is 20 W, with their primary beam emitting radiation at an angle of 20°. Power density measurements (using HF-60105V4, Germany) were carried out in the bedroom of each participant where they spent most of the time and hence have the longest constant level of electromagnetic field exposure. Power density measurement was carried out three times (morning, midday and evening), and the average was calculated for each residence around each base station. The main purpose of the measurement of power density was to ensure that RFR emission from each site did not exceed the safe public limits and to determine any difference in power density between selected households that were close to (within 80 m) and far (>300 m) from the mobile phone base stations. The safety limits for public exposure from mobile phone base stations are 0.45 W/m² for 900 MHz and 0.92 W/m² for 1800 MHz frequency as per Department of Telecommunications, Ministry of Communications, Government of India, New Delhi guidelines (DoT, 2012).

Selection of subjects

The study was carried out in Aizawl city (23°43'37.58''N and 92°43'3.49''E), Mizoram, India, during 2015 and 2016. Since the city is located in the hilly region, some residences are located horizontally with the top of the towers from which RFR are emitted, making it possible to get an exposure at a short distance of 1–20 m, despite being erected on the rooftop or in the ground. A minimum of two individuals were sampled from each household and at least five individuals were sampled around each mobile base station. Individuals sampled around each base station were matched for their age and gender (Table 1). The exposed group consisted of 40 healthy

Table 1. Composition of base stations and the demographic characteristics of the exposed group.

Base station	Components		Power density (mW/m ²)	Average age (years) of volunteers	Gender of volunteers	
	Disc antenna	Sector antenna			Male	Female
1	3	10	3.90-6.52	28.8	3	4
2	6	10	5.12-7.32	30.0	3	3
3	3	9	2.80-6.55	28.2	4	4
4	11	6	3.58-7.52	28.9	2	4
5	6	4	4.56-5.43	28.6	3	2
6	6	4	3.58-6.53	27.6	3	5

individuals who fulfilled the inclusion criteria of being above 18 years of age and residing in the vicinity of mobile phone base stations (within 80 m radius). The control group comprised of 40 healthy individuals matched for age and gender who had been living at least 300 m away from any mobile phone base stations. None of the participants have occupational exposure to RFR, and there were no electric transformer, high tension electric power line and radio and television transmitters close to (at least 500 m) their residences. Sampling was also done only from those residences who did not use microwave oven for cooking, Wifi devices and any other major source of electromagnetic field as they are known to cause adverse effects (Atasoy et al., 2013; Avendaño et al., 2012). The study was approved by the Human Ethics Committee, Mizoram University, Aizawl, India, and only those individuals who gave their voluntary written consent were included in the study.

Questionnaire used

A questionnaire was prepared to collect information on demographic data such as family and exposure histories, lifestyle such as smoking habit (≤ 10 cigarette in a day), alcohol consumption (three to four times a week) and dietary pattern, duration of stay near mobile phone base stations, duration of mobile phone use and average daily mobile phone use.

Blood sample collection and lymphocyte culture

The blood samples were collected by venipuncture from each volunteer of both groups in individual heparinized tubes. The lymphocyte culture was carried out according to the method described earlier (Jagetia et al., 2001). Briefly, the blood was allowed to sediment and the buffy coat containing nucleated cells was collected in individual sterile glass tubes. Usually 10^6 nucleated cells were inoculated into sterile glass tubes containing RPMI-1640 medium, supplemented with 10% fetal calf serum and phytohemagglutinin as the mitogen. The cells were allowed to grow for the next 44 h and cytochalasin B was added at a final concentration of 5 $\mu\text{g/ml}$ to block the cytokinesis

(Fenech and Morley, 1985). The cells were harvested at the end of 72 h after initiation of lymphocyte culture by centrifugation. The cell pellet was subjected to mild hypotonic treatment so as to retain the cell membrane and fixed in freshly prepared Carnoy's fixative (methanol: acetic acid, 3:1). The cell suspension was dropped onto precleaned coded slides to avoid observer's bias and stained with acridine orange. Usually a total of 1000 binucleate cells (BNCs) with well-preserved cytoplasm were scored from each individual using a fluorescence microscope (DM 2500, Leica Mikrosysteme Vertrieb GmbH, Wetzlar, Germany). Scoring of MN frequencies was performed based on the criteria of Fenech et al. (2003).

Biochemical estimations

The antioxidants were measured in the plasma of the study groups. Protein contents were measured by the method of Lowry et al. (1951) using BSA as the standard.

Glutathione

GSH contents were measured using the method given by Moron et al. (1979). Briefly, 80 μl of plasma was mixed with 900 μl of 0.02 M sodium phosphate buffer and 20 μl of 10 mM DTNB and incubated for 2 min at room temperature. The absorbance of the sample was read against blank at 412 nm in a UV-Visible spectrophotometer (SW 3.5.1.0. Biospectrometer, Eppendorf India Ltd., Chennai), and the GSH concentration was calculated from the standard curve and expressed in $\mu\text{mol/mg}$ protein.

Superoxide dismutase

The SOD activity was measured by the method of Fried (1975). Briefly, 100 μl each of plasma and 186 μM PMS were mixed with 300 μl of 3 mM NBT and 200 μl of 780 μM NADH. The mixture was incubated for 90 s at 30°C and 1 ml of acetic acid and 4 ml of *n*-butanol were added to stop the reaction. The blank consisted of all the reagents, and distilled H₂O was added instead of plasma. The absorbance of test and blank was measured at 560 nm using a UV-VIS spectrophotometer, and the

enzyme activity has been expressed in units (1U = 50% inhibition of NBT reduction)/mg protein.

$$\% \text{ inhibition} = (\text{OD of blank} - \text{OD of test} / \text{OD of blank}) \times 100$$

$$\text{SOD unit} = 1/50 \times \% \text{ inhibition.}$$

Catalase

The CAT activity was determined using the modified protocol of Aebi (1984). Briefly, 200 μl of 3% H_2O_2 was mixed with 50 μl each of plasma and 150 μl of 50 mM phosphate buffer (pH 7.0). The absorbance was recorded at 240 nm in a UV-VIS spectrophotometer. The decomposition of H_2O_2 can be followed directly by the decrease in absorbance. The enzyme activity has been expressed in units/mg protein. The catalytic activity of CAT at a time interval of 15 s was calculated by the following formula,

$$K = 0.153 (\log A_0/A_1)$$

where A_0 is the absorbance at 0 s and A_1 is the absorbance at 15 s.

Lipid peroxidation

The LOO was estimated by the method of Beuege and Aust (1978). Briefly, plasma was mixed with 10% TCA, 0.8% TBA and 0.025 N HCl in a 1:2 ratio. The mixture was boiled for 10 min in a boiling water bath. After centrifugation, the absorbance of the supernatant was recorded at 540 nm UV-VIS spectrophotometer.

Statistical analyses

The data are expressed as mean $\pm$ standard error of the mean. Student's " t " and Chi-square tests were used for comparison of demographic variables of the exposed and control groups. Pearson's correlation analysis was performed to determine the relationship between power density and the distance of residences from the base stations. Mann Whitney U test was applied to determine the significance between the control and exposed group for MN frequencies. Student's " t " test was performed to determine the significance between the groups for antioxidants. Multiple linear regression analyses were carried out for the prediction of MN frequency and antioxidants status separately from the demographic characteristics. SPSS Ver.16.0 software (SPSS Inc, Chicago, IL, USA) was used for statistical analyses. A p -value of less than 0.05 was considered statistically significant.

Results

The demographic characteristics of both exposed and control groups are depicted in Table 2. The groups matched for most of the demographic data such as age, gender, dietary pattern, smoking habit, alcohol consumption, mobile phone usage, duration of mobile phone use and average daily mobile phone use (Table 2). A highly significant variation ($p < 0.0001$) was observed for the distance of household from the base station (40.10 ± 3.02 vs. 403.17 ± 7.98 in m) between exposed and control groups. The data of RF

Table 2. Demographic data of the exposed and control groups.

Characteristics	Category	Exposed group		Control group		t/χ^2 -value	p -value (t/χ^2 -value)
		N (%)	M $\pm$ SEM	N (%)	M $\pm$ SEM		
Age (years)	20–30	26 (65)	28.6 $\pm$ 0.85	29 (72.5)	28.6 $\pm$ 0.85	1.074/–	0.286/–
	31–40	14 (35)		11 (27.5)			
Gender	Male	18 (45)		21 (52.5)		–/0.450	–/0.502
	Female	22 (55)		19 (47.5)			
Diet	Vegetarian	5 (12.5)		7 (17.5)		–/0.392	–/0.531
	Nonvegetarian	35 (87.5)		33 (82.5)			
Smoking habit	Yes	16 (40)		14 (35)		–/0.213	–/0.644
	No	24 (60)		26 (65)			
Alcohol consumption	Yes	7 (17.5)		9 (22.5)		–/0.312	–/0.576
	No	33 (82.5)		31 (77.5)			
Mobile phone usage	User	37 (92.5)		35 (87.5)		–/0.556	–/0.456
	Nonuser	3 (7.5)		5 (12.5)			
Duration of mobile phone use (years)	≤ 5	9 (24.32)	6.32 $\pm$ 0.265	11 (31.42)	5.91 $\pm$ 0.296	1.032/–	0.306/–
	> 5	28 (75.68)		24 (68.58)			
Daily mobile phone use (hours)	≤ 3	24 (64.86)	3.054 $\pm$ 0.229	25 (71.42)	2.800 $\pm$ 0.156	1.145/–	0.256/–
	> 3	13 (35.13)		10 (28.58)			
Distance from the base station (m)	1–20	8 (20)	40.10 $\pm$ 3.02		403.17 $\pm$ 7.98	42.046/–	0.0001/–
	21–40	12 (30)					
	41–60	13 (32.5)					
	61–80	7 (17.5)					
Power density (mW/m ²)	Range	2.80–7.52	5.002 $\pm$ 0.182	0.014–0.065	0.035 $\pm$ 0.002	27.247/–	0.0001/–
Duration of residing near the base station (years)	5–10	33 (82.5)	7.85 $\pm$ 0.419	–	–	–	–
	11–15	7 (17.5)					

power density were collected from 23 houses, each of the exposed group staying within a perimeter of 80 m and those of control group staying at least 300 m away from mobile phone base stations. The RF power density of the exposed group ($2.80\text{--}7.52\text{ mW/m}^2$; average $5.002 \pm 0.182\text{ mW/m}^2$) was significantly higher ($p < 0.0001$) when compared to the control group ($0.014\text{--}0.065\text{ mW/m}^2$; average $0.035 \pm 0.002\text{ mW/m}^2$). The highest power density was recorded at a distance of 1–20 m ($6.44 \pm 0.31\text{ mW/m}^2$), which is significantly higher ($p < 0.0001$) than those at a distance of 21–40 m (4.79 ± 0.33), 41–60 m (4.48 ± 0.22) and 61–80 m (4.61 ± 0.10). No significant variation was observed for the RFR power density among the distance ranges of 21–40 m, 41–60 m and 61–80 m (Table 1). Nevertheless, there was a highly significant negative correlation between distance from the base station and the power density ($r = -0.509$, $p < 0.0001$).

The MN frequency and LOO were significantly ($p < 0.0001$ for MN and LOO) higher in the exposed group as compared to that of control group, while antioxidants were significantly ($p < 0.01$ for GSH; $p < 0.001$ for CAT and SOD) lower for the exposed group compared to controls irrespective of their demographic characteristics (Tables 3 and 4). On consideration of the demographic characteristics, smokers had significantly higher MN frequency ($p < 0.001$) and LOO ($p < 0.01$) and significantly lower GSH ($p < 0.01$) and SOD ($p < 0.01$) than nonsmokers within each study group. Similarly, alcoholics compared to nonalcoholics had significantly higher MN frequency ($p < 0.01$) and

significantly lower GSH ($p < 0.01$) within the exposed group and significantly higher MN frequency ($p < 0.001$) and LOO ($p < 0.01$) within the control group. The smokers of the exposed group had significantly higher MN frequency ($p < 0.001$) and LOO ($p < 0.01$) and significantly lower CAT ($p < 0.001$) and SOD ($p < 0.05$) activities than the smokers of control group. Alcoholic among exposed group also had significantly higher MN frequency ($p < 0.05$) and significantly lower GSH ($p < 0.05$) concentration and CAT ($p < 0.01$) and SOD ($p < 0.05$) activities than the alcoholic of control group. MN frequency and antioxidant status with LOO showed no significant variations between the ages, genders and dietary pattern within the exposed group. Among controls, males compared to females had significantly ($p < 0.05$) higher MN frequency (Table 3).

There was no significant variation in the MN frequency and antioxidant status between mobile phone user and nonuser of exposed group, while individuals who have been using mobile phone for more than 5 years had significantly higher MN frequency ($p < 0.01$) and lower GSH ($p < 0.05$) than those using for less than 5 years. Similarly, exposed group with average daily mobile phone use of above 3 h showed a higher MN frequency ($p < 0.05$) than those having the average daily use of less than 3 h (Table 4). Among the control group, features of mobile phone usage showed no variation in MN frequency and antioxidant status. Significantly lower levels of antioxidants ($p < 0.05$ for GSH; $p < 0.001$ for CAT; $p < 0.01$ for SOD) and higher

Table 3. Function of the demographic characteristics on MN frequencies and the antioxidant status of exposed and control groups.

