

EMR and Health

Report on electromagnetic radiation, health and well-being

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How EMFs affect our bodies

Electromagnetic fields can both damage the body and repair it. But how can both be true?

In a paper published recently online Dr Henry Lai and science journalist B Blake Levitt explain this apparent contradiction.

The story begins with the cell, they say. “As the primary building blocks of life, living cells are a true wonder of chemical and electrical activities.” There are many types of cells that perform many different functions and their activity is determined by microcurrents present in cell membranes.

Because electrical energy is intrinsic to a cell’s operation, cells can be affected by external energies from electrical and wireless technologies. The authors say that these EMFs are “speaking the same fundamental “language” in distorted fashion – beginning at the cellular level and affecting the entire organism.”

Lai and Levitt explain the process by which EMF damages the body. Firstly, EMF can cause changes in the oxidative status of the cell. “Oxidative changes are the most well-established effect of EMF,” they say. This causes molecular damage which triggers the cell’s stress response, a “brilliant evolutionary process” that enables cells to return to normal function.

Once molecular damage occurs, the cell cycle stops and the cell begins to repair damaged proteins, DNA, and lipids. If the damage is too great to repair, apoptosis (cell death) occurs.

In some cases, the cell neither repairs nor dies, but continues to live and replicate in a damaged or mutated state, potentially causing health problems.

According to Lai and Levitt, these cellular processes can affect the body in different ways.

Cancer

EMFs can both cause and cure cancer, the authors say.

When the stress response repairs or kills deviant cells, there can be a beneficial effect on cancer and EMF can be used therapeutically to treat cancer.

However, that’s not the only possibility. “Under EMF exposure, some cancer cells



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within a tumour probably go into apoptosis. Thus, there can be an initial decreased risk of cancer incidence. With continued exposure, however, surviving cancer cells can transform into a more resistant and aggressive state, likely leading to increased cancer risk. The actual response would depend on factors such as cell type, duration of exposure, and the characteristics of the EMF,” the authors say.

Neurodegenerative diseases

Similarly, EMFs have been shown to both increase risks of neurodegenerative diseases (such as Amyotrophic lateral sclerosis, Alzheimer’s and Parkinson’s diseases) and to prevent related cognitive disorders.

“Cellular stress, and particularly oxidative stress, can lead to protein misfolding. Aggregation of protease-resistant misfolded proteins can cause cell death and development of neurodegenerative diseases. Apparently, long-term high-intensity EMF exposure is needed to lead to these detrimental effects. On the other hand ... EMF can initiate cellular processes to repair or eliminate misfolded proteins and possibly retard the progress of some of these diseases.”

Behaviour

Exposure to EMFs can cause both improvements and reductions in behavioural performance. Lai and Levitt say this is because EMF changes levels of arousal and anxiety which affect performance.

Electromagnetic hypersensitivity (EHS)

The authors point out that free radical damage can affect the hypothalamic-pituitary-adrenal axis and, ultimately, the limbic system of the brain. It can also increase levels of nitric oxide which affect the limbic system, too.

Lai and Levitt suggest that some people may have a more sensitive limbic system than others, leading to EHS. They point out that the hypothalamic-pituitary-adrenal axis has been found to be more sensitive in some strains of rats than others.

What determines whether the body will respond in a positive or negative way to EMFs?

Lai and Levitt suggest there are different factors that need to be explored in more detail. One is the presence of other stressors on the body at the same time. EMFs can have a synergistic effect with ionizing radiation, heat, and even a psychological stress such as immobilization, as seen in some animal studies. Another is the characteristics of the EMF (frequency, duration, strength, modulation and so on). And a third is the genetic characteristics of the person or animal exposed.

Implications

This is an important paper because it coalesces decades of scientific research to arrive at a “likely unifying mechanism to explain both the many adverse and beneficial effects” of EMFs.

“[B]iological effects of EMF are simply “cellular stress responses” – a well-investigated cellular/molecular concept,’ Lai and Levitt say. “The fundamental biological dynamic inherent in the ‘cellular stress response’ is a fine balance between two potentially opposing mechanisms – the repair of cellular damage leading to healthy cell proliferation and survival, or cell death when the former is no longer viable.”

Lai and Levitt’s work has implications for radiation standards and public policy. The first is that it can no longer be argued that there is no known mechanism to explain how everyday levels of EMF can damage the body. Another is that harm can occur at very low levels of exposure – levels that comply with Australian and international standards and guidelines. In other words, these standards don’t protect us.

