Compilation of Research Relevant to 4G/5G Wireless Facilities

Examples of Published Scientific Research on 5G, Small Cells Wireless and Health

Published peer reviewed science already indicates that the current wireless technologies of 2G, 3G and 4G – in use today with our cell phones, computers and wearable tech – creates (create) radiofrequency exposures which poses (pose) a serious health risk to humans, animals and the environment. Scientists are cautioning that before rolling out 5G, research on human health effects urgently needs to be done first to ensure the public and environment are protected.

“Small cells” are microwave antennas (basically shorter cell towers) rapidly being installed in public areas on utility poles and street lights in front of homes, parks and schools. Just like cell towers, these wireless antennas generate and emit microwave radiofrequency (RF) radiation to transmit 2G, 3G and 4G network signals. Companies soon plan to add a new technology called 5G which will use current 4G technology plus even higher frequencies. The higher frequencies include millimeter-wave emissions that were not previously released into public areas.

Companies state that these 4Gand 5Gantennas will increase the wireless radiation levels in the area so much that they are working to loosen several governments’ radiation limits in order to roll it out. More than 240 scientists published an appeal to the United Nations to reduce public exposure and called for a moratorium on 5G citing “established” adverse biological effects of RF radiation.

5G will utilize not only the frequencies currently in use, but also higher millimeter wave and sub-millimeter wave frequencies. Small cells being installed in cities are usually 4G technology with a wide variety of frequencies. Thus, when we consider the health impacts of 5G and small cells we are looking at research on current technologies and frequencies in use in addition to research on sub-millimeter and millimeter waves. The 5G standard is new there are no studies that have looked at long term human exposure to 5G. However, the current body of research finding effects from current wireless technology provides enough data for scientists to call for a moratorium.

This page lists important research on 5G, millimeter waves, cellular antennas, the environment and human health.

- Learn more about 5G on EHT's database of resources here.
- Click here for EHT's list of Scientists letters on Health Impacts of 5G
- Click here to read research in cell tower radiation linked to health effects

- Click here to get the EHT factsheet on 5G
- Dr. Martin Pal, "5G: Great risk for EU, U.S. and International Health! Compelling Evidence for Eight Distinct Types of Great Harm Caused by Electromagnetic Field(EMF) Exposures and the Mechanism that Causes Them"
- Published article on the EMF Scientist Appeal in the European Journal of Oncology.

Published Research Documents Adverse Effects of RF Exposure

Published peer reviewed science associating exposure with biological effects already indicates that the current wireless technologies of 2G, 3G and 4G – in use today with our cell phones, computers and wearable tech poses serious risks to humans, animals and the environment. More than 240 scientists published an appeal to the United Nations to reduce public exposure and are calling for a moratorium on 5Gciting "established" adverse biological effects of RF radiation.

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5G will utilize not only the frequencies currently in use, but also higher millimeter wave and sub-millimeter wave frequencies. Small cells (wireless antenna installations) being installed in cities are usually 4G technology with the capacity for 5G installations at a later date. Cell phones and wireless devices in use today and the near future have multiple antennas with a range of frequencies and modulations. Thus, when we consider the health impacts of 5G and "small cells" we need to consider research on current technologies already in use (2G, 3G and 4G) in addition to research on sub-millimeter and millimeter waves. The 5G standard is new and there are no studies that have looked at long term human exposure to 5G specifically.

Published Research Documents Adverse Effects of RF Exposure

Publications on 5G

"5G Wireless Expansion: Public Health and Environmental Implications" is a research review that documents the range of reported adverse effects of RF and millimeter waves—effects range from cancer to bacteria growth changes to DNA damage. The study concludes that "a

moratorium on the deployment of 5G is warranted" and "the addition of this added high frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome … from both physical and mental health perspectives" (Russell 2018).

"Towards 5G communication systems: Are there health implications?" is a research review detailing research findings that millimeter waves can alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes." The researchers conclude, "available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle" (Di Ciaula 2018).

"Systematic Derivation of Safety Limits for Time-Varying 5G Radiofrequency Exposure Based on Analytical Models and Thermal Dose" documents how significant tissue heating can be generated by 5G technology's rapid short bursts of energy. "The results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines." (Neufeld and Kuster 2018)

"The Human Skin as a Sub-THz Receiver – Does 5G Pose a Danger to It or Not?" and "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin" are two papers by physicists presenting research that found higher 5G frequencies are intensely absorbed into human sweat ducts (in skin), at a much higher absorption levels than other parts of our skin's tissues (Betzalel 2017, Betzalel 2018). The researchers conclude, "we are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored."

"Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz" published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power between 3% to 370% when the insects were exposed to the frequencies. Researchers concluded, "This could lead to changes in insect behaviour, physiology, and morphology over time…." (Thielens 2018)

Review Publications on Electromagnetic Radiation and RF

A 2019 literature review "Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation" found that 93 of the 100 peer-reviewed studies dealing with oxidative effects of low-intensity RFR, confirmed that RFR induces oxidative effects in biological systems.

"Planetary Electromagnetic Pollution: It Is Time to Assess Its Impact" published in The Lancet documents the significant increase in environmental levels of radio-frequency (RF) electromagnetic wireless radiation over the last two decades. The study cites an evaluation that found 68.2% of 2266 studies in humans, animals, and plants demonstrated significant biological or health effects associated with exposure to electromagnetic fields. 89% of experimental studies that investigated oxidative stress endpoints showed significant effects and "radiofrequency electromagnetic radiation causes DNA damage apparently through oxidative stress. The paper also highlights research that has associated RF exposure with altered neurodevelopment and behavioural disorders, structural and functional changes in the brain and the sensitivity of pollinators. "These findings deserve urgent attention.This weight of scientific evidence refutes the prominent claim that the deployment of wireless technologies poses no health risks at the currently permitted non-thermal radiofrequency exposure levels." (Bandara and Carpenter 2018)

The review "Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective" published by researchers of the European Cancer Environment Research Institute in Brussels, Belgium and the Institute for Health and the Environment, University at Albany, NY, USA reviews current research findings and states that, "the mechanism(s) responsible include induction of reactive oxygen species, gene expression alteration and DNA damage through both epigenetic and genetic processes." The paper states that "exposure to low frequency and radiofrequency electromagnetic fields at low intensities poses a significant health hazard that has not been adequately addressed by national and international organizations such as the World Health Organization."

The literature review "Effect of radiofrequency radiation on reproductive health" published by the Division of Reproductive Biology & Maternal Health, Child Health, Indian Council of Medical Research documents research that has found a link between radiofrequency radiation and oxidative stress and changes to the reproductive system including sperm count, motility, normal morphology and viability. The review concludes that the "available data indicate that exposure to EMF can cause adverse health effects. It is also reported that biological effects may occur at very low levels of exposure."

A 2010 landmark review studyon 56 studies that reported biological effects found at very low intensities, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular and metabolic changes, and increases in cancer risk (Lai and Levitt, 2010).

Cancer

Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields is a comprehensive research review of RF effects in human and animal research. The review concludes that scientific evidence is now adequate to conclude radiofrequency radiation is carcinogenic to humans (Miller 2018). Several previously published studies also concluded that RF can "cause" cancer, for example, Hardell 2017, Atzman 2016and Peleg 2018.

The US National Toxicology Program (NTP) Study on Cell Phone Radiation Found "clear evidence" of cancer, heart damage and DNA damage in a $30-million study designed to test the basis for federal safety limits (NIEHS2018). The heart and brain cancers found in the NTP rats are the same cell type as tumors that researchers have found to be increased in humans who have used cell phones for over 10 years. Thus, researchers say this animal evidence confirms the human evidence associating the exposure to cancer(Hardell 2019.)