	Characteristics	Category	N	GSH	CAT	SOD	LOO	MN/1000 BNC
				(M±SEM)	(M±SEM)	(M±SEM)	(M±SEM)	(M±SEM)
EXPOSED GROUP	Age (years)	20–30	26	4.604 ± 2.68**	0.022 ± 0.001***	1.832 ± 0.11***	0.646 ± 0.064***	38.15 ± 1.65**
		31–40	14	3.882 ± 2.09	0.021 ± 0.001***	1.791 ± 0.11**	0.755 ± 0.101*	43.71 ± 2.64**
		Total	40	4.351 ± 1.95**	0.021 ± 0.001***	1.823 ± 0.08***	0.677 ± 0.054***	40.10 ± 1.46***
	Gender	Male	18	4.209 ± 3.08*	0.020 ± 0.001***	1.802 ± 0.12**	0.667 ± 0.072**	40.77 ± 2.71*
		Female	22	4.467 ± 2.54	0.023 ± 0.001***	1.834 ± 0.11***	0.686 ± 0.080**	39.54 ± 1.51***
	Dietary pattern	Vegetarian	5	4.360 ± 4.26*	0.019 ± 0.001**	1.913 ± 0.18**	0.650 ± 0.040***	40.20 ± 2.87***
		Nonvegetarian	35	4.350 ± 2.17*	0.022 ± 0.001***	1.807 ± 0.09***	0.682 ± 0.053***	40.08 ± 1.63***
	Smoking habit	Yes	16	3.713 ± 2.28 ^a	0.022 ± 0.001***	1.645 ± 0.11*	0.892 ± 0.102 ^a **	46.50 ± 1.65***
		No	24	4.777 ± 2.56**	0.021 ± 0.001***	1.932 ± 0.11***	0.535 ± 0.039**	35.83 ± 1.69***
	Alcohol consumption	Yes	7	3.394 ± 2.35 ^a *	0.021 ± 0.001**	1.792 ± 0.22*	0.683 ± 0.119	49.71 ± 3.12 ^a *
		No	33	4.554 ± 2.16*	0.022 ± 0.001***	1.823 ± 0.08***	0.676 ± 0.061**	38.27 ± 1.47***
CONTROL GROUP	Age (years)	20–30	29	5.380 ± 1.54	0.038 ± 0.001	2.534 ± 0.09	0.389 ± 0.037	31.89 ± 1.64
		31–40	11	4.023 ± 3.82	0.036 ± 0.002	2.492 ± 0.21	0.482 ± 0.062	35.09 ± 1.96
		Total	40	5.007 ± 1.79	0.037 ± 0.001	2.526 ± 0.09	0.415 ± 0.032	32.77 ± 1.31
	Gender	Male	21	5.067 ± 2.70	0.038 ± 0.002	2.434 ± 0.11	0.385 ± 0.049	35.23 ± 1.99 ^a
		Female	19	4.940 ± 2.38	0.037 ± 0.001	2.622 ± 0.14	0.447 ± 0.040	30.05 ± 1.49
	Dietary pattern	Vegetarian	7	5.473 ± 2.53	0.039 ± 0.003	2.845 ± 0.17	0.378 ± 0.066	29.85 ± 1.95
		Nonvegetarian	33	4.908 ± 1.08	0.037 ± 0.001	2.453 ± 0.10	0.423 ± 0.038	33.39 ± 1.52
	Smoking habit	Yes	14	3.996 ± 2.66 ^a	0.036 ± 0.002	2.181 ± 0.17 ^a	0.522 ± 0.055 ^a	39.78 ± 1.70 ^a
		No	26	5.551 ± 1.53	0.040 ± 0.001	2.717 ± 0.08	0.356 ± 0.036	29.00 ± 1.30
	Alcohol consumption	Yes	9	4.416 ± 2.91	0.036 ± 0.002	2.212 ± 0.23	0.546 ± 0.073 ^a	42.44 ± 2.29 ^a
		No	31	5.178 ± 2.07	0.038 ± 0.001	2.616 ± 0.09	0.376 ± 0.033	29.96 ± 1.15

*Significant ($p \leq 0.05$) between the exposed and control groups.

**Highly significant ($p \leq 0.01$) between the exposed and control groups.

***Very highly significant ($p \leq 0.001$) between the exposed and control groups.

^aSignificant ($p \leq 0.05$) along the demographic characteristics within group.

Table 4. Function of mobile phone usage and residence near base stations on MN frequencies and antioxidants status on exposed and control groups.

			GSH	CAT	SOD	LOO	MN/1000 BNC	
	Characteristics	Category	N	(M±SEM)	(M±SEM)	(M±SEM)	(M±SEM)	(M±SEM)
EXPOSED GROUP	Mobile phone usage	User	37	4.336 ± 2.07**	0.020 ± 0.002***	1.852 ± 0.08***	0.66 ± 0.051***	40.21 ± 1.55***
		Nonuser	3	4.534 ± 6.04	0.022 ± 0.001***	1.394 ± 0.10*	0.890 ± 0.205*	38.66± 1.37**
	Duration of mobile phone use (years)	≤5	9	5.006 ± 3.26 ^a	0.023 ± 0.002**	1.834 ± 0.23**	0.673 ± 0.109*	34.77 ± 3.23 ^a
		>5	28	4.145 ± 2.24**	0.021 ± 0.001***	1.863 ± 0.08***	0.656 ± 0.058**	41.96 ± 1.66***
	Daily mobile phone use (hours)	≤3	24	4.410 ± 1.26*	0.023 ± 0.001***	1.902 ± 0.11***	0.653 ± 0.068**	37.87 ± 1.99 ^a *
		>3	13	4.233 ± 1.73*	0.020 ± 0.001***	1.765 ± 0.13***	0.674 ± 0.073**	44.53 ± 2.02***
	Distance from the base station (m)	1–20	8	3.884 ± 2.20**	0.018 ± 0.002***	1.654 ± 0.18***	0.720 ± 0.154**	43.00 ± 3.94**
		21–40	12	4.174 ± 3.72*	0.020 ± 0.001***	1.762 ± 0.13***	0.674 ± 0.106**	41.69 ± 2.49**
		41–60	13	4.692 ± 3.23	0.022 ± 0.001***	1.903 ± 0.15**	0.600 ± 0.069*	39.00 ± 1.24*
		61–80	7	4.631 ± 6.44	0.025 ± 0.002**	2.016 ± 0.17*	0.494 ± 0.084	36.71 ± 2.57
	Duration of residence near the base station (years)	5–10	33	4.406 ± 2.25*	0.024 ± 0.001***	1.872 ± 0.08**	0.642 ± 0.055***	40.03 ± 3.13**
		11–15	7	4.092 ± 2.54*	0.021 ± 0.001***	1.814 ± 0.12**	0.781 ± 0.170***	40.42 ± 1.66**
	Power density (mW/m ²)	≤4 mW/m ²	7	4.554 ± 2.22*	0.025 ± 0.002**	1.915 ± 0.16*	0.660 ± 0.122**	39.14 ± 0.21*
		>4 mW/m ²	33	4.308 ± 2.32**	0.021 ± 0.001***	1.807 ± 0.09***	0.681 ± 0.061***	40.30 ± 1.59***
CONTROL GROUP	Mobile phone usage	User	35	5.145 ± 1.86	0.037 ± 0.001	2.550 ± 0.09	0.417 ± 0.035	32.28 ± 1.40
		Nonuser	5	4.038 ± 4.21	0.041 ± 0.004	2.282 ± 0.25	0.456 ± 0.022	31.80 ± 1.22
	Duration of mobile phone use (years)	≤5	11	5.528 ± 2.24	0.036 ± 0.003	2.553 ± 0.10	0.372 ± 0.062	31.09 ± 1.88
		>5	24	5.039 ± 2.31	0.037 ± 0.001	2.568 ± 0.13	0.438 ± 0.043	32.83 ± 1.87
	Daily mobile phone use (hours)	≤3	25	5.258 ± 1.99	0.038 ± 0.001	2.524 ± 0.11	0.436 ± 0.041	30.10± 2.46
		>3	10	5.027 ± 3.75	0.036 ± 0.001	2.655 ± 0.19	0.371 ± 0.070	33.16 ± 1.70

*Significant ($p \leq 0.05$) between the exposed and control groups.**Highly significant ($p \leq 0.01$) between the exposed and control groups.***Very highly significant ($p \leq 0.001$) between the exposed and control groups.^aSignificant ($p \leq 0.05$) along the demographic characteristics within group.

MN frequency ($p < 0.001$) and LOO ($p < 0.001$) were observed in the exposed group residing in the vicinity of the base stations for 5–10 years and 11–15 years when compared to the control group. None of the parameters showed a significant variation among the exposed group residing for 5–10 years and 11–15 years in the vicinity of the base stations (Table 4).

As a function of distance from the base stations, MN frequency and LOO within the distance of 1–20 m ($p < 0.01$ for MN and LOO), 21–40 m ($p < 0.01$ for MN and LOO) and 41–60 m ($p < 0.05$ for MN and LOO) were significantly higher in the exposed group than that of the control group. There were no significant variation in MN frequency and LOO between the exposed group residing within 61–80 m away from mobile stations and the control group. GSH, CAT and SOD were significantly lower in the exposed group residing within a distance range of 1–20 m ($p < 0.01$ for GSH; $p < 0.001$ for CAT; $p < 0.001$ for SOD), 21–40 m ($p < 0.05$ for GSH; $p < 0.001$ for CAT; $p < 0.001$ for SOD), 41–60 m ($p < 0.001$ for CAT; $p < 0.01$ for SOD) and 61–80 m ($p < 0.01$ for CAT; $p < 0.05$ for SOD) than individuals residing at least 300 m away from the base stations. However, GSH contents did not differ between the exposed group residing between 41 and 80 m from the base stations and controls (Table 4). The individuals exposed to a power density of ≤ 4 mW/m² and >4 mW/m² showed a higher MN frequency ($p < 0.05$ for ≤ 4 mW/m²; $p < 0.001$ for >4 mW/m²) and LOO ($p < 0.01$ for ≤ 4 mW/m²; $p < 0.001$ for >4 mW/m²) and lower GSH ($p < 0.05$ for ≤ 4 mW/m²; $p < 0.01$ for

>4 mW/m²), CAT ($p < 0.01$ for ≤ 4 mW/m²; $p < 0.001$ for >4 mW/m²) and SOD ($p < 0.05$ for ≤ 4 mW/m²; $p < 0.001$ for >4 mW/m²) (Table 4).

Multiple linear regression analyses revealed a significant association with low GSH concentration and age ($p < 0.05$), smoking habit ($p < 0.001$), daily mobile phone use ($p < 0.05$) and increasing power density ($p < 0.05$). A similar association has been reported with reduced CAT activity with increasing power density ($p < 0.001$) and alleviated SOD activity with smoking habit ($p < 0.05$) and increasing power density ($p < 0.001$) (Table 5). The analyses also showed a significant relationship between higher MN frequency with smoking habit ($p < 0.001$) and increasing power density ($p < 0.001$) and higher LOO with smoking habit ($p < 0.001$), alcohol consumption ($p < 0.05$) and increasing power density ($p < 0.001$) (Table 5). The parameter of mobile phone usage was not included in the multiple linear regression analysis due to multicollinearity with the duration of mobile phone use and average daily mobile phone use. Similarly, distance from the base stations showed multicollinearity with power density in the preliminary analysis; therefore, the former is also excluded in the multiple linear regression analysis.

Discussion

Mobile phone base stations have become an integral part of telecommunication, which use RFR to transmit the signals. These electromagnetic waves are generated by

Table 5. Multiple linear regression in the exposed and control groups.

	Characteristics	Durbin-Watson	Model-F	B-value	t-value	p-value
GSH	Age	2.22	6.62***	-0.24	-2.10	0.043
	Gender			0.11	1.09	0.283
	Dietary pattern			-0.10	-0.99	0.328
	Smoking habit			0.44	-3.86	0.001
	Alcohol consumption			-0.06	-0.47	0.640
	Duration of mobile phone use			-0.09	-0.69	0.492
	Daily mobile phone use			0.22	2.06	0.039
	Power density			-0.18	-1.97	0.041
CAT	Age	2.10	11.19***	-0.09	-0.94	0.352
	Gender			0.03	0.29	0.774
	Dietary pattern			0.01	0.12	0.907
	Smoking habit			-0.01	-0.07	0.950
	Alcohol consumption			0.03	0.29	0.771
	Duration of mobile phone use			0.01	0.08	0.944
	Daily mobile phone use			-0.07	-0.77	0.447
	Power density			-0.72	-8.93	0.001
SOD	Age	2.23	4.94***	0.01	0.11	0.911
	Gender			0.00	0.01	0.993
	Dietary pattern			-0.12	-1.22	0.237
	Smoking habit			-0.32	-2.70	0.012
	Alcohol consumption			0.01	0.10	0.923
	Duration of mobile phone use			0.11	0.81	0.426
	Daily mobile phone use			-0.07	-0.61	0.551
	Power density			-0.46	-4.74	0.001
LOO	Age	1.82	6.53***	0.22	1.96	0.052
	Gender			-0.13	-1.30	0.208
	Dietary pattern			0.11	1.13	0.262
	Smoking habit			0.47	4.12	0.001
	Alcohol consumption			-0.15	-1.25	0.210
	Duration of mobile phone use			-0.01	-0.05	0.965
	Daily mobile phone use			0.02	0.15	0.886
	Power density			0.37	3.99	0.001
MN	Age	2.17	11.10***	0.09	0.87	0.390
	Gender			-0.05	-0.58	0.572
	Dietary pattern			0.03	0.38	0.718
	Smoking habit			0.44	4.41	0.001
	Alcohol consumption			0.28	2.62	0.013
	Duration of mobile phone use			-0.04	-0.34	0.733
	Daily mobile phone use			0.06	0.58	0.562
	Power density			0.36	4.45	0.001

Values in bold are significant ($p < 0.05$).

electric charges that are rapidly accelerated to and fro in the transmitting antenna. Although RFR are nonionizing electromagnetic radiations, yet there has been a great concern about their deleterious effects on the human body as it is assumed that RFR could produce some of the biological effects akin to those produced by ionizing radiations such as X or γ -rays. Because of its adverse health effects reported worldwide, the presence of mobile base stations in the residential areas could be an electromagnetic threat, which is silently creeping in the lives of residents staying near the mobile base stations. We have therefore attempted to obtain an insight into the adverse effects of RFR in the inhabitants residing in the vicinity (within 80 m) of mobile base stations emitting RFR for mobile connectivity.