What’s needed, the authors say, is to change the committees that develop these standards. “There should be a preponderance of committee members with backgrounds in biology, not just physics/engineering as is the case today,” they write.

Lai H, Levitt BB. Cellular and molecular effects of non-ionizing electromagnetic fields. Rev Environ Health. 2023 Apr 7. doi: [10.1515/reveh-2023-0023](https://doi.org/10.1515/reveh-2023-0023). Epub ahead of print. PMID: 37021652.

Children, health and wireless radiation

Wireless radiation could have harmful effects on children's development and health. This is the conclusion of a new scientific paper recently published by a group of scientific experts.

In it, the authors provide evidence linking wireless radiation with cancer and impacts on brain development, memory and reproduction. They also refer to effects on oxidative stress, DNA damage, cardiomyopathy, carcinogenicity, sperm damage, memory damage and neurological effects.

The paper was written by experts in medicine, epidemiology, toxicology, physics, biochemical engineering and public health who collectively have published more than 1,000 papers.

They point out that children are exposed to a large and growing number of wireless devices, none of which have been tested for safety on children. Further, their brains and organs have been shown to absorb far more radiation than those of adults. 'Children absorb proportionally more RFR than adults; about 2-fold greater in the pediatric cerebellum, ten-fold greater in the bone marrow of the skull and up to 30-fold greater in the hippocampus. Children's eyes can absorb 2- to almost 5-fold higher doses than adults,' the authors say. Further, 'Children's brain and body tissues have a higher dielectric constant, a measurement of the ease with which electromagnetic fields can move through different media.'

The authors say that young people are particularly vulnerable to wireless radiation. 'Pregnancy, infancy, and childhood are periods of critical susceptibility, especially for the brain, which is developing rapidly. Children have a faster rate of neuronal cell growth and the fatty protective sheath of myelin is not fully formed until the mid-20s. Even very low levels of an environmental exposure early in development can have lifelong implications for neurodevelopment. Stem cells are more active in children and have been found to be more sensitive to wireless frequencies than differentiated cells.'

The new paper provides evidence showing that the growing foetus is particularly vulnerable. 'In both animals and humans, prenatal EMF exposures have been linked with impaired development of structures and functions of the brain, as well as the reproductive organs and reproductive capacity of offspring,' it says. It moreover shows that prenatal exposures can have harmful effects on the central nervous system and can alter behaviour and cognition in the offspring.

The authors also draw attention to the worrying link between mobile phone radiation and brain tumours in children. They say, 'Despite major limitations in design, the Mobikids study of cell phone use in Canadian children reported a doubled risk of glioblastoma multiforme from using cell phones, a risk that should provide a sobering message to those that seek to prevent such disease from occurring in the first place.'

Further, wireless radiation adversely affects the endocrine system. 'RFR has all the classic hallmarks of endocrine disruptors that affect reproduction, development of the hypothalamic-pituitary-gonadal axis (HPG) and alter normal male and female reproductive endpoints,' the authors write.

Children's use of screen devices can be harmful in other ways, they say. 'Higher levels of adolescent screentime, social media access and cell phone use in teenagers' bedrooms are associated with reduced sleep time as well as negative effects on daily functioning, behavior and mood.' Further, 'Up to 8.5% of U.S. youth 8 to 18 years of age and 4.6 % of Chinese youth meet criteria for Internet gaming disorder defined by the World Health Organization in its standard Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5) as an uncontrollable, persisting need to engage directly with digital media and games that cannot be stopped.'



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The authors point out that international radiation limits do not provide adequate protection. 'FCC and ICNIRP regulatory limits have been long criticized by experts and the court because they do not address children's unique vulnerability, the biological and health effects of long-term exposure nor the current ways that children are exposed to cell phone and wireless radiation.' They point to other countries and authorities that have developed lower exposure limits.

Recommendations

The authors made the following recommendations.