The Ramazzini Institute (RI) Study on Base Station RF was another large scale rat study that also found increases in the same heart cancers that the NTP study found—yet the Ramazzini rats were exposed to much lower levels of RF than the NTP rats. In fact, all the RI Ramazzini radiation exposures were below FCC limits, as the study was specifically designed to test the safety of RF limits for cell tower/base stations (Falconi 2018.) Thus the Ramazzini study corroborates the NTP findings.

Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans"is a replication study that used very, very low RF exposures (lower than the Ramazzini and NTP study) and combined the RF with a known carcinogen. Researchers found elevated lymphoma and significantly higher numbers of tumors in the lungs and livers in animals exposed to both RF and the carcinogen, leading researchers to state that previous research (Tillman 2010) was confirmed and that "our results show that electromagnetic fields obviously enhance the growth of tumors" (Lerchl 2015).

Environment

"A review of the ecological effects of RF-EMF" reviewed 113 studies finding RF-EMF had a significant effect on birds, insects, other vertebrates, other organisms and plants in 70% of the

studies (Cucurachi 2013). Development and reproduction in birds and insects were the most strongly affected. As an example of the several studies on wildlife impacts, a study focusing on RF from antennas found increased sperm abnormalities in mice exposed to RF from GSM antennas (Otitoloju 2010).

Studies on bees have found behavioral effects (Kumar 2011, Favre 2011), disrupted navigation Goldsworthy 2009, Sainudeen 2011, Kimmel et al. 2007) decreasing egg laying rate (Sharma and Kumar, 2010) and reduced colony strength (Sharma and Kumar, 2010, Harst et al. 2006).

Research has also found a high level of damage to trees from antenna radiation. For example, a field monitoring study ----spanning 9 years involving over 100 trees (Waldmann-Selsam 2016)found trees sustained more damage on the side of the tree facing the antenna.

5G and the Internet of Things will increase overall use of all types of wireless frequencies.

A published review of effects of Wi-Fi radiation entitled, "Wi-Fi is an important threat to human health" found that "repeated Wi-Fi studies show that Wi-Fi causes oxidative stress, sperm/testicular damage, neuropsychiatric effects including EEG changes, apoptosis, cellular DNA damage, endocrine changes, and calcium overload.

"The Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station"is a research study that compared people living close (within 80 meters) and far (more than 300 meters away) from cellular antennas and found that the people living closer had several significant changes in their blood predictive of cancer development (Zothansanga 2017). An earlier 2016 study looking at 116 persons exposed to radiation from mobile towers and 106 control subjects found DNA damage in peripheral blood lymphocytes (Gulati 2016).

"Mortality by neoplasia and cellular telephone base stations" is a 10 year study by the Belo Horizonte Brazil Health Department and several universities in Brazil that found an elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell installations (Dode 2011). Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the city's antennas be removed. Many antennas were dismantled.

A 2019 study of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory and attention (Meo 2019). Examples of other effects linked to cell towers in research studies include neuropsychiatric problems, elevated diabetes, headaches, sleep problems and genetic damage.

A published study entitled, "Effect of Mobile Tower Radiation on Microbial Diversity in Soil and Antibiotic Resistance"took soil samples from four different base stations located in Dausa city, and control samples from soil far from stations and then isolated and evaluated the microorganisms in the soil. The researchers found greater antibiotic resistance in microbes present in soil near base stations compared to the control. The study concludes, "our findings suggest that mobile tower radiation can significantly alter the vital systems in microbes and turn them multidrug resistant (MDR) which is the most important current threat to public health."

Research on 3G and 4G

3G and 4G technology is still very much in use around the world. In addition, 5G devices will also have 4G emissions and 5G will use the frequencies currently used in 2G, 3G and 4G.

A 2019 study on human blood found microwave 3G MT EMF/radiation - within the current exposure limits - had significant genotoxic action on human cells (Panagopoulos 2019). A series of landmark papers found that effects from microwaves on human lymphocytes can be dependant on carrier frequency (Belyaev 2005), that UMTS (3G) microwaves can affect chromatin and inhibit formation of DNA double-strand breaks (Belyaev 2009)and that stem cells are most sensitive to microwave exposure (Belyaev 2010). Children have more active stem cells.

4G or the fourth generation of cellular technology called Long Term Evolution or LTE was launched without premarket safety testing for long term exposure. Published research has found behavioral changes in mice (Broom 2019); damage to the testes and reproductive potential in mice (Yu 2019); reduction to EEG alpha power (Vecsei 2018); modulation to resting state EEG on alpha and beta bands (Yang 2017); alteration of spontaneous low frequency fluctuations induced by the acute LTE RF-EMF exposure (Lv 2014).

A 2018 double-blind, crossover, randomized, and counterbalanced design study Modulation of brain functional connectivity by exposure to LTE (4G) cell phone radiation found that acute LTE-EMF exposure did modulate connectivity in some brain regions and the authors conclude that "Our results may indicate that approaches relying on network-level inferences can provide deeper insights into the acute effects of LTE-EMF exposure with intensities below the current safety limits on human functional connectivity. In the future, we need to investigate the evolution of the effect over time." (Wei 2018).

The Building Industry

The paper "Building science and radiofrequency radiation: What makes smart and healthy buildings" with a long list of authors including former Microsoft Canada President Frank Clegg as well as Anthony Miller MD former Director of the Epidemiology Unit of the National Cancer Institute of Canada reviews research finding adverse health effects below regulatory limits and recommends reducing radiofrequency radiation in buildings by installing wired rather than wired internet connections and corded rather than cordless phones (Clegg 2019).

The Collaborative for High Performance Schools has developed Best Practices for LOW EMF classrooms that details how schools can replace wireless networks with wired networks. See CHPS Low EMF Criteria

Cell Towers and Health

A 2014 publication in Environmental Science & Policy by human rights experts argue that cell tower placement is a human rights issue for children because "the protection of children is a high threshold norm in Human Right law and the binding language of the Convention on the Rights of the Child obliges States Parties to provide a higher standard of protection for children than adults" and "any widespread or systematic form of environmental pollution that poses a long-term threat to a child's rights to life, development or health may constitute an international human rights violation." The article concludes that the "dearth of legislation to regulate the installation of base stations (cell towers) in close proximity to children's facilities and schools clearly constitutes a human rights concern…" (Roda and Perry 2014).

"Safety Zone Determination for Wireless Cellular Tower - A Case Study from Tanzania" *published in the International Journal of Research in Engineering and Technology*evaluated the radiation levels and concluded that "respective authorities should ensure that people reside far from the tower by 120m or more depending on the power transmitted to avoid severe health effect."

"Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems" published in Experimental Oncology reviews research findings on RF-EMF and states that it is "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." The paper concluded that "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" (Yakymenko 2011)

A cross-sectional case control study on genetic damage in individuals living near cell towers found genetic damage parameters of DNA were significantly elevated (Gandhi 2015).

"Neurobehavioral effects among inhabitants around mobile phone base stations" *published in Neurotoxicology* concluded that "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" and called for the revision of standard guidelines for public exposure to RER from mobile phone base station antennas" (Abdel-Rassoul, 2006).

"Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations" *published in the International Journal of Occupational Environmental Health*reviewed 10 epidemiological studies that assessed for health effects of mobile phone base stations and 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. The review concludes that" current guidelines may be inadequate in protecting the health of human populations" (Khurana, 2010).