The frequency of nonspecific health symptoms such as nausea, loss of appetite, visual disturbance, irritability and depression were found to be significantly higher in the population living close (within 100 m) to mobile phone base stations as compared to those living away from these stations (Santini et al., 2002, 2003). Besides the nonspecific health symptoms of fatigue, headache, dizziness and

muscle pain self-reported by the volunteers in the earlier study (Pachau et al., 2015), the present study showed a significant increase in MN frequency and decreased antioxidants among inhabitants residing close to the base station/s when compared to controls. A number of studies have reported an increase in the DNA damage/micronuclei in different study systems. The human PBLs exposed to RFR have shown an increased frequency of micronuclei earlier (d'Ambrosio et al., 2002; Garaj-Vrhovac et al., 1992; El-Abd and Eltoweissy, 2012; Tice et al., 2002; Zotti-Martelli et al., 2000). Various studies conducted in other systems have also revealed an increased micronuclei frequency after exposure to RFR (Balode, 1996; Busljeta et al., 2004; Gandhi and Singh, 2005; Trosic et al., 2002, 2004). Our results are in agreement with a recent study where buccal mucosa cells showed increased micronuclei in mobile phone users (Banerjee et al., 2016). However, some of the studies did not find any increase in the MN frequency after RFR exposure both *in vitro* and *in vivo* (Bisht et al., 2002; Scarfi et al., 2006; Vijayalaxmi et al., 1997, 1999, 2001; Zeni et al., 2003, 2008), and such reports emphasized on the lack of thermal effects from RFR

(Vijaylaxmi and Obe, 2004), whereas the observed effect in the present study may be due to the interaction of RFR with various cellular macromolecules by producing ROS. This contention is supported by the fact that RFR-exposed individuals showed increased LOO and alleviated GSH contents, CAT and SOD activities in the present study. A similar effect has been observed earlier in the CAT activity in the rats exposed to low level of RFR (Achudume et al., 2010). Also, RFR emitted from cell phones led to oxidative stress in human semen (Agarwal et al., 2009). RFR (2.45 GHz) has been reported to cause a significant increase in the LOO of exposed Wistar rats (Aweda et al., 2003). The present study also revealed the induction of LOO by RF radiation, which could possibly react with DNA and produce lesions in it. The increased LOO has been reported in the plasma of rats with a decline in GSH and other antioxidants earlier (Aydin and Akar, 2011).

The highest measured power density was 7.52 mW/m². Most of the measured values close to base stations (Table 1) are higher than that of the safe limits recommended by Bioinitiative Report 2012 (0.5 mW/m²), Salzburg resolution 2000 (1 mW/m²) and EU (STOA) 2001 (0.1 mW/m²). However, all the recorded values were well below the current ICNIRP safe level (4700 mW/m²) and the current Indian Standard (450 mW/m²). Although cigarette smoking increased the MN frequency and decreased the antioxidants, the statistical analysis also revealed a close correlation between the power density and MN frequency and antioxidant status. Thus, the effects of RF radiation cannot be ignored as unrepaired DNA damage and oxidative stress are associated with several diseases such as cancer and several age-related diseases (Bernstein et al., 2013; Dart et al., 2013). The persistence of low level of DNA damage could have negative effect on human health.

The exact mechanism of action of RFR in micronuclei induction and reduced antioxidant status is not apparent. The possible putative mechanism of generation of DNA damage may be the production of endogenous free radicals due to continuous exposure. RFR has been reported to produce different free radicals earlier (Avci et al., 2009; Burlaka et al., 2013; Barcal et al., 2014; Kazemi et al., 2015). Cells possess a number of compensatory mechanisms to deal with ROS and its effects. Among these are the induction of antioxidant proteins such as GSH, SOD and CAT. Enzymatic antioxidant systems function by direct or sequential removal of ROS, thereby terminating their activities. An imbalance between the oxidative forces and antioxidant defense systems causes oxidative injury, which has been implicated in various diseases, such as cancer, neurological disorders, atherosclerosis, diabetes, liver cirrhosis, asthma, hypertension and ischemia (Andreadis et al., 2003; Comhair et al., 2005; Dhalla

et al., 2000; Finkel and Holbrook, 2000; Kasparova et al., 2005; Sayre et al., 2001; Sohal et al., 2002). Because of the significant decrease in endogenous antioxidants and increased LOO among the exposed group, the extra burden of free radicals is unlikely to get neutralized, and these surplus ROS may react with important cellular macromolecules including DNA forming either DNA adducts or strand breaks, which may be later expressed as micronuclei once the cell decides to divide. The decline in the antioxidant status may be also due to the suppressed activity of Nrf2 transcription factor which is involved in maintaining the antioxidant status in the cells.

The present study has reported that RFR increased the frequency of MN and LOO and reduced GSH contents, CAT and SOD activities in the plasma of the exposed individuals. The induction of MN may be due to the increase in free-radical production. The present study demonstrated that staying near the mobile base stations and continuous use of mobile phones damage the DNA, and it may have an adverse effect in the long run. The persistence of DNA unrepaired damage leads to genomic instability which may lead to several health disorders including the induction of cancer.

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Declaration of interest

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Environmental radiofrequency radiation at the Järntorget Square in Stockholm Old Town, Sweden in May, 2018 compared with results on brain and heart tumour risks in rats exposed to 1.8 GHz base station environmental emissions

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Abstract. Radiofrequency (RF) radiation in the frequency range 30 kHz to 300 GHz was evaluated in 2011 by the International Agency for Research on Cancer (IARC) at WHO to be a 'possible human carcinogen' Group 2B. The conclusion was based on human epidemiological studies on an increased risk of glioma and acoustic neuroma. In previous measurement studies, we found high environmental RF radiation levels at certain public places and also in an apartment in Stockholm, Sweden. One such place was the Järntorget square in the Stockholm Old Town. The EME Spy exposimeter was used for these studies. We have now conducted a field spatial distribution measurement with a radiofrequency broadband analyser. The maximum E-field topped at 11.6 V/m at the centre of the square, where the antenna was focused. Järntorget's mean value was 5.2 V/m, median 5.0 V/m, range 1.2-11.6 V/m. Of interest is that this level can be compared to a lifespan carcinogenicity study on rats exposed to 1.8 GHz GSM environmental radiation performed at the Ramazzini Institute (RI) in Italy. A statistically significant increase in the incidence of malignant schwannoma in the heart was found in male rats at the highest dose, 50 V/m. In treated female rats at the highest dose, the incidence of malignant glial tumours was increased, although this was not statistically significant. On the whole, the findings of this study showed that RF radiation levels at one square,

Järntorget, in Sweden, were only one order of magnitude lower than those showing an increased incidence of tumours in the RI animal study. An increased cancer risk cannot be excluded for those working in the proximity of Järntorget for longer time periods.

Introduction

Radiofrequency (RF) radiation from wireless devices, such as mobile and cordless phones, base stations, and so on in the frequency range 30 kHz to 300 GHz was classified in 2011, as a 'possible human carcinogen' Group 2B by the International Agency for Research on Cancer (IARC), a part of WHO (1,2). In spite of that evaluation, little or mostly nothing has been done to inform and protect the population from RF radiation (3,4). On the contrary, human exposure has increased rapidly in recent years and will increase substantially with the introduction of the fifth generation (5G) for wireless communication (5-7).

Of special concern is the involuntary environmental exposure to RF radiation. This is the situation in most places with few or no possibilities to avoid exposure. Thus, RF radiation should by now be regarded as environmental pollution that is hard to detect using our senses.

Previously, we reported RF radiation levels in different places in Stockholm in Sweden, such as at the Central Railway station (8), the Old Town (9), in an apartment close to base stations (10) and in the City (11).

High ambient exposure was found at several places, and particularly at the Järntorget square in the Old Town, that was measured in April, 2016 [mean, 24,277.1 $\mu\text{W}/\text{m}^2$ (3.03 V/m); median, 19,990.0 $\mu\text{W}/\text{m}^2$ (2.75 V/m); ranging from 257.0 $\mu\text{W}/\text{m}^2$ (0.31 V/m) to 173,301.8 $\mu\text{W}/\text{m}^2$ (8.08 V/m)] (9).

Recently, the US National Toxicology Program (NTP) released results from their large animal two-year study on cell phone RF radiation exposure (12,13) that we have discussed in further detail elsewhere (14). A statistically significant

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increased risk was found for brain glioma and malignant schwannoma in heart nerves, but also in other organs. There was some evidence of an increased risk of thyroid cancer, and clear evidence that RF radiation is a multi-site carcinogen (14). These results are similar to those found in human epidemiological studies, as reviewed elsewhere (7,15,16).

In the study by the Ramazzini Institute (RI) in Italy, rats were exposed from prenatal life until natural death to a 1.8 GHz GSM far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day similar to that from base stations. Increased incidence of similar tumour types that have been associated in individuals using wireless phones were found (17). Thus, a statistically significant increase in the incidence of malignant schwannoma in the heart was found in male rats at the highest dose, 50 V/m. An increased incidence of heart Schwann cell hyperplasia was observed in the treated male and female rats at the highest dose (50 V/m), but was not statistically significant. In treated female rats at the highest dose (50 V/m), the incidence of malignant glial tumours was increased, although this was not statistically significant.

The aim of this study was to make additional measurements at Järntorget in Stockholm Old city (Fig. 1) and to compare the levels with the results from the RI study (17). This was a measurement study with no involvement of test persons. Thus, no ethical permission was required.

Materials and methods

Study design. Field spatial distribution measurements were conducted with a radiofrequency broadband analyser. The square was covered with spot measurements, whereas in each spot the field was measured with slow circular movements to cover a 1 sqm area at heights of 0.7-2 m. In order to minimize field perturbation by the measurer, the meter was held at arm's lengths from the investigator, with the outward extending probe. The measurements were conducted in about 0.8-0.9 m from the investigator. On the whole, 51 spots were measured in the square and the street area connected to the square.

The radiofrequency broadband analyser make and model was Wandell & Goltermann EMR300, E-field probe 2244/90. The characteristics include: A resolution of 0.01 V/m; settling time typically 1 sec; displaying instantaneous measured value, maximum value and average value.

The E-field probe used had the following characteristics: A frequency range 100 kHz to 3 GHz, measurement range 0.6 to 800 V/m, linearity 0.7 to 3 dB depending on the amplitude, frequency response ± 2.4 dB and isotropy deviation ± 1.0 dB. At each spot, the average electric field in Volts per meter (V/m) was recorded.

An EME Spy 200 exposimeter was also used in this study. The exposimeter measures 20 predefined frequency bands, as presented in Table I. They cover the frequencies of most public RF radiation emitting devices currently used in Sweden. The exposimeter covers frequencies from 88 to 5,850 MHz. For FM, TV3, TETRA, TV4&5, Wi-Fi 2G and Wi-Fi 5G the lower detection limit is 0.01 V/m ($0.27 \mu\text{W}/\text{m}^2$); for all other bands the lower detection limit is 0.005 V/m ($0.066 \mu\text{W}/\text{m}^2$). For all bands the upper detection limit is 6 V/m ($95,544 \mu\text{W}/\text{m}^2$; $9.5544 \mu\text{W}/\text{cm}^2$). The sampling time used in this study was 4 sec which is the fastest for the given exposimeter.

Table I. Predefined measurement frequency bands of EME Spy 200 Exposimeter Frequency ranges.

Frequency band	Frequency MIN (MHz)	Frequency MAX (MHz)
FM	88	107
TV3	174	223
TETRA I	380	400
TETRA II	410	430
TETRA III	450	470
TV4&5	470	770
LTE 800, 4G (DL ^a)	791	821
LTE 800, 4G (UL ^b)	832	862
GSM 900 + UMTS 900, 3G (UL)	880	915
GSM 900 + UMTS 900, 3G (DL)	925	960
GSM 1800 (UL)	1,710	1,785
GSM 1800 (DL)	1,805	1,880
DECT	1,880	1,900
UMTS 2100, 3G (UL)	1,920	1,980
UMTS 2100, 3G (DL)	2,110	2,170
Wi-Fi, 2 GHz	2,400	2,483.5
LTE 2600, 4G (UL)	2,500	2,570
LTE 2600, 4G (DL)	2,620	2,690
WiMax	3,300	3,900
Wi-Fi 5 GHz	5,150	5,850

^aDL, down link; transmission from base station to mobile phone;

^bUL, up link, transmission from mobile phone to base station.

The exposimeter measures different telecommunications protocols: Frequency modulation (FM) radio broadcasting; television (TV) broadcasting; TETRA emergency services (police, rescue, etc.); global system for mobile communications (GSM) second generation mobile communications; universal mobile telecommunications systems (UMTS) third generation mobile communications, 3G; long-term evolution (LTE) fourth generation mobile communications standard, 4G; digital European cordless telecommunications (DECT) cordless telephone systems standard; Wi-Fi wireless local area network protocol; worldwide interoperability for microwave access (WIMAX) wireless communication standard for high speed voice, data and internet. The location of the mobile phone base station antenna at the square is presented in Fig. 2.

Results

Järntorget, Stockholm Old Town. The field spatial distribution measurement conducted at Järntorget square (Fig. 3) illustrates the propagation of the microwaves from the mobile phone base station's several antennas. Based on the radiofrequency broadband analyser spot measurements, the maximum E-field topped at 11.6 V/m at the centre of the square, where the antenna is focused. The Järntorget's mean value was 5.2 V/m; median, 5.0 V/m; range, 1.2-11.6 V/m; whereas in the whole square the field level was nowhere below 2 V/m. When distancing from



Figure 1. The map shows the location of Järntorget square in The Old Town at Stockholm city. Map from Lantmäteriet, Sweden.



Figure 2. Järntorget square in Stockholm; the red circle indicates a mobile phone base station antenna.

the square, into the narrow streets, the field level gradually dropped; note top in figure scale 11.43 V/m.

Fig. 4 depicts different radiofrequency components at Järntorget across different communication bands. The main

contributors to the radiofrequency exposure, time averaged over half an hour period, were all mobile telephony bands: LTE 2600 DL 1.7 V/m, GSM+UMTS 900 DL 1.6 V/m, LTE 800 DL 1.2 V/m, UMTS 2100 DL 0.9 V/m.