- Parents should:
 - reduce children's use of screen-based devices, as recommended by the American Academy of Pediatrics. (none for children under 18 months; limited for children 18 months – 2 years; no more than 1 hour a day for children 2 – 5)
 - read aloud to children
 - limit children's use of mobile phones
 - reduce household exposure to wireless radiation from internet, phones and wireless devices
 - take additional precautions during pregnancy.
- Clinicians should
 - keep informed about wireless radiation and health
 - ask patients about their use of digital media and Wi-Fi devices
 - develop plans for families to reduce use of wireless devices.
- Schools should
 - turn off and store mobile phones
 - not use cordless phones
 - reduce use of wireless technologies
 - teach children how to reduce wireless exposure
 - not allow mobile phone towers on/near school property
 - measure students' exposure annually.
- Health care centres should
 - decrease exposure in waiting rooms, treatment areas, hospital rooms and administrative rooms
 - accommodate sensitive patients
 - educate patients, families, and staff
 - use non-wireless equipment.



'Fortunately, alternatives to employing wireless devices can provide safer, faster and more efficient technical performance for many modern applications. There are many distinct physical, psychological and sociological grounds for moderating children's screen time to promote healthy development. The principle of ALARA—as low as reasonably achievable—ought to be adopted as a strategy for RFR health and safety protection,' the authors say.

Davis D, Birnbaum L, Ben-Ishai P, Taylor H, Sears M, Butler T, Scarato T. Wireless technologies, non-ionizing electromagnetic fields and children: Identifying and reducing health risks. *Curr Probl Pediatr Adolesc Health Care*. 2023 Mar 16:101374. doi: [10.1016/j.cppeds.2023.101374](https://doi.org/10.1016/j.cppeds.2023.101374). Epub ahead of print. PMID: 36935315,

Wireless radiation and free radicals

Wireless (radiofrequency) radiation (RFR) can affect the body via its effects on free radicals says a world authority on the effects of exposure on the body.

Dr Henry Lai, a Professor Emeritus of Bioengineering at the University of Washington, has put together a literature review of 290 relevant studies published since 1997.¹ He found that '263 studies (91%) reported statistically significant effects of radiofrequency radiation on free radical-related cellular processes; only 27 studies (9%) found no significant effects.'

The studies showed that exposure to wireless radiation caused 'consistent' changes in multiple organs and systems of the body in humans and animals, including the brain, heart, liver, lung, kidney, eye, blood, skin, testis/semen, and embryo. It also affected plants.

He concluded, 'Effects have been reported at different frequencies, exposure duration, and modulations, and in different biological systems, cell lines, and animal and plant species. Most of them could be caused by the effects of RFR on cellular free radical processes.'

Free radicals are highly reactive molecules that can damage molecules and cells in the body. Free radical damage, also known as oxidative stress, has been linked to a wide range of health problems, including atherosclerosis, heart disease, inflammatory diseases (arthritis etc), cancers, neurological disease (Alzheimer's Disease, Parkinson's disease, muscular dystrophy), acquired immunodeficiency syndrome, aging and others.²

Lai says that 'Radiofrequency radiation (RFR) can affect oxidative processes (free radicals) in many organs in the body. In addition, similar changes have also been observed after exposure to static and extremely low frequency (ELF) electromagnetic fields (EMF). There are hundreds of papers published on the topic and it is probably the most consistent effect of non-ionizing electromagnetic fields. (You can find lists of these studies (on RFR and Static/ELF EMF) in the BioInitiative Report.³) Effects on oxidative processes in cells are important and alarming because they are involved in many physiological and cellular functions. Changes in these processes can conceivably lead to detrimental health consequences, e.g., increasing risk in cancer development and neurodegenerative diseases.'

'Exposure to wireless radiation caused 'consistent' changes in multiple organs and systems of the body in humans and animals, including the brain, heart, liver, lung, kidney, eye, blood, skin, testis/semen, and embryo.'

One of the important findings of Lai's review is the fact that free radical effects occur at very low levels of exposure, levels that are lower than those allowed by Australian and other international standards.

He says, 'Effects of RFR have been observed in many biological systems after exposure to low field intensities (low absorption rates). (The median specific absorption rate (SAR) that a biological effect can occur is actually 0.0165 W/kg⁴). All these point to a conclusion that the present exposure guidelines used by most governmental agencies are not sufficient to protect the public from possible harmful effects of RFR. Guidelines should be re-evaluated based on new research data from different exposure situations and parameters and not on a single effect, i.e. interruption of an on-going behavior'.

1. Dr Henry Lai, ['The Effects of Radio Frequency Radiation Exposure on Free Radical-Related Cellular Processes \(290 studies\)'](#), Feb 4, 2023 Update.