"How does long term exposure to base stations and mobile phones affect human hormone profiles?" published in Clinical Biochemistry followed volunteers for six years and found that high radio frequency radiation had effects on pituitary–adrenal axis represented in the reduction of ACTH, cortisol, thyroid hormones, prolactin in young females, and testosterone levels (Eskander 2012).

A study of 530 people living near mobile phone masts reported more symptoms of headache, sleep disturbance, discomfort, irritability, depression, memory loss and concentration problems the closer they lived to the cellular antennas (Santini 2002).

A study from Spain "The Microwave Syndrome: A preliminary Study" published in *Electromagnetic Biology and Medicine found statistically* significant associations between field intensity and the symptoms of fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems (Navarro 2003). "Subjective symptoms,

sleeping problems, and cognitive performance in subjects living near mobile phone base stations." published in Occupational Environmental Medicine found a significant correlation between measured power density and headaches, fatigue, and difficulty in concentration in 365 subject (Hutter 2006). Abdel-Rassoul 2007 found residents living beneath and opposite a long established mobile phone mast reported significantly higher occurrences of headaches, memory changes, dizziness, tremors, depressive symptoms and sleep disturbance than a control group.

"Increased Incidence of Cancer Near a Cell-Phone Transmitter Station" published in the *International Journal of Cancer Prevention* found a four-fold increase in the incidence of cancer among residents living within 300m radius of a mobile phone mast after three and seven years of exposure (Wolf 2004).

"The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer" found a three-fold increase in the incidence of malignant tumours after five years' exposure in people living within 400m radius of a mobile phone mast (Eger 2004).

Cell Antennas Increase Exposures in Communities

A 2019 study found increased RF-EMF exposure from small cell LTE networks in two urban cities in France and the Netherlands. Researchers measured the RF-EMF from LTE (Long-Term Evolution) MC (macro cells meaning large cell towers) and SC networks (low-powered small cell base stations) and found that the small cell networks increased the radio emissions from base stations (called downlink) a factor of 7–46while decreasing the radio emissions from user equipment exposure (called)a factor of 5–17. So while the devices themselves could emit less radiation, the cell antennas will increase the levels from cell antennas (Mazloum 2019). This study shows the increased exposures would be involuntary. We can turn our phones off, but we cannot turn off the antennas in the neighborhood.

An Australian study also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters (Bhatt 2016).

A 2018 multi-country study that measured RF in several countries found that cell phone tower radiation is the dominant contributor to RF exposure in most outdoor areas exposure in urban areas was higher and that exposure has drastically increased. As an example, the measurements the researchers took in Los Angeles, USA were 70 times higher than the US EPA estimate 40 years ago (Sagar 2018).

As an example of how rapidly RF is increasing from wireless antennas, a 2014 published study looked at RF in three European cities and found in just one year (between April 2011 and March 2012) that the total RF-EMF exposure levels in all outdoor areas in combination increased by 57.1% in Basel by 20.1% in Ghent and by 38.2% in Brussels (Urbinello 2014). "Exposure increase was most consistently observed in outdoor areas due to emissions from mobile phone base stations."

Another study, Birks 2018, looked at 529 children in Denmark, the Netherlands, Slovenia, Switzerland and Spain who wore meters around the waist or carried in a backpack during the day and placed close to the bed at night. Researchers found "the largest contributors to total personal environmental RF-EMF exposure were downlink (meaning from cell tower base stations) and broadcast."

Cell tower radiation is a significant contribution to our daily dose of RF. A study on Australian adults where participants carried a measuring device in a small hip bag for approximately 24 consecutive hours also found "downlink and broadcast are the main contributors to total RF-EMF personal exposure." Downlink (RF from mobile phone base station) contributed 40.4% of the total RF-EMF exposure (Zeleke 2018). Another published study (Choi 2018) that gave 50 Korean adult child pairs a special radiation measuring device for 48 hours evaluated the types of radiation the participants were exposed to and found that "the contribution of base-station exposure to total RF-EMF exposure was the highest both in parents and children."

The Bioeffects of Millimeter Waves Documented Years Ago

A Russian Review on Millimeter Waves declassified by the CIA in 2015 "Biological Effect of Millimeter Waves" reported multiple research findings and concluded that "Morphological, functional and biochemical studies conducted in humans and animals revealed that millimeter wave caused changes in the body manifested in structural alterations in the skin and internal organs, qualitative and quantitative changes of the blood and bone marrow composition and changes of the conditioned reflex activity, tissue respiration, activity of enzymes participating in the process of tissue respiration and nucleic metabolism." (Zalyubovskaya)

"Current state and implications of research on biological effects of millimeter waves: a review of the literature" published in Bioelectromagnetics reviewed dozens of research findings on low-intensity millimeter waves and concluded that the reported "MMW effects could not be readily explained by temperature changes during irradiation." The review concludes by questioning the adequacy of regulatory limits stating that, "Safety limits for these types of

exposure are based solely on predictions of energy deposition and MMW heating, but in view of recent studies this approach is not necessarily adequate." (Pakhomov)

The evidence supports the International EMF Scientist Appeal By 244 scientists from 41 countries who have published on the subject in peer-reviewed literature and collectively petitioned the WHO and the UN for immediate measures to reduce public exposure to artificial electromagnetic fields and radiation.

Attenuation by a Human Body and Trees as well as Material Penetration Loss in 26 and 39 GHz Millimeter Wave Bands,International Journal of Antennas and Propagation

- "In this paper, attenuation by human body and trees and penetration loss of different materials at 26 and 39 GHz are investigated for 5G wireless communications.."
- "The results show that the upper bound of the KE model is better to predict the attenuation by a human body compared with UTD one-cylinder and two-cylinder models at both 26 and 39 GHz. ITU model overestimates the attenuation by willow trees, and a modified attenuation model by trees is proposed based on our measurements at 26 GHz."
- "It is found that the penetration loss for wood is smaller than that of transparent glass in the same thickness, and the penetration loss of frosted glass is slightly larger than that of transparent glass."
- "The measurement and modeling results in this paper are significant and necessary for simulation and planning of fifth-generation (5G) mm-wave radio systems in ITU recommended frequency bands at 26 and 39 GHz."

Skin Heating and Injury by Prolonged Millimeter-Wave Exposure: Theory Based on a Skin Model Coupled to a Whole Body Model and Local Biochemical Release From Cells at Supraphysiologic Temperatures, IEEE TRANSACTIONS ON PLASMA SCIENCE, VOL. 34, NO. 4, AUGUST 2006

- "Second, the biophysical mechanism of biochemical release through cell membranes within the tissue regions that reach supraphysiologic temperatures is also considered. The released molecules are delivered to other skin regions by diffusion and into the bloodstream by perfusion, where according to our hypothesis, the molecules interact with susceptible cells. This raises the possibility of additional indirect injury at nearby deeper skin regions that experience insignificant heating. Biochemical release may also lead to injury at distant sites within the body by perfusion clearance that transfers molecules into the systemic circulation to reach other susceptible cells."

"Numerical Model of Heat Transfer in the Rabbit EyeExposed to 60-GHz Millimeter Wave Radiation" 2011

- "We have presented a new model of the anterior part of the rabbit eye, which takes into account the fluid dynamics of the aqueous humor, with realistic boundary conditions implemented at the interface between the cornea and the environment. "
- This paper is not about health effects but rather about how to model the eye for research on exposures.