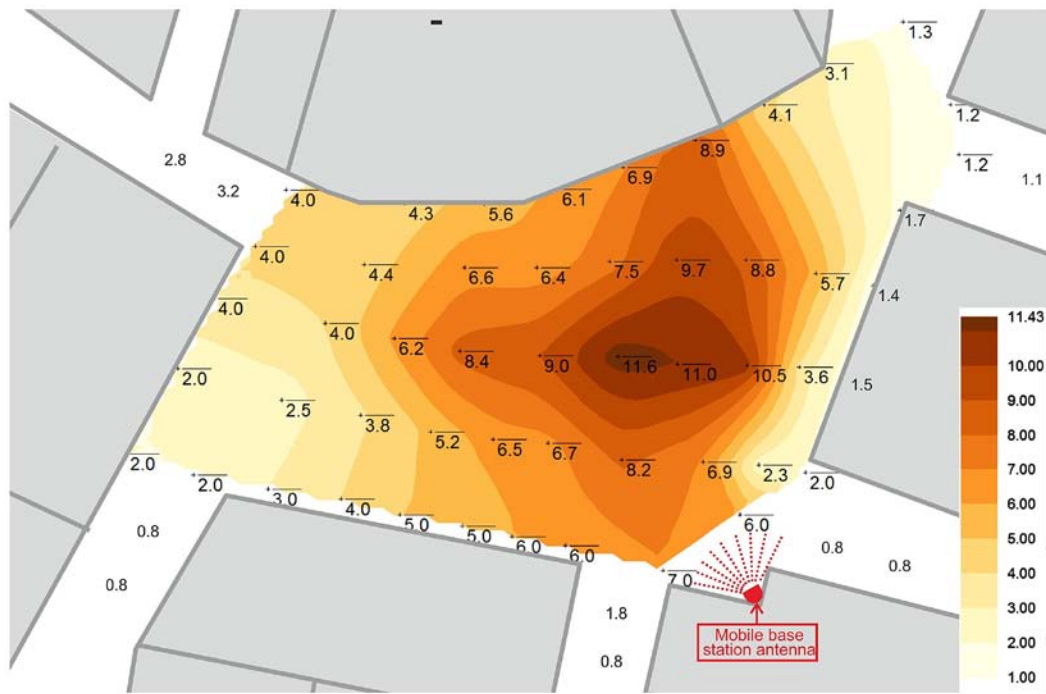


Figure 3. Järntorget square radiofrequency E-field distribution, units in Volts per meter (V/m), 5.05.2018 12:00, measured by a broadband meter (Wandell & Goltermann EMR-300) covering 100 kHz to 3 GHz.

Discussion

Ramazzini Institute rat study. In this lifespan carcinogenicity study, Sprague-Dawley rats were exposed to 1.8 GHz GSM environmental radiation (17). A statistically significant increase in the incidence of malignant schwannoma in the heart was found in male rats at the highest dose, 50 V/m, corresponding to 0.66 mW/cm² (6,63 W/m²) and whole-body SAR of 0.1 W/Kg (Fig. 5.)

An increased incidence of heart Schwann cell hyperplasia was observed in the treated male and female rats at the highest dose (50 V/m), although this was not statistically significant (Fig. 6). In the treated female rats at the highest dose (50 V/m) the incidence of malignant glial tumours was increased, although this was not statistically significant (Fig. 7). No conclusive evidence on glia cell hyperplasia was found (Fig. 8).

More prominent effects on health due to lower compared to higher RF radiation exposure have been observed in studies, which could indicate a frequency and power-window based response. This has been shown in studies with RF-radiation exposure down to peak power output of 1 mW from a GSM mobile phone, where the blood brain barrier opened and led to leakage into the brain tissues of large molecules, e.g., albumin and big molecules that can be toxic to brain tissue (18,19). In the Ramazzini Institute study, it was shown in Figs. 7 and 8, that 25 V/m yielded a higher incidence of glial cell hyperplasia and glia cell malignant tumours in male rats, than exposure to 50 V/m.

In this study we used a broadband meter, Wandell & Goltermann EMR-300, covering 100 kHz to 3 GHz for measuring radiofrequency E-field distribution, units in Volts per meter. The measurement was done at midday on May 5, 2018 and encompassed the Järntorget square in the Stockholm

Old Town. That place was selected since in our previous study with measurements from 2016, the Järntorget square had the highest RF radiation levels in the Old Town (see Table VI and Fig. 11 in that publication) (9).

The new spot measurements carried out in Järntorget square illustrate very high exposure levels at a popular tourist destination. The square was crowded with tourists and the local population either walking or sitting in the open-air cafés. The exposure levels in the entire square were needlessly high, as mobile communications services could be provided to subscribers in the square at orders of magnitude less power as presently used. This investigation revealed that mobile telephony service providers create unnecessary high exposure at public places, by using relatively high output power in base station antennas positioned close to people. Sufficient service coverage could be provided with much less radiation levels and carefully selected positions for base station antennas.

We measured the RF radiation at Järntorget with a mean of 5.2 V/m, a median of 5.0 V/m and a range of 1.2-11.6 V/m. Interestingly, the mean and median levels were only one order of magnitude lower than the radiation in the RI study, 50 V/m, with a statistically significant increase in the incidence of malignant schwannoma in the heart in male rats. In the same exposure group, an increased incidence of glia cell tumours in the brain was found in female rats. Based on thermal effects, a safety factor of 10 has been used for workers and additionally one fifth of that level for individuals with increased vulnerability, such as children, those with illness and otherwise sensitive individuals yielding a specific absorption rate (SAR) of 2 W/kg for mobile phones. This safety factor is based on acute thermal effects on the eye with 100 W/kg yielding lens clouding [see the study by Lin (20)]: 'Clearly, the motivation was to limit temperature rises inside the eye to prevent formation of lens

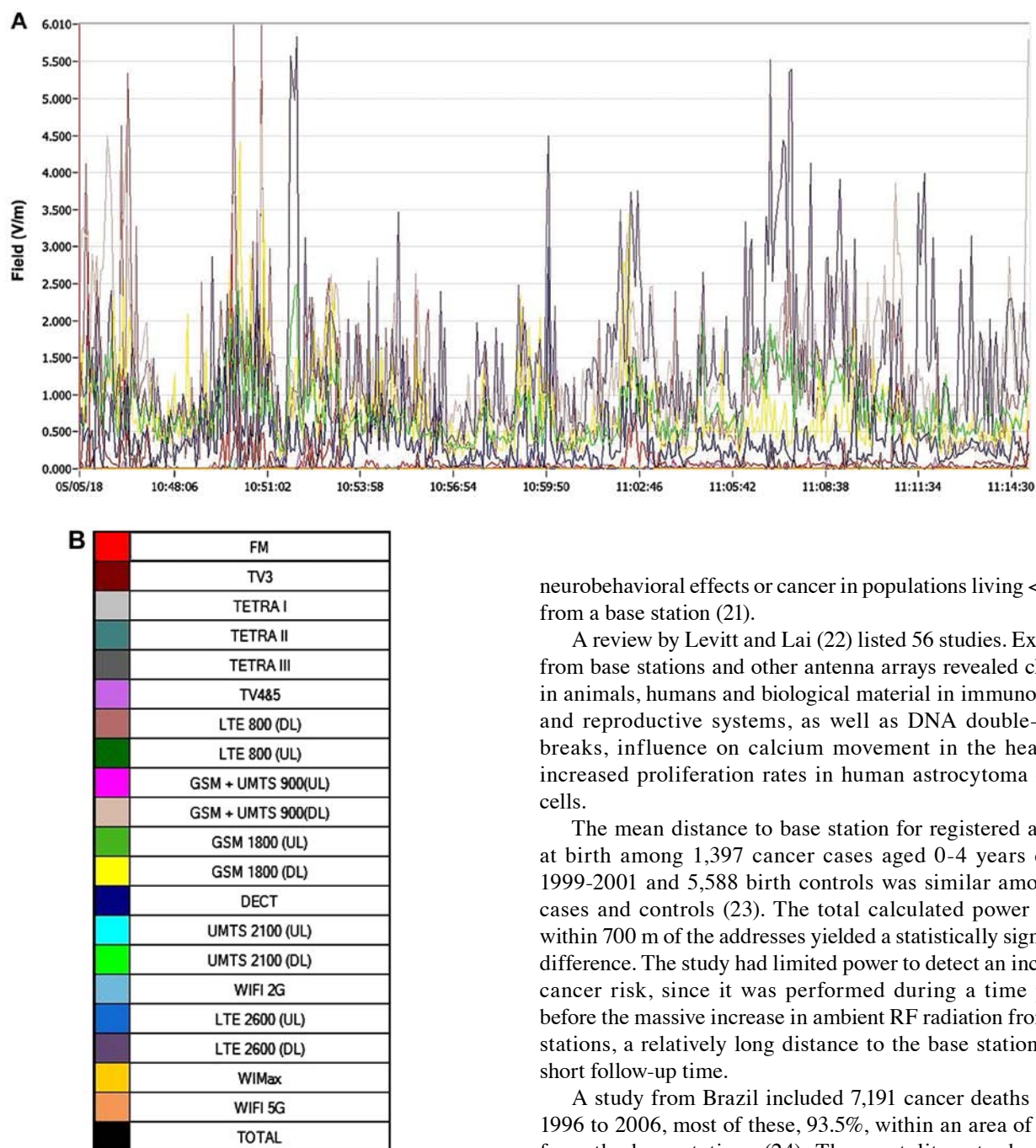


Figure 4. Radiofrequency components in Järntorget square across different communication bands (A and B); the horizontal axis of time represents walking around the square. Same colours for the different bands are used in (A and B).

opacity-cataracts. Specifically, a safety factor of ten was applied to reduce the SAR threshold of 100 to 10 W/kg. To provide for an additional margin of safety for the general public, an extra factor of five was introduced to arrive at 2 W/kg over 10 g of contiguous tissue, including the eye'. Using the same logic in safety factors as for SAR regarding the RI results would yield 2.5 V/m as a safety level. Thus, our results at Järntorget exceed that RF radiation magnitude.

The literature on cancer risks relating to RF radiation from base stations is limited. A review on 10 studies up to 2009 revealed that eight of these studies showed either

neurobehavioral effects or cancer in populations living <500 m from a base station (21).

A review by Levitt and Lai (22) listed 56 studies. Exposure from base stations and other antenna arrays revealed changes in animals, humans and biological material in immunological and reproductive systems, as well as DNA double-strand breaks, influence on calcium movement in the heart and increased proliferation rates in human astrocytoma cancer cells.

The mean distance to base station for registered address at birth among 1,397 cancer cases aged 0-4 years during 1999-2001 and 5,588 birth controls was similar among the cases and controls (23). The total calculated power output within 700 m of the addresses yielded a statistically significant difference. The study had limited power to detect an increased cancer risk, since it was performed during a time period before the massive increase in ambient RF radiation from base stations, a relatively long distance to the base station and a short follow-up time.

A study from Brazil included 7,191 cancer deaths during 1996 to 2006, most of these, 93.5%, within an area of 500 m from the base stations (24). The mortality rate decreased outside that area. The largest accumulated electric field measured was 12.4 V/m and the lowest 0.4 V/m. The density power varied between 400 $\mu\text{W}/\text{m}^2$ to 407,800 $\mu\text{W}/\text{m}^2$. Our measured RF radiation levels at Järntorget were within that range.

Cancer incidence and mortality data were investigated after an alleged cancer cluster in West Midlands, UK following the installation of a mobile phone base station (25). A total of 19 persons had developed cancer, but did not fulfil criteria for cancer cluster, standardized mortality rates (SMR) for all cancer excluding non-melanoma skin cancers was for all persons 1.27, and 95% confidence interval (CI) =1.06-1.51 during 2001-2003.

Environmental exposure to RF radiation and the risk of malignant lymphoma was investigated in a case-control study in Sardinia, Italy (26). Self-reported distance of the three longest held residential addresses for 322 cases and

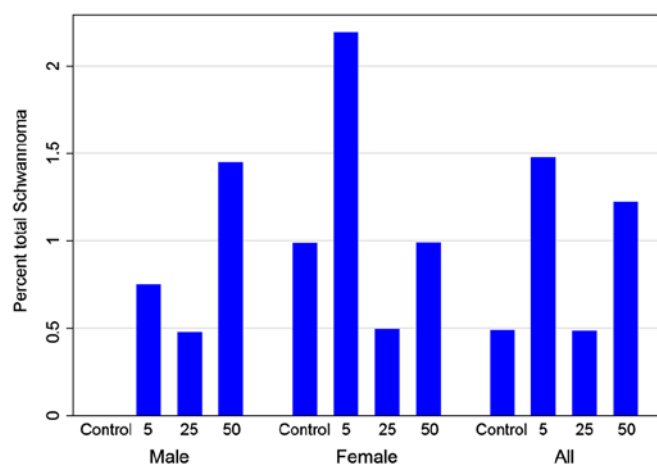


Figure 5. Total schwannoma incidence according to Table 2 in the study by Falcioni *et al* (17).

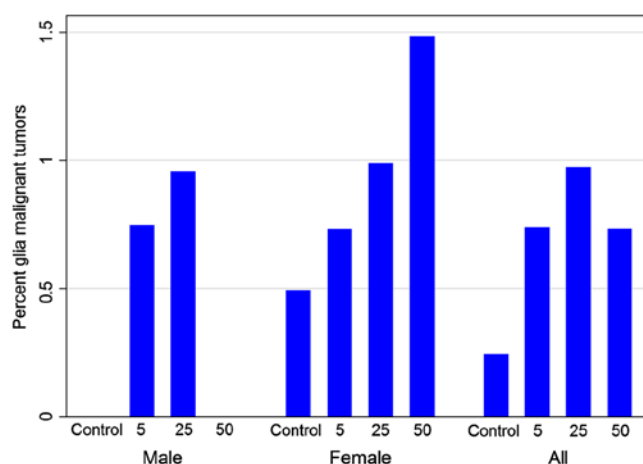


Figure 7. Glia cell malignant tumours according to Table 3 in the study by Falcioni *et al* (17).

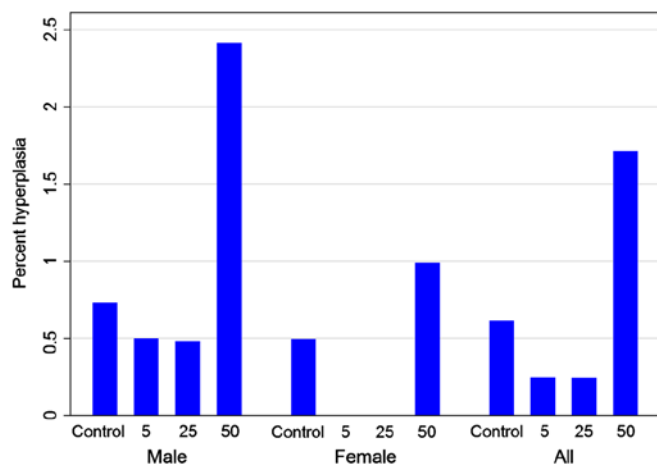


Figure 6. Schwann cell hyperplasia according to Table 2 in the study by Falcioni *et al* (17).