2. Lobo V, Patil A, Phatak A, Chandra N. [Free radicals, antioxidants and functional foods: Impact on human health](#). Pharmacogn Rev. 2010 Jul;4(8):118-26. doi: 10.4103/0973-7847.70902. PMID: 22228951; PMCID: PMC3249911;

3. [BioInitiative Report](#).

4. Supplement 1 in Lai H, Levitt BB. The roles of intensity, exposure duration, and modulation on the biological effects of radiofrequency radiation and exposure guidelines. Electromagn Biol Med. 41(2):230-255, 2022. doi: [10.1080/15368378.2022.2065683](#). Epub 2022 Apr 19. PMID: 35438055

Why we're not protected from 5G

New and higher-frequency 5G technology is on its way and there's no guarantee we're going to be adequately protected from it, say scientists from New Zealand and Australia.

In a paper published recently, Drs Mary Redmayne and Don Maisch explain what's different about the higher-frequency 5G waves and what's wrong with Australian and international limits for reducing our exposure.¹

Whereas much of the 5G technology currently in use operates at frequencies similar to those that have been used in the past (700 MHz to 4.2 GHz), newer 5G technologies will operate at frequencies from 24 to 40 GHz and potentially even higher. These higher frequencies, called millimetre frequencies because of the size of the wavelength, are known to penetrate the body as far as the skin. But that's not all they do – and more on that in a moment.

Another feature of the mm-wave 5G technologies is that they utilise a new feature called beamforming. This feature means that a 5G transmitter will send narrow, focused beams of radiation towards particular devices, say a 5G mobile phone or smart car driving past. This differs from previous technologies where radiation has been transmitted uniformly by the antenna.

This beamforming feature of the technology will affect people's exposure. '[T]he energy in 5G beams will be relatively high for those in their path and those handling receiving/sending devices; the beamed energy will interact with people, trees and animals in its path,' the authors say. This includes pollinating insects, like bees, which will absorb more 5G radiation because of the size of their bodies.

According to the authors, there are problems with the 2020 Guidelines of the International Commission for Nonionizing Radiation (ICNIRP) on which radiation standards of many countries, including Australia, are based. They point out that ICNIRP is anything but an independent authority. '[T]he ICNIRP is a self-governing private organization (NGO) that elects their members internally. Members have been criticized for having telecommunication industry ties and conflicts of interest with other work they have undertaken for the World Health Organisation.'

Its exposure limits are based on various scientific assumptions that have been shown to be flawed.²

When it comes to assessing the risk of 5G millimetre waves, the ICNIRP Guidelines focus on measuring effects on the skin and ignore 'internal heating from absorbed energy', the authors point out.

However, it is possible that 5G millimeter waves may, in fact, cause heating inside the body and not just on the skin. 'Using these and higher frequencies for 5G may create pulses that carry some of the energy more deeply into the body.'



The type of pulse that is most of concern, they say, is the Brillouin pulse which they describe as follows: 'the generation of electrical charge through living tissue carries mechanical force. Many membranes have charged surfaces; there are dissociated ionic sites in proteins and DNA, and there are a host of chemical ions in tissue. All these are subject to these forces, so they, in turn, "radiate a portion of that energy as a propagating electromagnetic field". Therefore not only does the energy propagate more deeply than expected, but there is then an increased rate of collisions as they pass on their mechanical energy. This progression raises the total kinetic energy and, thus, the temperature of the medium as a whole.'

In other words, the Brillouin pulse could be causing changes deep inside the body that are not being considered in the ICNIRP Guidelines and Australian radiation standard.

When asked about this, Dr Redmayne added, 'It's not just Brillouin pulses. Even with the lower GHz beam-forming there is no requirement to assess exposure to local areas such as hand, head or chest by volume under the surface – a type of 3-D

measurement. But earlier research has shown that those measurements can be unacceptably high even when surface measurements are fine.'

The authors conclude that 'we still do not have adequate research on 5G mmW to be able to assure the public that the many thousands of 5G antennas, in many instances placed very near homes and workplaces, are without a possible health risk because the necessary research has not yet been conducted.'

They say, 'Once the 5G mmW band is internationally operational, a significant proportion of the world's population will be exposed to new hazards. The intensity and complexity of near-field exposure, such as when carrying a phone in a pocket or using it next to the head, will be different for 5G, and this is the first time mmW have been used for public telecommunications and the first time beamforming has been deliberately introduced for near-field use. Without research on the impact of near-field 5G, this global step is an experiment at the population level.'