This page has just a sampling of research that has found effects from radiofrequency radiation exposure. For more studies please see

The Bioinitiative Report

Annotated Bibliography of Scientific Papers Finding Evidence of Harm from Cell Phone Radiation ExposurePublished between August, 2016 and July, 2018 Joel M. Moskowitz, Ph.D. School of Public Health University of California, Berkeley which contains 92 papers published in scientific journals during the last two years that report evidence of harm from cell phone radiation exposure.

PowerWatch: 1,670 Peer-Reviewed Scientific Papers on Electromagnetic Fields and Biology or Health

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

Panagopoulos, D. J., Johansson, O., & Carlo, G. L. (2015). Real versus Simulated Mobile Phone Exposures in Experimental Studies. *BioMed research international*, *2015*, 607053. doi:10.1155/2015/607053

Hardell, L., & Carlberg, M. (2018). Comments on the US National Toxicology Program technical reports on toxicology and carcinogenesis study in rats exposed to whole-body radiofrequency radiation at 900 MHz and in mice exposed to whole-body radiofrequency radiation at 1,900 MHz. *International journal of oncology*, *54*(1), 111–127. doi:10.3892/ijo.2018.4606

Michael Carlberg and Lennart Hardell, "Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation," *BioMed Research International*, vol. 2017, Article ID 9218486, 17 pages, 2017. https://doi.org/10.1155/2017/9218486.

Belyaev, I., Dean, A., Eger, H., et al. (2016). EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. *Reviews on Environmental Health*, 31(3), pp. 363-397. Retrieved 14 May. 2019, from doi:10.1515/reveh-2016-0011

Dominique Belpomme, Lennart Hardell, Igor Belyaev, Ernesto Burgio, David O. Carpenter, Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international

perspective, *Environmental Pollution*, Volume 242, Part A, 2018, Pages 643-658, ISSN 0269-7491,

https://doi.org/10.1016/j.envpol.2018.07.019.

Research on People Near Cell Towers Links Exposure to Adverse Effects

"*The Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station"*is a research study that compared people living close (within 80 meters) and far (more than 300 meters away) from cellular antennas and found that the people living closer had several significant changes in their blood predictive of cancer development (Zothansiama 2017). Researchers controlled for various demographics, including the use of microwaves and wireless in the homes.

"Mortality by neoplasia and cellular telephone base stations" is a 10 year study by the Belo Horizonte Brazil Health Department and several universities in Brazil that found an elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell installations (Dode 2011). Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the city's antennas be removed. Many antennas were dismantled.

A 2019 studyof students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory and attention (Meo 2019). Examples of other effects linked to cell towers in research studies include neuropsychiatric problems, elevated diabetes, headaches, sleep problemsand genetic damage. Such research continues to accumulate after the 2010 landmark review studyon 56 studies that reported biological effects found at very low intensities, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular and metabolic changes, and increases in cancer risk (Lai and Levitt, 2010).

A published study entitled, "Effect of Mobile Tower Radiation on Microbial Diversity in Soil and Antibiotic Resistance"took soil samples from four different base stations located in Dausa city, and control samples from soil far from stations and then isolated and evaluated the microorganisms in the soil. The researchers found greater antibiotic resistance in microbes present in soil near base stations compared to the control and a statistical significant difference in pattern of antibiotic resistance was found with Nalidixic acid, and cefixime when used as antimicrobial agents. The study concludes, "our findings suggest that mobile tower radiation can significantly alter the vital systems in microbes and turn them multidrug resistant (MDR) which is most important current threat to public health."

Cellular Antennas Create Measurable Increases in Radiation in the Area

A 2018 article published in The Lancet Planetary Health points to unprecedented increasing RF exposures (Bandara and Carpenter 2018). Another key finding from Zothansiama 2017was that

homes closer to antennas had measurably higher radiation levels—adding to the documentation that antennas increase RF levels. An Australian study also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters (Bhatt 2016).

Research Finds that Cell Tower Base Station Radiation is the Dominant Contributor to Overall Environmental Radiation Exposures

A 2018 multi-country study that measured RF in several countries found that cell phone tower radiation is the dominant contributor to RF exposure in most outdoor areas exposure in urban areas was higher and that exposure has drastically increased. As an example, the measurements the researchers took in Los Angeles, USA were 70 times higher than the US EPA estimate 40 years ago (Sagar 2018).

As an example of how rapidly RF is increasing from wireless antennas, a 2014 published study looked at RF in three European cities and found in just one year (between April 2011 and March 2012) that the total RF-EMF exposure levels in all outdoor areas in combination increased by 57.1% in Basel by 20.1% in Ghent and by 38.2% in Brussels (Urbinello 2014). "Exposure increase was most consistently observed in outdoor areas due to emissions from mobile phone base stations."

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A study on Australian adults where participants carried a measuring device in a small hip bag for approximately 24 consecutive hours also found "downlink and broadcast are the main contributors to total RF-EMF personal exposure." Downlink (RF from mobile phone base station) contributed 40.4% of the total RF-EMF exposure (Zeleke 2018).

Another published study (Choi 2018) that gave 50 Korean adult child pairs a special radiation measuring device for 48 hours evaluated the types of radiation the participants were exposed to and found that "the contribution of base-station exposure to total RF-EMF exposure was the highest both in parents and children." These two studies are an important example of the research that shows that radiation from base stations is the dominant contributor to a person's cumulative exposure. Therefore we cannot only focus on a persons cell phone use as the way people are exposed to this radiation. People are exposed to wireless radiation even when they

are not using a mobile device due to cell towers, antennas and hotspots and they have no control over this.

Russell CL. 5G wireless telecommunications expansion:Public health and environmental implications. Environmental Research. Available online 11 April 2018. in press.

- "On the horizon, a new generation of even shorter high frequency 5G wavelengths is being proposed to power the Internet of Things (IoT)."
- "It is argued that the addition of this added high frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives."
- "Like other common toxic exposures, the effects of radiofrequency electromagnetic radiation (RF EMR) will be problematic if not impossible to sort out epidemiologically as there no longer remains an unexposed control group. This is especially important considering these effects are likely magnified by synergistic toxic exposures and other common health risk behaviors. Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radio frequencies, it will be years or decades before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated."
- "Current radiofrequency radiation wavelengths we are exposed to appear to act as a toxin to biological systems. A moratorium on the deployment of 5G is warranted, along with the development of independent health and environmental advisory boards that include independent scientists who research biological effects and exposure levels of radiofrequency radiation. Sound regulatory policy regarding current and future telecommunications initiative will require more careful assessment of risks to human health, environmental health, public safety, privacy, security and social consequences. Public health regulations need to be updated to match appropriate independent science with the adoption of biologically based exposure standards prior to further deployment of 4G or 5G technology."

Betzalel N, Ben Ishai P, Feldman Y., The human skin as a sub-THz receiver - Does 5G pose a danger to it or not?Environ Res. 2018 May;163:208-216. doi: 10.1016/j.envres.2018.01.032. Epub 2018 Feb 22.

- Experimentally we showed that the reflectance of the human skin in the sub-THz region depends on the intensity of perspiration, i.e. sweat duct's conductivity, and correlates with levels of human stress (physical, mental and emotional). Later on, we detected circular dichroism in the reflectance from the skin, a signature of the axial mode of a helical antenna. The full ramifications of what these findings represent in the human condition are still unclear. We also revealed correlation of electrocardiography (ECG) parameters to the sub-THz reflection coefficient of human skin. In a recent work, we

developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it. The presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band.