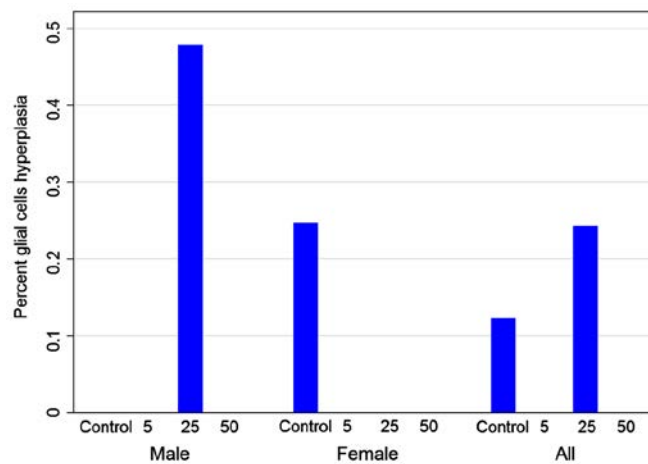


Figure 8. Glia cell hyperplasia according to Table 3 in the study by Falcioni *et al* (17).

444 controls were analysed for radio-TV transmitters and base stations. In addition, some measurements of exposure were done. Residence within 50 meters to a fixed radio-TV transmitter yielded overall for lymphoma odds ratio (OR) =2.7, and 95% CI =1.5-4.6. For mobile base stations no association was found.

Long term studies on low exposure to RF radiation on humans have shown influence on the neurotransmitters adrenaline, noradrenaline, dopamine and phenylethylamine when a GSM 900 MHz base station was installed in the village of Rimbach in Germany (27) and cortisol and thyroid hormones in people living near base stations (28,29). The chronic dysregulation of psychobiological stress markers may contribute to health problems and chronic illnesses.

Genetic damage using comet assay in blood leucocytes was used in 63 persons residing within 300 m from a base station and 28 healthy controls (30). DNA migration length, genetic damage frequency and damage index were statistically significantly elevated in the sample group compared to the controls. The power density was statistically significantly higher for the cases than for the controls. The linear regression analysis revealed daily mobile phone use, location of residence

and power density as statistically significant predictors of genetic damage.

DNA damage was also analysed in a study group of 40 persons residing within 80 m of mobile phone base stations compared with a control group living 300 m or more from base stations (31). Multiple linear regression analyses revealed in the exposed group statistically significantly elevated micronucleus activity and lipid peroxidation and reduced concentrations of some analysed antioxidants (glutathione, catalase and superoxide dismutase).

In conclusion, this study demonstrated RF radiation levels at one square, Järntorget, in Stockholm, Sweden one order of magnitude lower than those showing an increased incidence of tumours (schwannoma and glioma) in the RI animal study with life-long exposure to 1.8 GHz base station environmental radiation. These results indicate that an increased cancer risk may be the situation for individuals staying at the square, primarily for those working in shops and cafés around the square. We have not measured RF radiation emissions in apartments around the square. It cannot be excluded that at certain places, the radiation may even be higher than those now measured, c.f. Hardell *et al* (10).

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Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

All authors participated in the conception, design and writing of the manuscript and have read and approved the final version. MC constructed all Figures based on the study by Falcioni *et al* (17). TK made measurements of radiofrequency radiation levels.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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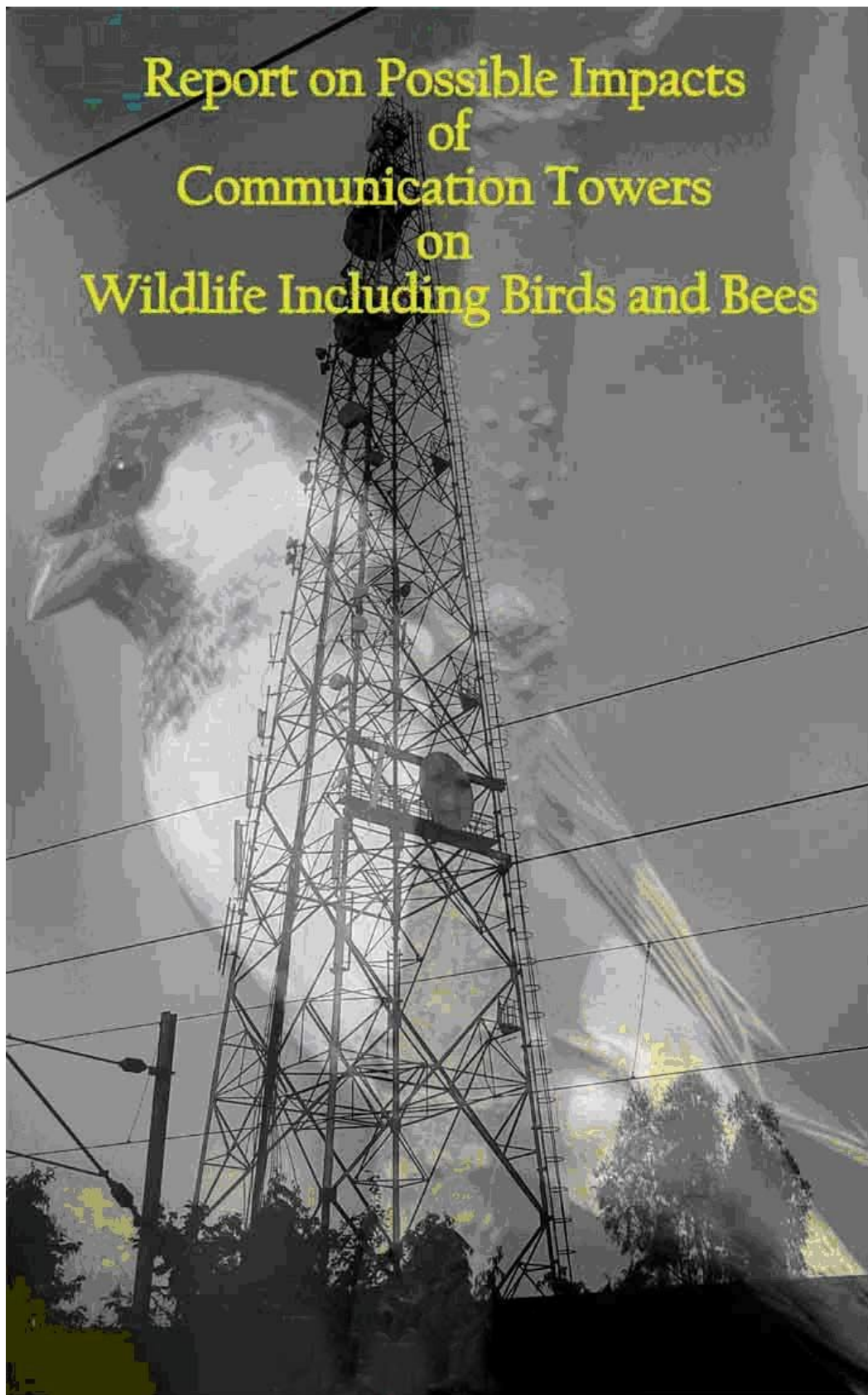
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Cell Towers; Indian Government, Ministry of Environment and Forest,
Report on Possible Impacts of Communication Towers on
Wildlife Including Birds and Bees. 919 studies reviewed; 2011



Expert Group to study the possible impacts of communication towers on Wildlife including Birds and Bees

Executive summary

India is one of the fastest growing mobile telephony industries in the world. It is estimated that by 2013, 1 billion plus people will be having cell phone connection in India. To support this growth of cell phone subscriber in the country, there has also been a tremendous growth of infrastructure in the form of mobile phone towers. Today, in absence of any policy on infrastructure development and location of cell phone towers, large numbers of mobile phone towers are being installed in a haphazard manner across urban and rural areas including other sparsely populated areas in India.

The transmission towers are based on the electromagnetic waves, which over prolonged usage have adverse impacts on humans as well as on other fauna. The adverse effects of electromagnetic radiation from mobile phones and communication towers on health of human beings are well documented today. However, exact correlation between radiation of communication towers and wildlife, are not yet very well established.

The Ministry of Environment and Forests usually receives several questions regarding this issue. In view of one such Lok Sabha Starred question regarding 'Ill effects of Mobile Towers on Birds' received on 11th August, 2010, an 'Expert committee to Study the possible Impacts of Communication Towers on Wildlife including Birds and Bees' was constituted on 30th August, 2010 by Ministry of Environment and Forest, Government of India.

The Expert Committee had five important mandates which are as follows:

- I. To review all the studies done so far in India and abroad on aspects of ill effects of mobile towers on animals, birds and insects.
- II. To assess the likely impacts of the growth in the number of mobile towers in the country
- III. To suggest possible mitigatory measures.
- IV. To formulate guidelines for regulating the large-scale installation of mobile towers in the country
- V. To identify the gap areas for conducting further detailed research.

The Committee studied all the peer reviewed articles/ journals published on the impact of radiations on wildlife throughout the world and compiled them. Subsequently, detailed analysis of the papers was done to find out the impacts of electronic magnetic fields (**EMF**) on wildlife

including birds and bees and the gap areas for conducting further detailed research were identified.

The review of existing literature shows that the Electro Magnetic Radiations (EMRs) are interfering with the biological systems in more ways than one. There had already been some warning bells sounded in the case of bees and birds, which probably heralds the seriousness of this issue and indicates the vulnerability of other species as well. The electromagnetic radiations are being associated with the observed decline in the population of sparrow in London and several other European cities (Balmori, 2002, Balmori, 2009, Balmori & Hallberg, 2007). In case of bees, many recent studies have linked the electromagnetic radiations with an unusual phenomenon known as 'Colony Collapse Disorder'. A vast majority of scientific literature published across the world indicate deleterious effects of EMFs in various other species too.

In spite of the recent studies indicating possible harmful impact of EMF on several species, there are no long-term data available on the environmental impacts of EMRs as of now. Studies on impact of cell phone towers and EMR on birds and other wildlife are almost non-existent in India. Moreover, pollution from EMRs being a relatively new environmental issue, there is a lack of established standard procedures and protocols to study and monitor the EMF impacts especially among wildlife, which often make the comparative evaluations between studies difficult. In addition to the gap areas in research, the necessary regulatory policies and their implementation mechanism also have not kept pace with the growth of mobile telephoning. Our guidelines on exposure limits to EMF need to be refined since the ICNIRP Standard currently followed in India is coined based on only thermal impact of Radio Frequency and are dismissive of current epidemiological evidence on impacts of non-thermal nature on chronic exposure from multiple towers. Meanwhile, the precautionary principle should prevail and we need to better our standards on EMF to match the best in the world.

Along with the growth of phone towers and subscribers, India is also witnessing a rapid population growth. To feed and support this rapidly growing population the agricultural security and the factors influencing them should be of concern. However, the population of many species such as honey bees, which is one of the most important pollinator and important factor for agricultural productivity, has seen a drastic population drop. Unfortunately we do not have much data about the effects of EMR available for most of our free-living floral and faunal species in India. Therefore, there is an urgent need to do further research in this area before it would be too late.

Introduction

During recent years, there has been an increase in the usage of telecommunication devices, which has become an easy means for communication. The use of mobiles have become more conspicuous, during the last decade and this has led to construction of transmission towers in large numbers, both in the urban, as well as in rural areas including other sparsely populated areas. Transmission towers are based on the electromagnetic waves, which over prolonged usage have adverse impacts on humans as well as on other fauna. The adverse effects of electromagnetic radiation from mobile phones and communication towers on health of human beings are well documented today. Recently the electromagnetic fields from mobile phones and other sources have been classified as “possibly carcinogenic to human” by the WHO’s International Agency for Research on Cancer (IARC). However, exact correlation between radiation of communication towers and wildlife, are not yet very well established. Though, there have been growing concerns about the impacts of mobile towers on wildlife, and couple of studies conducted in India and worldwide indicates the possibility of negative effects of radiation.

The Ministry of Environment and Forests (MoEF) usually receives questions on such subject during the last couple of years. One such question, that the Ministry of Environment and Forests replied to on 11th August, 2010 was a Lok Sabha Starred question number 244 regarding ‘Ill effects of Mobile Towers on Birds’. In the above mentioned question, Hon’ble Member of Parliament (Lok Sabha), wanted to know, whether any studies have been conducted on the ill effects of mobile towers on birds and bees and also whether the Government has set up any committee to look into the issue.

In view of this, an urgent need was felt to constitute an Expert Group to assess the level of possible impacts of growth of mobile towers in urban, sub-urban and even rural/forest areas on the wildlife including birds and bees and to suggest appropriate mitigative measures for the problem. Hence, the ‘Expert committee to Study the possible impacts of communication towers on wildlife including Birds and Bees’ was constituted on 30th August, 2011 by Ministry of Environment and Forest, Government of India. The constitution and the terms of references of the committee are at **Annexure I**.

The committee had the following important five mandates to be completed:

- I. To review all the studies done so far in India and abroad on aspects of ill effects of mobile towers on animals, birds and insects.
- II. To assess the likely impacts of the growth in the number of mobile towers in the country
- III. To suggest possible mitigatory measures.

- IV. To formulate guidelines for regulating the large-scale installation of mobile towers in the country
- V. To identify the gap areas for conducting further detailed research.

In order to achieve its mandate, the committee had convened three meetings and discussed the issue thread bare. After the discussions, in third meeting, the committee had decided to finalise its report. Subsequently, hundreds of research papers were collated, analyzed and reviewed. Detailed descriptions were noted of important and relevant papers. Drafts were circulated within the Committee members for comments.

It should be noted that this is not a complete review of the impact of the electromagnetic radiation on all life forms as **the mandate of the Committee was limited to birds and bees.** However, for the context purpose the committee has referred to many papers concerning other taxa (See Literature Cited).

The findings of the committee based on the above mandates are provided in detail in the following paragraphs.

Scientific background on the issue

Rapid developments in various fields of science and technology in recent years have intensified the human interference into the natural environment and associated physical, biological and ecological systems resulting in various unintended and undesirable negative impacts on environment. With economic, social and scientific development, increasingly fresh avenues for environmental pollution are being thrown open in recent times. Pharmaceutical, genetic, nano-particulates and electro-magnetic pollutions are the prominent ones among them which were in the limelight in recent times for all the negative reasons.