Redmayne, M.; Maisch, D.R. ICNIRP Guidelines' Exposure Assessment Method for 5G Millimetre Wave Radiation May Trigger Adverse Effects. [Int. J. Environ. Res. Public Health 2023, 20, 5267.](#)

Solutions for mobile phone radiation

In a paper published earlier this month, scientists from the International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), explained that, by implementing simple engineering adjustments, the amount of radiofrequency (wireless) radiation that these phones emit could be reduced dramatically. And so could our exposure.

The authors explain why reducing our exposure is so important. 'Epidemiological [population] studies have reported significant associations between exposure to RFR [radiofrequency radiation] and increased risks of glioma, acoustic neuroma, and thyroid cancer, among others. Numerous peer-reviewed studies on cell phones indicate that prolonged use leads to glioma as well as acoustic neuroma,' they say. And children are particularly vulnerable, not just because they are more exposed to mobile phone radiation than adults, but they have a potential lifetime of exposure.

They also point out that people throughout the world are hypersensitive to this radiation, which has also been found to affect animals and the environment.

Further, international standards and guidelines supposed to protect the public and workers are inadequate for the task. 'The safety limits promoted by the IEEE [Institute of Electrical and Electronics Engineers] and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) have been adopted by many nations despite the fact that these limits were only aimed at protecting workers and the public from acute heating effects of RFR. These limits ignored the non-thermal interactions between RFR fields and the free electric charges present within living tissues,' the authors say.

But solutions are available. The paper outlines six engineering solutions that could reduce people's exposure and that could be easily implemented.

- Use existing body sensors in Android and iPhone devices to detect when the mobile phone is near the body and automatically turn off emissions. This would encourage

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'studies have reported significant associations between exposure to RFR [radiofrequency radiation] and increased risks of glioma, acoustic neuroma, and thyroid cancer, among others.'

users to hold the phone at a distance from the ear, dramatically reducing their exposure.

- Install existing technology—already patented by many mobile phone manufacturers—underneath antennas. This could conserve battery power and reduce exposure between 2 and 100 times.
- Program mobile phone software to choose Wi-Fi for calling whenever it is available. This would reduce the transmitting power of the phone from 0.6 – 3 watts to connect via a phone tower to 0.1 watts to connect via Wi-Fi. It would also extend battery life.
- Reduce “handshake” transmissions (that allow mobile phone towers to track phone locations) by eliminating them when the user and their phone are not moving. The phone’s built-in GPS and accelerometer make reducing handshakes possible by tracking changes in location and motion.
- Program mobile phones to default to airplane mode when the phone is not being used. This would reduce exposure and conserve power. [Please note that airplane mode does not always turn off wireless radiation in Australia. Ed]

Install software to limit the duration of mobile phone calls.

‘Given the growing evidence of the health effects of radiation from cellphones and cell towers, I believe the wireless industry is going to have to start competing on safety,’ said Joel Moskowitz, one of the authors of the paper. ‘This competition for safety can move forward without a change in the current government standards,’ he explained. ‘Ultimately, I believe governments around the world will be playing catch-up with industry and consumers.’

Héroux, P.; Belyaev, I.; Chamberlin, K.; Dasdag, S.; De Salles, A.A.A.; Rodriguez, C.E.F.; Hardell, L.; Kelley, E.; Kesari, K.K.; Mallery-Blythe, E.; Melnick, R.L.; Miller, A.B.; Moskowitz, J.M.; on behalf of the International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF). Cell Phone Radiation Exposure Limits and Engineering Solutions. *Int. J. Environ. Res. Public Health* 2023, 20, 5398. <https://doi.org/10.3390/ijerph20075398>; <https://www.mdpi.com/1660-4601/20/7/5398>

Electronic devices and energy consumption

The Environmental Health Trust reports that the more we use wireless electronic devices, the more energy we will consume. 5G will exponentially increase energy usage. The Small Cell Forum predicts the installed base of small cells to reach 70.2 million in 2025 and the total installed base of 5G or multimode small cells in 2025 to be 13.1 million.

Read more here: <https://ehtrust.org/science/reports-on-power-consumption-and-increasing-energy-use-of-wireless-systems-and-digital-ecosystem/>

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measures radiation from
40 MHz to 10 GHz and
24 GHz to 32 GHz

‘children are particularly vulnerable, not just because they are more exposed to mobile phone radiation than adults, but they have a potential lifetime of exposure.’