- In this paper, we summarize the physical evidence for this phenomenon and consider its implication for the future exploitation of the electromagnetic spectrum by wireless communication. Starting from July 2016 the US Federal Communications Commission (FCC) has adopted new rules for wireless broadband operations above 24 GHz (5 G). This trend of exploitation is predicted to expand to higher frequencies in the sub-THz region. One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned.
- We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.

Thielens**et al., "Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz" Scientific Reports volume 8, Article number: 3924 (2018)**

- Excerpts from abstract: "Insects are continually exposed to Radio-Frequency (RF) electromagnetic fields at different frequencies. This paper is the first to report the absorbed RF electromagnetic power in four different types of insects as a function of frequency from 2 GHz to 120 GHz. A set of insect models was obtained using novel Micro-CT (computer tomography) imaging. These models were used for the first time in finite-difference time-domain electromagnetic simulations. All insects showed a dependence of the absorbed power on the frequency. All insects showed a general increase in absorbed RF power at and above 6 GHz, in comparison to the absorbed RF power below 6 GHz. Our simulations showed that a shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370%."
- "This could lead to changes in insect behaviour, physiology, and morphology over time due to an increase in body temperatures, from dielectric heating. The studied insects that are smaller than 1 cm show a peak in absorption at frequencies (above 6GHz), which are currently not often used for telecommunication, but are planned to be used in the next generation of wireless telecommunication systems."

Miller AB, Morgan LL, Udasin I, Davis DL. Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). Available online Sep 6, 2018. https://doi.org/10.1016/j.envres.2018.06.043

• Increased risk of brain, vestibular nerve and salivary gland tumors are associated with mobile phone use.
• Nine studies (2011–2017) report increased risk of brain cancer from mobile phone use.
• Four case-control studies (3 in 2013, 1 in 2014) report increased risk of vestibular nerve tumors.

• Concern for other cancers: breast (male & female), testis, leukemia, and thyroid.
• Based on the evidence reviewed it is our opinion that IARC's current categorization of RFR as a possible human carcinogen (Group 2B) should be upgraded to Carcinogenic to Humans (Group 1).

Betzalel, Y. Feldman, and P. Ben Ishai, "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin,"IEEE Trans. THz Sci. Tech. (Paris) 7(5), 521–528 (2017).

- In 2008, we demonstrated that the coiled portion of the sweat duct in upper skin layer could be regarded as a helical antenna in the sub-THz band. The full ramifications of what these findings represent in the human condition are still very unclear,**but it is obvious that the absorption of electromagnetic energy is governed by the topology for the skin and its organelles, especially the sweat duct.**

Di Ciaula, Towards 5G communication systems: Are there health implications?, Int J Hyg Environ Health. 2018 Feb 2.

- "Preliminary observations showed that MMW increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, affect neuro-muscular dynamics."
- "Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular. However, available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle, to define exposed subjects as potentially vulnerable and to revise existing limits.

Nasim I, Kim S. Human Exposure to RF Fields in 5G Downlink. Submitted on 10 Nov 2017 to IEEE International Communications Conference.

- "Prior research on human exposure to radio frequency (RF) fields in a cellular communications system has been focused on uplink only due to the closer physical contact of a transmitter to a human body. However, this paper claims the necessity of thorough investigation on human exposure to downlink RF fields, as cellular systems deployed in mmW bands will entail (i) deployment of more transmitters due to smaller cell size and (ii) higher concentration of RF energy using a highly directional antenna.
- In this paper, we present human RF exposure levels in downlink of a Fifth Generation Wireless Systems (5G). Our results show that 5G downlink RF fields generate significantly higher power density (PD) and specific absorption rate (SAR) than a current cellular system. This paper also shows that SAR should also be taken into account for determining human RF exposure in the mmW downlink."

Pogam et al., Untargeted metabolomics unveil alterations of biomembranes permeability in human HaCaT keratinocytes upon 60 GHz millimeter-wave exposure,Scientific Reports volume 9, Article number: 9343 (2019)

- "this report represents the first metabolomic investigation focusing on the effects of MMW."
- "it is reasonable to assume that the vast amount of dysregulations reported in these sequences do not stem from alterations of gene expression but rather from alterations in membrane permeability, consistently with previous reports on acellular phospholipidic systems. "
- "further studies will be necessary to assess MMW bioeffects on animal models and to investigate potential dysregulations induced by lower IPD values prior to the wide-scale deployment of technologies based on these specific frequencies."
- "This unexpected extent of modifications can hardly stem from the mild changes that could be reported throughout transcriptomics studies, leading us to hypothesize that MMW might alter the permeability of cell membranes, as reported elsewhere."

Soubere Mahamoud Y, Aite M, Martin C, Zhadobov M, Sauleau R, Le Dréan Y, et al. (2016) Additive Effects of Millimeter Waves and 2-Deoxyglucose Co-Exposure on the Human Keratinocyte Transcriptome. PLoS ONE 11(8): e0160810.

- Millimeter Waves (MMW) will be used in the next-generation of high-speed wireless technologies, especially in future Ultra-Broadband small cells in 5G cellular networks. Therefore, their biocompatibilities must be evaluated prior to their massive deployment. Using a microarray-based approach, we analyzed modifications to the whole genome of a human keratinocyte model that was exposed at 60.4 GHz-MMW at an incident power density (IPD) of 20 mW/cm^2 for 3 hours in athermic conditions. No keratinocyte transcriptome modifications were observed. We tested the effects of MMWs on cell metabolism by co-treating MMW-exposed cells with a glycolysis inhibitor, 2-deoxyglucose (2dG, 20 mM for 3 hours), and whole genome expression was evaluated along with the ATP content. We found that the 2dG treatment decreased the cellular ATP content and induced a high modification in the transcriptome (632 coding genes). The affected genes were associated with transcriptional repression, cellular communication and endoplasmic reticulum homeostasis. The MMW/2dG co-treatment did not alter the keratinocyte ATP content, but it did slightly alter the transcriptome, which reflected the capacity of MMW to interfere with the bioenergetic stress response. The RT-PCR-based validation confirmed 6 MMW-sensitive genes (*SOCS3*, *SPRY2*, *TRIB1*, *FAM46A*, *CSRNP1* and *PPP1R15A*) during the 2dG treatment. These 6 genes encoded transcription factors or inhibitors of cytokine pathways, which raised questions regarding the potential impact of long-term or chronic MMW exposure on metabolically stressed cells.

Mandl P, Pezzei P, Leitgeb E. Selected Health and Law Issues Regarding Mobile Communications with Respect to 5G. Presented at 2018 International Conference on

Broadband Communications for Next Generation Networks and Multimedia Applications (CoBCom).Graz, Austria. July 11-13, 2018.