The intensity of manmade electromagnetic radiation has become so ubiquitous and it is now increasingly being recognized as a form of unseen and insidious pollution that might perniciously be affecting life forms in multiple ways (Balmori 2006a; Balmori 2006b; Balmori 2009; Tanwar 2006). The **electro-magnetic fields (EMF)** as a pollution called 'electro-smog' is unique in many ways. Unlike most other known pollutants, the **electro-magnetic radiations (EMR)** are not readily perceivable to human sense organs and hence not easily detectable. However, their impacts are likely to be insidious and chronic in nature. However, it is possible that other living beings are likely to perceive these fields and get disturbed or sometimes fatally misguided. Because the EMR pollution being relatively recent in origin and lately being recognized as a pollutant coupled with its expected long-term impacts and lack of data on its effect on organisms, the real impacts of these pollutants are not yet fully documented in the scientific literature.

The electromagnetic radiations (EMR) are extensively used in modern communication and technology. Radio waves and microwaves are forms of electromagnetic energy that are collectively described by the term "**radiofrequency**" or "**RF**". RF emissions and associated phenomena can be discussed in terms of "energy", "power", "radiation" or "field". Electromagnetic "radiation" can best be described as waves of electric and magnetic energy moving together (i.e., radiating) through space (Cleveland, Fields, and Ulcek 1999).

The first mobile telephone service started on the non-commercial basis on 15 August 1995 in Delhi. During the last 16 years, India has seen exponential growth of mobile telephoning. With this growth, a number of private and government players are coming in to this lucrative and growing sector. At present nearly 800 million Indians have mobile phones, making it the second largest mobile subscribers in the world after China. At present, there are nearly 15 companies providing mobile telephoning. However, necessary regulatory policies and their implementation mechanism have not kept pace with the growth of mobile telephoning. Moreover, there have been not enough scientific studies on the impact of mobile phone towers on human health or its environmental impacts.

Most of the short-term studies primarily looking into the thermal impacts of EMR exposure on biological systems have neither succeeded to detect any statistically significant changes in the biological processes nor could prove any acute change in health conditions at the present background levels of exposures (Brent 1999; Hanowski Niemi and Blake 1996; Hoskote, Kapdi and Joshi 2008; Lönn *et al.* 2005; Mixson *et al.* 2009; Zach and Mayoh 1984; Zach and Mayoh 1986). On the other hand, long-term studies have reported alarming observations, detecting negative consequences on immunity, health, reproductive success, behaviour, communication, co-ordination, and niche breadth of species and communities (Preece *et al.* 2007; Levitt and Lai 2010; Hardell *et al.* 2008; Hardell *et al.* 2007; Fernie and Bird 2001).

- **Impact on birds and bees:** Of the non-human species, impacts on birds and bees appear to be relatively more evident. Exposure to EMR field is shown to evoke diverse responses varying from aversive behavioural responses to developmental anomalies and mortality in many of the studied groups of animals such as bees, amphibians, mammals and birds (Zach and Mayoh 1982; Zach and Mayoh 1982; Batellier *et al.* 2008; Nicholls and Racey 2007; Bergeron 2008; Copplesstone *et al.* 2005; Sahib 2011). Honey bees appear to be very sensitive to EMF (Ho 2007; Sharma and Kumar 2010; Ho 2007) and their behavioural responses, if scientifically documented, could be used as an indicator of EMF pollution.
- **Impacts on other wildlife:** Other wildlife such as amphibians and reptiles also appear to be at high risk with possible interference of EMF with metamorphosis and sex ratios where temperature dependent sex determination is operational. Several investigations into

environmental effects of EM fields are covered in some of the unpublished / grey literature and impact assessments submitted to various regulatory government agencies (Bergeron 2008a; Bergeron 2008b; Cleveland, Fields, and Ulcek 1999; Copplesstone *et al.* 2005; G. Kumar 2010; Hutter *et al.* 2006). Such reports are either not in the public domain, or scattered and often difficult to access.

- **Impacts on Human:** Since its inception, there have been concerns about the ill-effect of the mobile towers and mobile phones. Despite being a relatively newly acknowledged form of pollution, EMRs and their negative impacts on biological systems and environment have already been reported by several studies. However most of the available scientific literature on the negative environmental effects of electromagnetic fields reports the results of experimental and epidemiological studies examining the impact on various aspects of human health (Tanwar 2006; Savitz 2003; Preece *et al.* 2007; Oberfeld *et al.* 2004; Navarro *et al.* 2003; Lönn *et al.* 2005; Kundi and Hutter 2009; Hardell *et al.* 2007; Kapdi, S. Hoskote and Joshi 2008; Hallberg and Johansson 2002).

Present scenario: At present, there could be more than 5 billion mobile phone subscribers globally (www.who.int/mediacentre/factsheets/fs193/en). Recently, in May 2011, the WHO's International Agency for Research on Cancer (IARC) has classified electromagnetic fields from mobile phones and other sources "possibly carcinogenic to human" and advised the public to adopt safety measures to reduce exposures, like use of hand-free devices or texting. For details please see Press Release No. 208, dated 31 May 2011 on IARC-WHO (http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf). Their findings were published in the July 2011 issue of the medical journal **Lancet**. Later, WHO clarified that some of the findings published in **Lancet** were not reported properly in the media and the risk is not as great as made out in the media. Some of the cell phone manufactures have objected to these findings (For example see www.Physorg.com). Some earlier investigators also have contended that there is no measurable risk of reproductive failure and birth defects from EMF exposures in humans (Brent *et al.* 1993), while several others do not agree with that conclusion (Gandhi 2005; Kapdi, Hoskote and Joshi 2008; Poursis 2009; G. Kumar 2010). Studies carried out on the RF levels in North India, particularly at the mobile tower sites at Delhi have shown that people in Indian cities are exposed to dangerously high levels of EMF pollution (Tanwar 2006).

Existing world-wide standard and permissible limits

Two major transmission protocols currently in use for mobile telephony are GSM (900 to 1800 MHz) and CDMA (824-844 MHz paired with 869-889 MHz). The Telecom Engineering Centre (TEC) of DoT had proposed display of Specific Absorption Rate (SAR) value in handsets. As indicated in the table below, current Indian standards on exposure are much higher than many other countries.

Power Density (W/m ²)	International Exposure limits adopted by various countries
10	FCC (USA) OET-65, Public Exposure Guidelines at 1800 MHz
9.2	ICNIRP and EU recommendation 1998 – Adopted in India
3	Canada (Safety Code 6, 1997)
2	Australia
1.2	Belgium (ex Wallonia)
0.5	New Zealand
0.24	Exposure limit in CSSR, Belgium, Luxembourg
0.1	Exposure limit in Poland, China, Italy , Paris
0.095	Exposure limit in Italy in areas with duration > 4hours
0.095	Exposure limit in Switzerland
0.09	ECOLOG 1998 (Germany) <i>Precaution recommendation only</i>
0.025	Exposure limit in Italy in sensitive areas
0.02	Exposure limit in Russia (since 1970), Bulgaria, Hungary
0.001	"Precautionary limit" in Austria, Salzburg City only
0.0009	BUND 1997 (Germany) <i>Precaution recommendation only</i>
0.00001	New South Wales, Australia

Table 1. Guidelines and Limits on Exposure Limits in Various Countries (Source: Girish Kumar 2010)

1. ICNIRP Guidelines (International Radiofrequency Guidelines):

In April 1998, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published, guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields in the frequency range up to 300 GHz. These guidelines replaced previous advice issued in 1988 and 1990. The main objective of the ICNIRP Guidelines is to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects (ICNIRP, 1998). An adverse health effect is defined by ICNIRP as one which causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.

2. Guidelines and Limits followed by Other Countries:

Some countries have established new, low-intensity based exposure standards that respond to studies reporting effects that do not rely on heating. Consequently, new exposure guidelines are having hundreds or thousands times lower than those of Institution of Electronics and Electrical Engineers (IEEE) and ICNIRP. Table 2, shows some of the countries that have lowered their limits, for example, in the cell phone frequency range of 800 MHz to 900 MHz. The levels range from 10 microwatts per centimeter squared in Italy and Russia to 4.2 microwatts per centimeter squared in Switzerland. In comparison, the United States and Canada limit such exposures to only 580 microwatts per centimeter squared (at 870MHz) and then averaged over a time period (meaning that higher exposures are allowed for shorter times, but over a 30 minute period, the average must be 580 microwatts per centimeter squared or less at this frequency). The United Kingdom allows one hundred times of this level, or 580 x 100 microwatts per centimeter squared. Higher frequencies have higher safety limits, so that at 1000 MHz, for example, the limit is 1000 microwatts per centimeter squared (in the United States). The exposure standards for each individual frequency in the radiofrequency radiation range needs to be calculated. These are presented as reference points only. Emerging scientific evidence has encouraged some countries to respond by adopting planning targets, or interim action levels that are responsive to low-intensity or non-thermal radiofrequency radiation bio effects and health impacts.

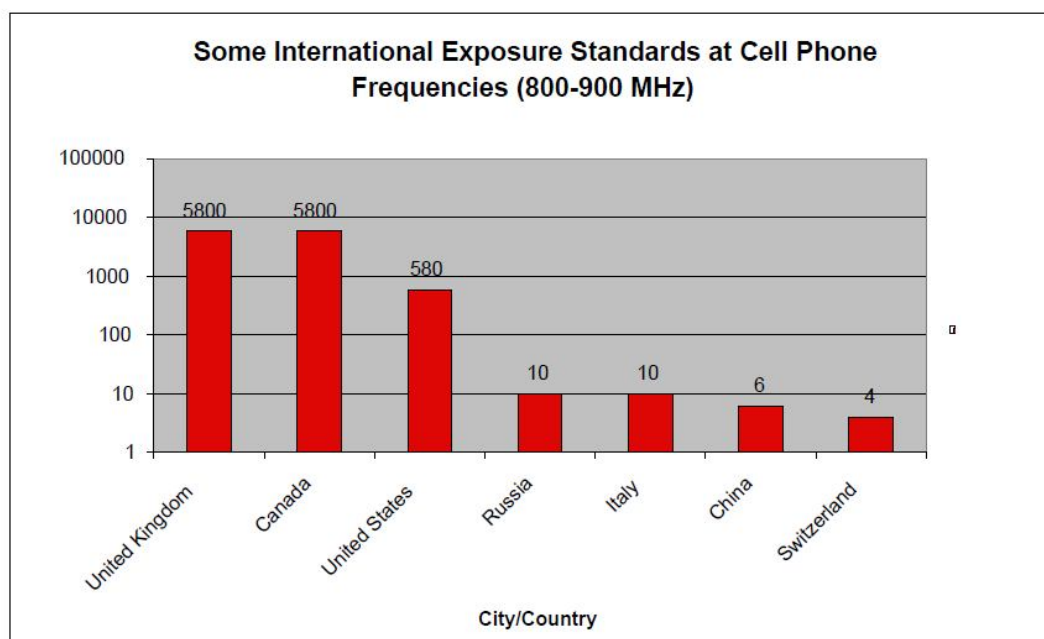


Table 2. Some International Exposure Standards at Cell Phone Frequencies (800-900 MHz) (Values of exposure in microwatts per centimeter squared)

Professional bodies such as IEEE and ICNIRP continue to support “thermal-only” guidelines:

- a) by omitting or ignoring study results reporting bio-effects and adverse impacts to health and wellbeing from a very large body of peer-reviewed, published science because it is not yet “proved” according to their definitions;
- b) by defining the proof of “adverse effects” at an impossibly high a bar (scientific proof or causal evidence) so as to freeze action;
- c) by requiring a conclusive demonstration of both “adverse effect” and risk before admitting low-intensity effects should be taken into account;
- d) by ignoring low-intensity studies that report bio-effects and health impacts due to modulation;
- e) by conducting scientific reviews with panels heavily burdened with industry experts and under-represented by public health experts and independent scientists with relevant low-intensity research experience;
- f) by limiting public participation in standard-setting deliberations; and other techniques that maintain the status quo.

(Source: “Bio Initiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)” by 'Cindy Sage, and David Carpenter (2007))

Detailed analysis of the Issue vis-à-vis the TORs

- **TOR I: To review all the studies done so far in India and abroad on aspects of ill effects of mobile towers on animals, birds and insects.**

Though EMR is a relatively newly recognised pollutant, many recent studies have pointed to their harmful long-term impacts on health and environment. Hence the most important mandate of the committee was to study all the peer reviewed articles/ journals published on the impact of radiations on wildlife throughout the world and to compile them. Subsequently, detailed analysis of the papers was done to find out the impacts of electronic magnetic fields (EMF). The research papers were then listed in to three categories: showing impact on organisms, no impact and neutral or inconclusive evidence (See Table No. 3).

Literature review:

A review during the international seminar entitled “Effects of electromagnetic fields on the living environment” held in Ismaning, Germany in 1999, organized under WHO’s International EMF Project, observed that the EMF impacts on environment are minimal and localized and has opined that the human EMF exposure limits recommended by the International Commission on Non-Ionizing Radiation (ICNIRP, 1998) would also be protective of the environment as well (Foster and Repacholi 1999). However, recent research reports are at odds with these propositions, including the latest report from WHO indicating a possible link with cell phone use and brain glioma (Baan *et al*, 2011).

Several species are known to have the capability to sense and respond to EM fields, especially the earth's magnetic field (Kirschvink 1982). However, little is known of the exact physiological mechanisms involved. Three major hypotheses of magnetic-field detection have been proposed (Lohmann and Johnsen 2000): a) *Electromagnetic induction* (as in Electro sensitive sharks and rays), b) *Biogenic magnetite* and c) *Chemical reactions modulated by magnetic fields*. Despite notable recent progress, primary magneto-receptors have not yet been identified unambiguously.

Most of the reported studies examined (n=919) deal with the EMF impacts on human subjects (81%), while only 3% of them reports impact on birds and just 2% on wildlife. The present report is based on relevant papers and documents obtained mainly from online archives of JSTOR (www.jstor.org) and Google scholar (<http://scholar.google.co.in/>). Salient features of the reported studies on the impact of EMF on different faunal groups are discussed below (can be included below).

An Analysis of Results of Literature Survey:

After careful screening that involved deletion of duplicate records and addition of new references, the 1080 references initially compiled for the analysis of literature (which formed the base for our overview) were reduced to 919 references. These final 919 study reports are used here for the present final analysis.

The studies were broadly classified based on the subject organisms into four categories- Birds, Bees, Other Animals (including wildlife) and humans. Based on the study's findings regarding the impact of EMFs on the subject, each category was further subdivided into three groups- Impact, No Impact or Neutral/ Inconclusive, as given in table 3 below. As noted below majority of the studies reported negative impacts by EMFs.

Table 3. Number of research studies (collected from Open access Bibliographic databases) collected and collated based on the study subjects and results

	Impact	No Impact	Neutral/ inconclusive	Total (n)
Birds	23	3	4	30
Bees	6	1	0	7
Human	459	109	174	742
Other Animals (+Wildlife)	85(+13)	16(+1)	10(+7)	111(+21)
Plants	7	0	1	8
Total	593	130	196	919

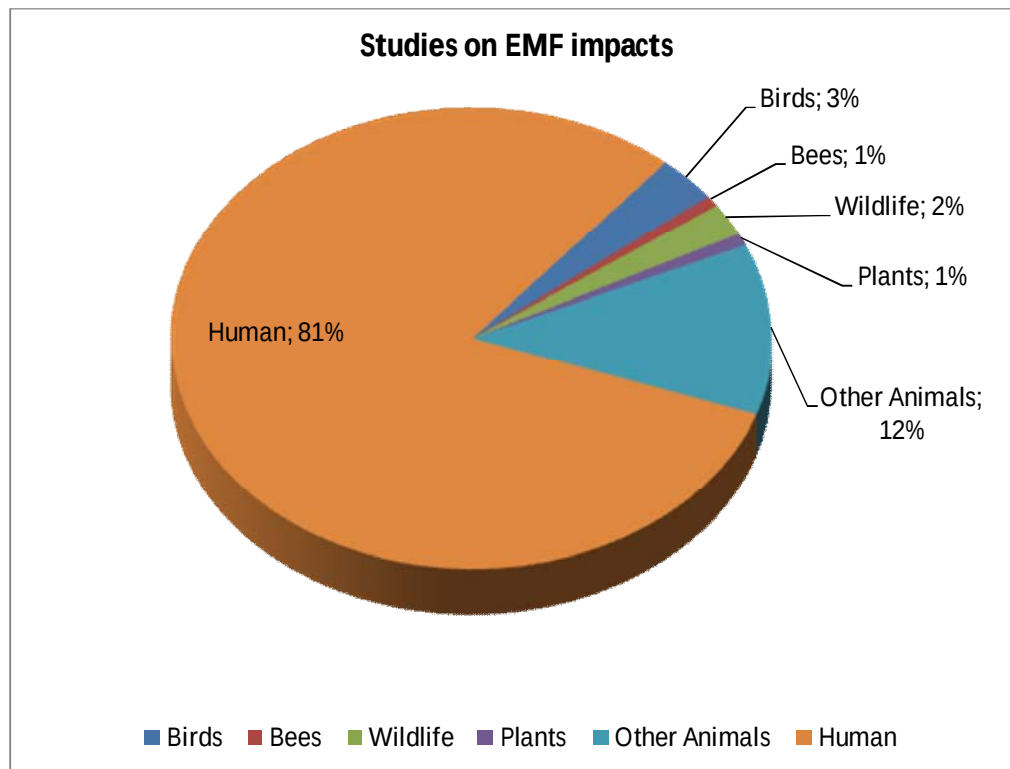


Fig 1. Proportion of studies on different groups of organisms

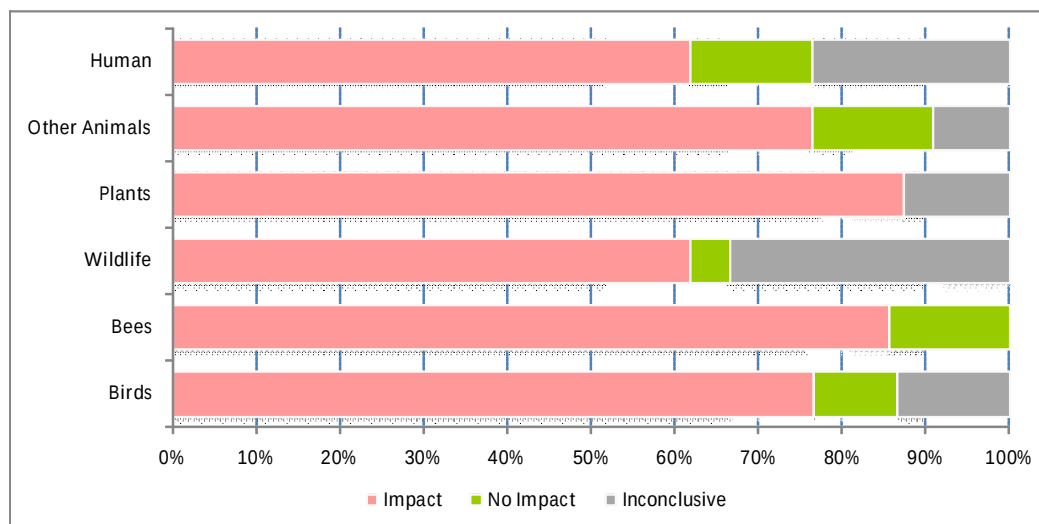


Fig 2. Proportion of study results in various groups of organisms (n=919). The 'Impact' (in red) indicates percentage of studies that reported harmful effect of EMR

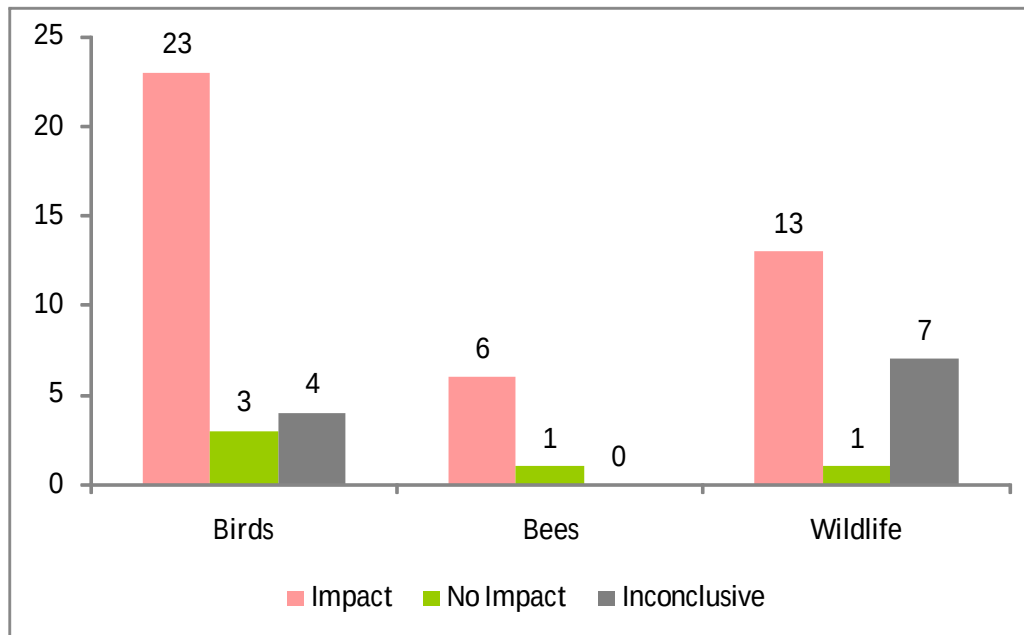


Fig 3. Proportion of study results in Birds, Bees and Wildlife (n=919).

- **TOR II: To assess the likely impacts of the growth in the number of mobile towers in the country.**

India has the second largest population of mobile subscribers in the world and in the absence of any proper policy regulating the construction of mobile towers, the risk of the likely negative impacts of EMF on the health of humans and wildlife is huge. Based on the analysis of the reported studies, the impacts of EMF on different faunal groups were identified, the salient features of which are as discussed below:

Effect on Birds: The earliest reported study on impacts of microwave radiation on birds dates back to 1960s (Tanner, Romero-Sierra, and Davie 1967). In birds, their ability to fly expose them to a greater risk of direct irradiation and hence they appear to be at greater risk as far as effects of EMRs are concerned (Balmori 2005; Balmori and Hallberg 2007; Summers-Smith 2003; Zach and Mayoh 1982; Zach and Mayoh 1984; Zach and Mayoh 1982; Joris and Dirk 2007). Observed effects of exposure to non-ionizing radiation in avian species are mostly from radiation-induced temperature increases (Batellier *et al.* 2008). The incubating avian egg provides a model to study non-thermal effects of microwave exposure since ambient incubation temperature can be adjusted to compensate for absorbed thermal energy. Non-thermal levels of non-ionizing radiation can affect a bird's ability to recover from acute physiological stressors, apart from other potential physiological and behavioural repercussions. Although earlier research indicated that modulated radiofrequency radiation increased calcium-ion efflux in chick forebrain tissue, disagreement on experimental techniques and incongruous results among related studies have

made final conclusions elusive. In another study, which was carried out by National Research Centre of Canada on interaction of electromagnetic fields and living systems with special reference to birds, it was observed that following the onset of radiation, stabilizing period of the egg production in birds was affected (Bigu, 1973).

Birds have been shown to be able to reliably detect magnetic fields in both the field and laboratory. The rapidly increasing number of cell-phone subscribers is resulting in higher concentration levels of electromagnetic waves in the air, which clashes with the earth's electromagnetic field (Hyland, 2000). Some researchers have reported malformations in chicken embryos exposed to a sinusoidal bipolar oscillating magnetic field (Balmori and Hallberg 2007).

According to a thermal modelling study of a bird subjected to continuous wave (CW) microwave radiation (2.45 GHz), the model predicted that tolerance to microwave radiation for a bird was positively correlated with its mass and that ambient temperature is the environmental variable that has most influence on the level of tolerance for microwave radiation (Byman *et al.* 1986).

Effect on House Sparrows: House Sparrow (*Passer domesticus*) is associated with human habitation and it is one of the indicator species of urban ecosystems. A declining population of the bird provides a warning that the urban ecosystem is experiencing some environmental changes unsuitable for living in the immediate future (Kumar, 2010). London has witnessed a 75 per cent fall in House Sparrow population since 1994, which coincides with the emergence of the cell-phone (Balmori, 2002). Electromagnetic radiation may be responsible, either by itself or in combination with other factors, for the observed decline of the sparrows in European cities (Balmori, 2009, Balmori & Hallberg, 2007). Research in Spain proved that the microwaves released from these towers are harmful to House Sparrows and the increase in the concentration of microwaves results into decrease in House Sparrow populations (Everaert & Bauwen, 2007). Reproductive and co-ordination problems and aggressive behavior has also been observed in birds such as sparrows (Balmori, 2005). General methodology used for such study was, from each area, all sparrows were counted in addition to the mean electric field strength (Everaert & Bauwens, 2007). In similar studies in India, population of *Passer domesticus* was found fast disappearing from areas contaminated with electromagnetic waves arising out of increased number of cell phones, in Bhopal, Nagpur, Jabalpur, Ujjain, Gwalior, Chhindwara, Indore & Betul (Dongre & Verma, 2009). It was also observed that when 50 eggs of House Sparrow, exposed to electromagnetic radiation (EMR) for durations of five minutes to 30 minutes, all the 50 embryos were found damaged in a study carried out by the Centre for Environment and Vocational Studies of Punjab University (Kumar 2010, Ram 2008).

Male sparrows were seen at locations with relatively high electric field strength values of GSM base stations, providing evidence of how long-term exposure to higher levels of radiation negatively affects the abundance or behavior of House Sparrows in the wild. Thus,

electromagnetic signals are associated with the observed decline in the sparrow population in urban areas.

Effect on White Storks: In monitoring a White Stork (*Ciconia ciconia*) population in Valladolid (Spain) in vicinity of Cellular Phone Base Stations, the results indicated the possibility that microwaves are interfering with the reproduction of White Stork (Balmori, 2010).

Effect of Mobile Radiation on Honey Bees: Many recent studies have linked the electromagnetic radiations with an unusual phenomenon in bees known as ‘Colony Collapse Disorder’. Colony Collapse Disorder (CCD) occur when a hive's inhabitants suddenly disappear, leaving only queens, eggs and a few immature workers. The vanished bees are never found, but thought to die solitarily far from home. The theory is that radiation from mobile phones interferes with bees' navigation systems, preventing them from finding their way back to their hives. Even the other animals, parasites and other bees, that normally would raid the honey and pollen left behind when a colony dies, refuse to go anywhere near the abandoned hives. Some scientists believe that CCD is the result of high electromagnetic radiation. As long back as early 1970s, Wellenstein (1973) had reported that the navigational skills of the honey bees were being impacted by high tension lines. In a recent study (Stefan *et al.* 2010) significant differences have been detected in returning of honeybees to their hives: 40% of the non-irradiated bees came back compared to 7.3% of the irradiated ones.

The alarm was first sounded in last autumn, but has now hit half of all American states. The West Coast is thought to have lost 60 per cent of its commercial bee population, with 70 per cent missing on the East Coast. CCD has since spread to Germany, Switzerland, Spain, Portugal, Italy and Greece. John Chapple, one of London's biggest bee-keepers, announced that 23 of his 40 hives have been abruptly abandoned (<http://www.independent.co.uk/environment/nature/are-mobile-phones-wiping-out-our-bees-444768.html>).

In India, studies conducted by Sainudeen (2011) have proved experimentally that once mobile phones in working condition with frequency of 900 MHz for 10 minutes were kept in the beehives, the worker bees stopped coming to the hives after ten days. He also found drastic decrease in the egg production of queen bees (100 eggs/ day compared to 350 eggs/ day in the control colonies). Earlier studies have also shown (e.g. Greenberg *et al.* 1981) lower eggs being laid in beehives exposed to high voltage transmission lines. Another possible impact of EMR on the bees is the eggs that are exposed to cell phone radiation produce only drones (Brandes and Frish, 1986). Similar studies on a larger scale and better sample size are required in India.

Other wildlife: Phone masts located in the living areas of animals and birds are continuously irradiating some species that could suffer long-term effects, like reduction of their natural defences, deterioration of their health, problems in reproduction and reduction of their useful territory through habitat deterioration. Electromagnetic radiation can exert an aversive

behavioural response in rats, bats and birds such as sparrows. Therefore microwave and radiofrequency pollution constitutes a potential cause for the decline of animal populations and deterioration of health of plants living near phone masts (Balmori, 2005).