- Abstract: Over the next years the demand of wireless communication will increase tremendously. More and more mobile end devices require a high data rate connection e.g. to a smart home (Internet of Things, IoT) or to the internet. The radiation power pattern of base stations and mobile end devices will completely change for the 5G Next Generation Mobile Network technology which will use frequency bands up to 100 GHz. Therefore the electromagnetic exposure especially to human body will increase in the future, because most of the wireless connections are realized in RF technology. In this contribution two different measurement setups are presented. The first shows the electromagnetic radiation regarding a base station powered by a mobile phone provider over a timespan of a number of days. The second figures out the electromagnetic radiation of a handheld mobile end device to a human head in an area with very poor reception values. The results of those measurements where compared with legal and health limits. All measured and calculated results regarding the base stations were within the legal exposure limits. The calculated legal exposure limits of mobile devices were exceeded twice in areas within very poor reception values. Regarding the expected higher bandwidth and corresponding higher electromagnetic exposure to human bodies in future there have to be periodic measurements to comply with radiation limits.
- Excerpts: "Regarding the above mentioned circumstances it will be necessary to measure the radiation exposure of base stations in the future on a regular basis in order to ensure the legal limits and to reduce possible health hazards. It also will be necessary to develop new measurement strategies and/or technologies regarding the large frequency spectrum 5G will use up to 100 GHz. ...When measuring directly on a mobile phone (simulating the use of an end device directly on the human head), it was found that the calculated SAR of 3.834 *W/kg* exceeds the legal limit of 2 W*/ kg*. This shows clearly that the legal limit values can be exceeded significantly in areas with very poor reception values ...Increasing the distance between a mobile end device and the head, e.g. by using a hands-free set or a headset can significantly reduce the human exposure to electromagnetic radiation when such a device is used in badly supplied areas and transmits with maximum power."

Neufeld E, Kuster N. Systematic Derivation of Safety Limits for Time-Varying 5G Radiofrequency Exposure Based on Analytical Models and Thermal Dose. Health Phys. 2018 Sep 21.

Extreme broadband wireless devices operating above 10 GHz may transmit data in bursts of a few milliseconds to seconds. Even though the time- and area-averaged power density values remain within the acceptable safety limits for continuous exposure, **these bursts may lead to short temperature spikes in the skin of exposed people.**

- In this paper, a novel analytical approach to pulsed heating is developed and applied to assess the peak-to-average temperature ratio as a function of the pulse fraction α

(relative to the averaging time [INCREMENT]T; it corresponds to the inverse of the peak-to-average ratio).
- To stay consistent with the current safety guidelines, safety factors of 10 for occupational exposure and 50 for the general public were applied.
- The results demonstrate that the maximum averaging time, based on the assumption of a thermal time constant of 100 s, is 240 s if the maximum local temperature increase for continuous-wave exposure is limited to 1 K and $\alpha \geq 0.1$. For a very low peak-to-average ratio of 100 ($\alpha \geq 0.01$), it decreases to only 30 s.
- **The results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures,**highlighting the importance of revisiting existing exposure guidelines.

TRIPATHI et al., Frequency of the resonance of the human sweat duct in a normal mode of operation, BIOMEDICAL OPTICS EXPRESS 130, Vol. 9, No. 3 | 1 March 2018

- This result indicates that careful consideration should be given while designing electronic and photonic devices operating in the sub-terahertz frequency region in order to avoid various effects on human health due to these waves.

Declassified by CIA in 2015: Russian Review on Millimeter Waves Biological Effect of Millimeter Wavesby Zalyubovskaya

- "Morphological, functional and biochemical studies conducted in humans and animals revealed that millimeter wave caused changes in the body manifested in structural alterations in the skin and internal organs, qualitative and quantitative changes of the blood and bone marrow composition and changes of the conditioned reflex activity, tissue respiration, activity of enzymes participating in the process of tissue respiration and nucleic metabolism. The degree of unfavorable effect of millimeter wave depended on the duration of the radiation and individual characteristics of the organism."

Pakhomov et. al., Current state and implications of research on biological effects of millimeter waves: a review of the literature. Bioelectromagnetics. 1998;19(7):393-413.

- “This paper analyzes general trends in the area and briefly reviews the most significant publications, proceeding from cell-free systems, dosimetry, and spectroscopy issues through cultured cells and isolated organs to animals and humans.
- The studies reviewed demonstrate effects of low-intensity MMW (10 mW/cm2 and less) on cell growth and proliferation, activity of enzymes, state of cell genetic apparatus, function of excitable membranes, peripheral receptors, and other biological systems. In animals and humans, local MMW exposure stimulated tissue repair and regeneration, alleviated stress reactions, and facilitated recovery in a wide range of diseases (MMW therapy). Many reported MMW effects could not be readily explained by temperature changes during irradiation."

- Full paper in draft form is online as **CURRENT STATE AND IMPLICATIONS OF RESEARCH ON BIOLOGICAL EFFECTS OF MILLIMETER WAVES: A REVIEW OF LITERATURE** **CURRENT STATE AND IMPLICATIONS OF RESEARCH ON BIOLOGICAL EFFECTS OF MILLIMETER WAVES: A REVIEW OF LITERATURE** Andrei G. Pakhomov, Yahya Akyel, Olga N. Pakhomova, Bruce E. Stuck, and Michael R. Murphy McKesson BioServices (A.G.P., Y.A., O.N.P.), U. S. Army Medical Research Detachment of the Walter Reed Army Institute of Research (B.E.S.), and Directed Energy Bioeffects Division, Human Effectiveness Directorate, Air Force Research Laboratory (M.R.M.), Brooks Air Force Base, San Antonio, TX
- "It is important to note that, even with the variety of bioeffects reported, no studies have provided evidence that a low-intensity MMW radiation represents a health hazard for human beings. Actually, none of the reviewed studies with low-intensity MMW even pursued the evaluation of health risks, though in view of numerous bioeffects and growing usage of MMW technologies this research objective appears very reasonable. Such MMW effects as alterations of cell growth rate and UV light sensitivity, biochemical and antibiotic resistivity changes in pathogenic bacteria, as well as many others are of potential significance for safety standards. MMW therapy in many cases employs field intensities comparable to or lower than allowed by current safety standards; still, even local and short-term exposures were reported to produce marked effects. It should also be realized that biological effects of a prolonged or chronic MMW exposure of the whole body or a large body area have never been investigated. Safety limits for these types of exposure are based solely on predictions of energy deposition and MMW heating, but in view of recent studies this approach is not necessarily adequate."

Wu T, Rappaport TS, Collins CM, "The Human Body and Millimeter-Wave Wireless Communication Systems: Interactions and Implications,"(2015). Accepted in 2015 IEEE International Conference on Communications (ICC), NYU WIRELESS. 2015

- This paper gives examples of today's regulatory requirements, and provides an example for a 60 GHz transceiver. Also, the propagation characteristics of millimeter-waves in the presence of the human body are studied, and four models representing different body parts are considered to evaluate thermal effects of millimeter-wave radiation on the body. Simulation results show that about 34% to 42% of the incident power is reflected at the skin surface at 60 GHz. This paper shows that power density is not suitable to determine exposure compliance when millimeter wave devices are used very close to the body. A temperature-based technique for the evaluation of safety compliance is proposed in this paper.

Wu T et al., Safe for Generations to Come.IEEE Microw Mag. 16(2): 65–84. 2015

"A literature survey representing the most recent available results related to the biological effects of mmWave exposure, from the well-understood and well-accepted effects of thermal

heating to recent reports of nonthermal effects and the attempt to motivate further discussion and research for appropriate emission standards."

- “We highlighted the findings of mmWave radiation studies on the eyes and skin since, in communication applications, these tissues would receive the most radiation, with other tissues receiving, by comparison, a negligible amount. Ocular injury can be induced by short-term high-intensity exposure (e.g., 2,000 mW/cm2, 1.5–5 s) far beyond the anticipated future communication device levels, but the eyes do not appear to suffer damage from longer low-intensity exposure (e.g., 10 mW/cm2, 8 h), which might be experienced from mmWave communication technologies in the far field.
- More work may be required to determine the possible effects from exposure above 10 mW/cm2that might be experienced in the near field from specific communication devices with adaptive antennas as well as to ensure that mechanisms are in place to ensure that no hazardous levels of energy are transmitted into the eyes. We also showed that using typical power levels, there would be no unsafe temperature increase caused by exposure of skin to mmWave communication technologies in the far field.
- As with the eyes, however, more work is required to determine temperature increases from higher exposure levels that might be experienced in the near field from specific communication devices with high-gain antennas and to develop and demonstrate reliable mechanisms to ensure that no hazardous levels of energy are transmitted to the skin.”