Arguably, the most serious concern about the impact of EMF on the living systems appears to be its long term effects on genes and reproductive fitness of species. Today, there is evidence that Electromagnetic Radiation is genotoxic (Blaasaas, Tynes, and Lie 2003; Joris and Dirk 2007; Poulis 2009; Cherry 2000). An experiment on Common Frog (*Rana temporalis*, new name *Hylarana temporalis*) indicated that radiation emitted by phone masts in a real-time situation may affect the development and may cause rise in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts (Balmori 2010). However, it requires long-term monitoring studies for establishing any causative link between reproductive fitness and EMFs and such data is presently lacking. Moreover, available short term studies are grossly inadequate. For instance a recent review that analysed the literature (till 2001) on the effects of EMF associated with mobile telephony on the prenatal and postnatal development of vertebrates reported that the majority of the studies examined indicated no strong impact on the animal reproduction and development (Poulis 2009).

Effect on bats: Activity of bats seems to be much reduced in areas with Electro-magnetic fields with densities more than 2V/m (Balmori, 2009). Based on this fact it was recommended to use EMR to repel bats from wind farms (Nicholls and Racey, 2007). In another study in a Free-tailed bat colony (*Tadarida teniotis*) the number of bats decreased when several phone masts were placed 80m from the colony (Balmori *et al.*, 2007).

- **TOR III: To suggest possible mitigatory measures**

Decision was taken in the first and second meetings of the Expert Group to study all peer reviewed articles/ journals published on the impact of radiations on wildlife and to compile the list of the measures taken throughout the world to mitigate the effects of radiations on wildlife including birds and bees. Hence, the standards and exposure limits of radio frequency of different countries were studied in this regard.

Various organizations and countries have developed standards for exposure to radio frequency energy as discussed above. Some countries have established new, low-intensity based exposure standards that respond to studies reporting effects that do not rely only on heating. Currently, the World Health Organization is working to provide a framework for international harmonization of RF safety standards.

Emerging scientific evidence has encouraged some countries to respond by adopting planning targets, or interim action levels that are responsive to low-intensity or non-thermal radiofrequency radiation bio effects and health impacts. It is the WHO's view that scientific

assessments of risk and science-based exposure limits should not be undermined by the adoption of arbitrary cautionary approaches. Therefore, throughout the world there has been a growing movement to adopt a precautionary approach.

- **TOR IV: *To formulate guidelines for regulating the large-scale installation of mobile towers in the country***

With the rapid growth of the mobile industry in India, mobile towers are being built in a haphazard manner without any prior planning and regulation. Hence in view of this, along with lack of any policy controlling the construction of such mobile towers, one of the main tasks of the committee is to formulate guidelines to regulate their installation. At the first meeting of the Expert Committee held on 09.2010, it was decided that few members of the Expert Group will participate in the meeting of the Inter-Ministerial Committee on EMF Radiation held in Ministry of Telecommunications on 06.12.2010, to share the concerns on human as well as wildlife health and to devise a common set of guidelines for mobile towers in the country. The minutes of the meeting was submitted to the Ministry.

- **TOR V: *To identify the gap areas for conducting further detailed research***

At the first meeting of the committee, all the members had agreed that the research in India on this issue is very scanty and much research has to be done in this field especially on birds and bees, as well as to find solutions to this issue. Hence, in the second meeting of the Expert Group held on 14.02.2011, a decision was taken to identify the gap areas in research on the issue of impact of radiations on wildlife including birds and bees.

Gap areas for research: Ample information on the impact of EMF on human health is available. However these results cannot be extrapolated to reflect impacts on wildlife impacts since the impact highly varies even within same species depending on multiple factors such as body size, age, earthing, fat content in the body, objects in the immediate vicinity and so on.

Not much data is also available on biological impacts on wild species except for a few species like sparrows and bees. Even this little available information is not reflective of the impact of present background levels of radiation. Information on effects with regards to specific frequencies and species response is lacking. Data on navigation and seasonal migrations as indicated by studies on homing pigeons (Kirchwink 1982) are lacking from the Indian context.

The current ICNIRP guidelines on EMF are developed based especially on laboratory studies, epidemiological data on humans, occupational exposures, in-vitro investigations, observations on cellular changes under control conditions etc. Ecological issues appear to be hardly taken care of. One needs to acknowledge that laboratory observations need not necessarily reflect field effects. Therefore we have to re-visit the guidelines taking account low level electro-smog on wild species especially birds, bees, amphibians etc and modify them accordingly. Our guidelines need to be refined since the ICNIRP Standard currently followed in India is coined

based on only thermal impact of RF and is dismissive of current epidemiological evidence on impacts of non-thermal nature on chronic exposure from multiple towers. The limit on whole-body average SAR is 0.08 W/kg. It is a long way to go before we can have the required long-term 'Species specific data' to decide on the threshold exposure levels for various wildlife species. Till such time a **precautionary principle approach to be used to minimize the exposure levels and we may have to move ahead and adopt stricter norms followed in some other countries like Russia, China, New Zealand etc.**

Since EMF being an invisible form of pollution there needs to be an independent system for monitoring of EMF pollution across the country.

The EMF pollution has reportedly caused population declines on sparrows and bees (causing disorientation and Colony Collapse Disorder (CCD)). It has also resulted in aversive behaviour in bats and sparrows, abnormal behaviour in Tits, Kestrels, reproductive failure in White Storks and also fatal bird collisions with involving communication towers causing the death of several million birds of 230 species each year in the USA alone. However, sound scientific investigations in this regard are lacking in India and such studies needs to be undertaken on an urgent basis.

The following areas for specific studies are suggested to be taken up:

- Field studies on impact of cell towers on bee colonies and apiculture,
- Bird/bat/insect mortalities at mobile phone towers with special reference to towers along bird migratory paths,
- Studies on birds / bats / bees to find the effect of EMR on their communication, orientation and co-ordination
- Effect of EMF on amphibian metamorphosis and sex determination in reptiles
- Laboratory studies to develop an understanding on certain species, on their physiological and behavioural aspects, making use of the techniques of bioassay/bio-monitoring
- Measurement, monitoring and mapping of background EMF levels and power density across India involving independent research agencies.
- Regulations/standards to include the ecological characteristics of an area while determining the location of transmission towers, relay stations etc
- Regulations to control installation of transmission towers in human residences/hospitals/dense habitations
- Conduct ecological impact assessment of transmission towers and base stations, with standardised protocols/parameters

Future Scenario

India is one of the fastest growing mobile telephony industries in the world. It is estimated that by 2013, 1 billion plus people will be having cell phone connection in India. With the growth of cell phone subscriber, it has also lead to growth of infrastructure in the form of mobile phone towers. Today, in absence of any policy on infrastructure development and location of cell phone towers, large number of mobile phone towers are being installed in a haphazard manner across urban and sub urban habitats in India.

Along with the growth of phone towers and subscribers, India is also witnessing a rapid population growth. To feed and support this rapidly growing population the agricultural security and the factors influencing them should be of concern. However, the population of many species such as honey bees, which is one of the most important pollinator and important factor for agricultural productivity, has seen a drastic population drop.

Precautionary approach

Throughout the world there has been a growing movement to adopt a precautionary approach. The WHO defines the Precautionary Principle as a risk management concept that provides a flexible approach to identify and manage possible adverse consequences to human health even when it has not been established that the activity or exposure constitutes harm to health.

It is the WHO's view that scientific assessments of risk and science-based exposure limits should not be undermined by the adoption of arbitrary cautionary approaches. The compliance of mobile phone networks and handsets with the ACMA regulations is regarded as a prudent and cautious approach to ensure that the community is not adversely affected by, but benefits from developments in communications.

The Department Of Telecom has constituted an Inter-Ministerial Committee to examine the effect of EMF Radiation on health. The report of the committee is placed in DOT website. The IMC report is under examination of DOT at present.

Recommendations

Following recommendations have been put forward by few members of the Committee:

- 1) EMF should be recognised as a pollutants/ regular auditing of EMF should be conducted in urban localities/educational/hospital/industrial/residential/recreational premises and around the protected areas and ecologically sensitive areas.
- 2) Introduce a law for protection of urban flora and fauna from emerging threats like ERM/EMF as conservation issues in urban areas are different from forested or wildlife habitats.
- 3) Bold signs and messages on the dangers of Cell phone tower and radiation which is emitted from it are displayed in and around the structures where the towers are erected. Use visual daytime markers in areas of high diurnal raptor or waterfowl movements.
- 4) To avoid bird hits, security lighting for on-ground facilities should be minimized and point downwards or be down-shielded.
- 5) Independent monitoring of radiation levels and overall health of the community and nature surrounding towers is necessary to identify hazards early. Access to tower sites should be allowed for monitoring radiation levels and animal mortality, if any.
- 6) Procedure for removal of existing problematic mobile towers should be made easy, particularly in and around protected area or urban parks and centres having wildlife .
- 7) Strictly control installation of mobile towers near wildlife protected areas, Important Bird Areas, Ramsar Sites, turtle breeding areas, bee colonies, zoos, etc up to a certain distance that should be studied before deciding and should also be practical. Ecological assessment / review of sites identified for installing towers before their installation also may be considered in wildlife / ecologically / conservational important areas.
- 8) The locations of Cell phone towers and other EMF radiating towers along with their frequencies should be made available on public domain. This can be at city/ district/ village level. Location wise GIS mapping of all cell phone towers be done by DoT. This information will help in monitoring the population of birds and bees in and around the mobile towers and also in and/or around wildlife protected areas.
- 9) Public consultation to be made mandatory before installation of cell phones towers in any area. The Forest Department should be consulted before installation of cell phone towers in and around PAs and zoos. The distance at which these towers should be installed should be studied case by case basis.
- 10) Awareness drive with high level of visibility in all forms of media and regional languages should be undertaken by the Government to make people aware about various norms in regard to cell phone towers and dangers from EMR. Such notices should be placed in all wildlife protected areas and in zoos.
- 11) To prevent overlapping high radiations fields, new towers should not be permitted within a radius of one kilometer of existing towers.

- 12) If new towers must be built, construct them to be above 80 ft and below 199 ft. tall to avoid the requirement for aviation safety lighting. Construct unguyed towers with platforms that will accommodate possible future co-locations and build them at existing 'antenna farms', away from areas of high migratory bird traffic, wetlands and other known bird areas.

Note: Many of the above recommendations have already been given by Government of Delhi and West Bengal (appendix III). The Supreme Court of India has sought explanation from all mobile phone operators and various government and semi-government agencies over the issue of alleged "illegal" and unregulated constructions of mobile phone towers on top of buildings across the country (see www.thehindubusinessline.in/2005/09/27/stories/2005092703950900.htm). Similarly, recent rulings in June 2011 by Punjab and Haryana High Courts also direct the government to inform public about the health hazards (www.indianexpress.com/news/Inform/public/about/health/hazards/of/mobile/tower//HC-to-Govt/800786/).

Conclusion

The review of existing literature shows that the EMRs are interfering with the biological systems in more ways than one and there had already been some warning bells sounded in the case on bees (Warnke 2007; vanEngelsdorp *et al.* 2010; Gould 1980; Sharma and Neelima R Kumar 2010) and birds, which probably heralds the seriousness of this issue and indicates the vulnerability of other species as well. Despite a few reassuring reports (Galloni *et al.* 2005), a vast majority of published literature indicate deleterious effects of EMFs in various species. The window of frequency range and exposure time required to make measurable impacts would vary widely among species and unfortunately we do not have any such data available for most of our free-living floral and faunal species in India. There is an urgent need to focus more scientific attention to this area before it would be too late.

Microwave and radiofrequency pollution appears to constitute a potential cause for the decline of animal populations (Balmori 2006; Balmori and Hallberg 2007; Balmori Martínez 2003; Joris and Dirk 2007; Summers-Smith 2003) and deterioration of health of plants and humans living near radiation sources such as phone masts. Studies have indicated the significant non-thermal long-term impacts of EMFs on species, especially at genetic level which can lead to various health complications including brain tumours (glioma), reduction in sperm counts and sperm mobility, congenital deformities, Psychiatric problems (stress, 'ringxiety', sleep disorders, memory loss etc.) and endocrine disruptions. However similar aspects are yet to be studied among animal populations.

Pollution from EMRs being a relatively new environmental issue, there is a lack of established standard procedures and protocols to study and monitor the EMF impacts especially

among wildlife, which often make the comparative evaluations between studies difficult. Moreover, there are no long-term data available on the environmental impacts of EMRs as of now. Well-designed long-term impact assessment studies would be required to monitor the impact of ever-increasing intensities of EMRs on our biological environment. Meanwhile the precautionary principle should prevail and we need to better our standards on EMF to match the best in the world.

Studies on impact of Cell phone tower radiation on Birds and wildlife are almost non-existent from India. There is an urgent need for taking up well designed studies to look into this aspect. Available information from the country on the subject of EMF impacts is restricted to few reports from honey-bees. However, these studies are not representative of the real life situations or natural levels of EMF exposure. More studies need to be taken up to scientifically establish if any, the link between the observed abnormalities and disorders in bee hives such as Colony Collapse Disorder (CCD).

Appendices

Appendix I: Photographs showing mobile towers

Appendix II: Precuatory boards about mobile towers

Appendix III: GRs of Delhi and West Bengal Governments

Appendix IV: Bibliography

Members of the Expert Committee

1. Dr. Asad Rahmani, Director, BNHS (Chairman)
2. Representative of Wildlife Institute of India (Dr. Dhananjai Mohan, Dr. B.C. Choudhary)
3. Representative of Deptt. of Telecommunications, New Delhi [Shri. P. K. Panigrahi, Sr. DDG (BW)]
4. Representative of the Centre for Environment & Vocational Studies, Punjab University
5. Representatives of WWF India (Gp Captain Naresh Kapalia, Dr. Parikshit Gautam)
6. Representative of Indian Institute of Science, Bangalore (Prof. H.S. Jamadagni)
7. Representative of Indian Institute of Technology, New Delhi (Prof. R.K. Patney, Deptt. of Electrical Engineering)
8. Representative of SACON (Dr. P.A. Azeez, Director, Dr. Arun Kumar)
9. Dr. Sainuddin Pattazhy, Associate Professor, Deptt. of Zoology, University of Kerala
10. Ms. Prakriti Srivastava, DIG(WL), MoEF (Member Secretary)

Appendix I



Cell phone Towers on commercial and residential Structures



Cell Phone Tower