Ramundo-Orlando A., Effects of millimeter waves radiation on cell membrane – A brief review.(2010) Journal of Infrared, Millimeter, and Terahertz Waves. 2010; 31(12):1400–1411.

- The millimeter waves (MMW) region of the electromagnetic spectrum, extending from 30 to 300 GHz in terms of frequency (corresponding to wavelengths from 10 mm to 1 mm), is officially used in non-invasive complementary medicine in many Eastern European countries against a variety of diseases such gastro duodenal ulcers, cardiovascular disorders, traumatism and tumor. On the other hand, besides technological applications in traffic and military systems, in the near future MMW will also find applications in high resolution and high-speed wireless communication technology. This has led to restoring interest in research on MMW induced biological effects. In this review emphasis has been given to the MMW-induced effects on cell membranes that are considered the major target for the interaction between MMW and biological systems.

Scientific Citations from the published study "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems" by Paul Ben-Ishai, PhD and Yuri Feldman, PhD

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RESEARCH ON MILLIMETER WAVES

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American Academy of Pediatrics Website

“Electromagnetic Fields: A Hazard to Your Health?” on Cell Tower Radiation

“In recent years, concern has increased about exposure to radio frequency electromagnetic radiation emitted from cell phones and phone station antennae. An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing:

- Headaches
- Memory problems
- Dizziness
- Depression
- Sleep problems

Short-term exposure to these fields in experimental studies have not always shown negative effects, but this does not rule out cumulative damage from these fields, so larger studies over longer periods are needed to help understand who is at risk. In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment.”

-American Academy of Pediatrics

Compilation of Research Studies on Cell Tower Radiation and Health

Zothansiama, et al. “Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations.”Electromagnetic Biology and Medicine 36.3 (2017): 295-305.

- This study evaluated effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters). The study found higher radiofrequency radiation exposures and statistically significant differences in the blood of people living closer to the cellular antennas. The group living closer to the antennas had for example, statistically significant higher frequency of micronuclei and a rise in lipid peroxidation in their blood. These changes are considered biomarkers predictive of cancer.

Neurobehavioral effects among inhabitants around mobile phone base stationsAbdel-Rassoul et al, Neurotoxicology, 2007

- This study found that living nearby mobile phone base stations (cell antennas) increased the risk for neuropsychiatric problems such as headaches, memory problems, dizziness, tremors,depression, sleep problems and some changes in the performance of neurobehavioral functions.

Biological Effects from Exposure to Electromagnetic Radiation Emitted by Cell Tower Base Stations and Other Antenna Arrays, Levitt & Lai, Environmental Reviews, 2010

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

Mortality by neoplasia and cellular telephone base stations.Dode et al. (Brazil), Science of the Total Environment, Volume 409, Issue 19, 1 September 2011, Pages 3649–3665

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

Epidemiological Evidence for a Health Risk from Mobile Phone Base StationsKhurana, Hardell et al., International Journal of Occupational Environmental Health, Vol 16(3):263-267, 2010

- A review of 10 epidemiological studies that assessed for negative health effects of mobile phone base stations (4 studies were from Germany, and 1 each from Austria, Egypt, France, Israel, Poland, Spain) found that seven showed altered neurobehavioral effects near cell tower and three showed increased cancer incidence. The review also 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. Lower cognitive performance was found in individuals living ≤ 10 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.

Health effects of living near mobile phone base transceiver station (BTS) antennae: a report from Isfahan, Iran. Shahbazi-Gahrouei et al, Electromagnetic Biology Medicine, 2013.

- This cross-sectional study found the symptoms of nausea, headache, dizziness, irritability, discomfort, nervousness, depression, sleep disturbance, memory loss and lowering of libido were statistically increased in people living closer than 300 m from cell antennas as compared to those living farther away. The study concludes that "antennas should not be sited closer than 300 m to people to minimize exposure."

Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems.Yakymenko(2011) Exp Oncology, 33(2):62-70.

- 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.

Association of Exposure to Radio-Frequency Electromagnetic Field Radiation (RF-EMFR) Generated by Mobile Phone Base Stations (MPBS)with Glycated Hemoglobin (HbA1c) and Risk of Type 2 Diabetes Mellitus, Sultan Ayoub Meo et al, International Journal of Environmental Research and Public Health, 2015

- Elementary school students who were exposed to high RF-EMFR generated by MPBS had a significantly higher risk of type 2 diabetes mellitus relative to their counterparts who were exposed to lower RF-EMFR.

How does long term exposure to base stations and mobile phones affect human hormone profiles?Eskander EF et al, (2011), Clin Biochem

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

Investigation on the health of people living near mobile telephone relay stations: Incidence according to distance and sexSantini et al, 2002 , Pathol Bio

- People living near mobile phone masts reported more symptoms of headache, sleep disturbance, discomfort, irritability, depression, memory loss and concentration problems

the closer they lived to the installation. Study authors recommend that the minimal distance of people from cellular phone base stations should not be < 300 m.

Navarro EA, Segura J, Portoles M, Gomez-Perretta C, The Microwave Syndrome: A preliminary Study. 2003 (Spain) Electromagnetic Biology and Medicine, Volume 22, Issue 2, (2003): 161 – 169

- Statistically significant positive exposure-response associations between RFR intensity and fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Two Important Animal Studies on Radiofrequency Radiation

These studies indicate that government limits are non protective. Government limits are based on the assumption that radiofrequency radiation is only harmful at thermal levels. However, the cancers developed in animals in these studies at radiation levels that were non thermal.

Belpoggi et al. 2018, "Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz base station environmental emission" Environmental Research Journal

- Researchers with the renowned Ramazzini Institute (RI) in Italy performed a large-scale lifetime studyof lab animals exposed to environmental levels (comparable to allowable limits from cell towers) of RFR radiation and found the rats developed increased cancers- schwannoma of the heart in male rats. This study confirms the $25 million US National Toxicology Programstudy which used much higher levels of cell phone radiofrequency (RF) radiation, but also reported finding the same unusual cancers as the Ramazzini- schwannoma of the heart in male rats. In addition, the RI study of cell tower radiation also found increases in malignant brain (glial) tumors in female rats and precancerous conditions including Schwann cells hyperplasia in both male and female rats.
- "Our findings of cancerous tumors in rats exposed to environmental levels of RF are consistent with and reinforce the results of the US NTP studies on cell phone radiation, as both reported increases in the same types of tumors of the brain and heart in Sprague-Dawley rats. Together, these studies provide sufficient evidence to call for the International Agency for Research on Cancer (IARC) to re-evaluate and re-classify their

conclusions regarding the carcinogenic potential of RFR in humans," said Fiorella Belpoggi PhD, study author and RI Director of Research.

- The Ramazzini study exposed 2448 Sprague-Dawley rats from prenatal life until their natural death to "environmental" cell tower radiation for 19 hours per day (1.8 GHz GSM radiofrequency radiation (RFR) of 5, 25 and 50 V/m). RI exposures mimicked base station emissions like those from cell tower antennas, and exposure levels were far less than those used in the NTP studies of cell phone radiation.
- Watch Press Conference

Wyde, Michael, et al. "National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposure).Statement on conclusions of the peer review meeting by NIEHS, released after external peer review meeting and the DNA damage presentation.

- This 25 million dollar study is the most complex study completed by the NTP and the world's largest rodent study on radiofrequency radiation exposure to date which found long term exposure at non thermal levels associated with brain cancer and schwannomas of the heart in male rats. In addition damage to heart was found in all exposure levels. The full report is expected to be released in Fall 2018.

More Important Studies on Cell Tower Radiation

Cindy L. Russell, 5 G wireless telecommunications expansion: Public health and environmental implications, Environmental Research, 2018, ISSN 0013-9351

- Radiofrequency radiation (RF) is increasingly being recognized as a new form of environmental pollution. This article reviews relevant electromagneticfrequencies, exposure standards and current scientific literature on the health implications of 2G, 3G, 4G and 5G.
- Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radiofrequencies, it will be years or decades before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated.

Noa Betzalel, Paul Ben Ishai, Yuri Feldman, The human skin as a sub-THz receiver – Does 5G pose a danger to it or not?, Environmental Research, Volume 163, 2018, Pages 208-216, ISSN 0013-9351,

- Researchers have developed a unique simulation tool of human skin, taking into account the skin multi-layer structuretogether with the helical segment of the sweat duct embedded in it. They found that the presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequencyband that will be used in 5G. “One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.”

Mobile phone infrastructure regulation in Europe: Scientific challenges and human rights protectionClaudia Roda, Susan Perry, Environmental Science & Policy, Volume 37, March 2014, Pages 204-214.

- This article was published in Environmental Science & Policy by human rights experts. It argues that cell tower placement is a human rights issue for children.
- “We argue that (1) because protection of children is a high threshold norm in Human Right law and (2) the binding language of the Convention on the Rights of the Child obliges States Parties to provide a higher standard of protection for children than adults, any widespread or systematic form of environmental pollution that poses a long-term threat to a child’s rights to life, development or health may constitute an international human rights violation.
- In particular we have explained how the dearth of legislation to regulate the installation of base stations (cell towers) in close proximity to children’s facilities and schools clearly constitutes a human rights concern according to the language of the Convention on the Rights of the Child, a treaty that has been ratified by all European States.

SAFETY ZONE DETERMINATION FOR WIRELESS CELLULAR TOWERNyakyi et al, Tanzania (2013)

- This research looked at the radiation that cell towers emit and states a safety zone is needed around the towers to ensure safe sleeping areas. The authors state that “respective authorities should ensure that people reside far from the tower by 120m or more depending on the power transmitted to avoid severe health effect.”

A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station.Ghandi et al, 2014 (India):

- This cross-sectional case control study on genetic damage in individuals living near cell towers found genetic damage parameters of DNA were significantly elevated. The authors state," 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."

Human disease resulting from exposure to electromagnetic fields, Carpenter, D. O. Reviews on Environmental Health, Volume 28, Issue 4, Pages 159172.

- This review summarizes the evidence stating that excessive exposure to magnetic fields from power lines and other sources of electric current increases the risk of development of some cancers and neurodegenerative diseases, and that excessive exposure to RF radiation increases risk of cancer, male infertility, and neurobehavioral abnormalities.

Signifikanter Rückgang klinischer Symptome nach Senderabbau – eine Interventionsstudie. (English-Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal – An Intervention Study) Tetsuharu Shinjyo and Akemi Shinjyo, 2014 Umwelt-Medizin-Gesellschaft, 27(4), S. 294-301.

- Japanese study Showed Statistically Significant Adverse Health Effects from electromagnetic radiation from mobile phone base stations. Residents of a condominium building that had cell tower antennas on the rooftop were examined before and after cell tower antennas were removed. In 1998, 800MHz cell antennas were installed, then later in 2008 a second set of antennas (2GHz) were installed. Medical exams and interviews were conducted before and after the antennas were removed in 2009 on 107 residents of the building who had no prior knowledge about possible. These results lead researchers to question the construction of mobile phone base stations on top of buildings such as condominiums or houses.

Effect of GSTM1 and GSTT1 Polymorphisms on Genetic Damage in Humans Populations Exposed to Radiation From Mobile Towers. Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R., Arch Environ Contam Toxicol. 2015 Aug 5. [Epub ahead of print]

- In our study, 116 persons exposed to radiation from mobile towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes by multiplex polymerase chain reaction method. DNA damage in peripheral blood

lymphocytes was determined using alkaline comet assay in terms of tail moment (TM) value and micronucleus assay in buccal cells (BMN). Our results indicated that TM value and BMN frequency were higher in an exposed population compared with a control group and the difference is significant. In our study, we found that different health symptoms, such as depression, memory status, insomnia, and hair loss, were significantly associated with exposure to EMR. Damaging effects of nonionizing radiation result from the generation of reactive oxygen species (ROS) and subsequent radical formation and from direct damage to cellular macromolecules including DNA.

Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations, Hutter HP et al, (May 2006), Occup Environ Med. 2006 May;63(5):307-13

- Found a significant relationship between some cognitive symptoms and measured power density in 365 subjects; highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels.

Oberfeld, A.E. Navarro, M. Portoles, C. Maestu, C. Gomez-Perretta, The microwave syndrome: further aspects of a Spanish study,

- A health survey was carried out in La Ñora, Murcia, Spain, in the vicinity of two GSM 900/1800 MHz cellular phone base stations. The adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Bortkiewicz et al, 2004 (Poland), Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review,Med Pr.2004;55(4):345-51.

- Residents close to mobile phone masts reported: more incidences of circulatory problems, sleep disturbances, irritability, depression, blurred vision and concentration difficulties the nearer they lived to the mast.
- 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.

Wolf R and Wolf D, Increased Incidence of Cancer Near a Cell-phone Transmitter Station, International Journal of Cancer Prevention, (Israel) VOLUME 1, NUMBER 2, APRIL 2004

- A significant higher rate of cancer (300% increase) among all residents living within 300m radius of a mobile phone mast for between three and seven years was detected.
- 900% cancer increase among women alone
- In the area of exposure (area A) 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). The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Changes of Neurochemically Important Transmitters under the influence of modulated RF fields – A Long Term Study under Real Life Conditions(Germany), Bucher and Eger, 2011

- German study showing elevated levels of stress hormones (adrenaline, noradrenaline), and lowered dopamine and PEA levels in urine in area residents during 1st 6 months of cell tower installation. Even after 1.5 years, the levels did not return to normal.

The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer(Umwelt·Medizin·Gesellschaft 17,4 2004) Eger et al, 2004 (Germany)

- 200% increase in the incidence of malignant tumors was found after five years' exposure in people living within 400m radius of a mobile phone mast. The proportion of newly developing cancer cases is significantly higher among patients who live within 400 meters of a cell phone transmitter. Early age of cancer diagnosis.

Microwave electromagnetic fields act by activating voltage-gated calcium channels: why the current international safety standards do not predict biological hazard.Martin L. Pall. Recent Res. Devel. Mol. Cell Biol. 7(2014).

- "It can be seen from the above that 10 different well-documented microwave EMF effects can be easily explained as being a consequence of EMF VGCC activation: oxidative stress, elevated single and double strand breaks in DNA, therapeutic responses to such EMFs, breakdown of the blood-brain barrier, cancer, melatonin loss, sleep dysfunction, male infertility and female infertility."

Pall ML. 2015. Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J. Chem. Neuroanat. 2015 Aug 20.

- Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation.
- Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships.
- Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.