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Long Term Radio Frequency and Electromagnetic Field Exposure on Health

Ten Recently Published Article Summaries

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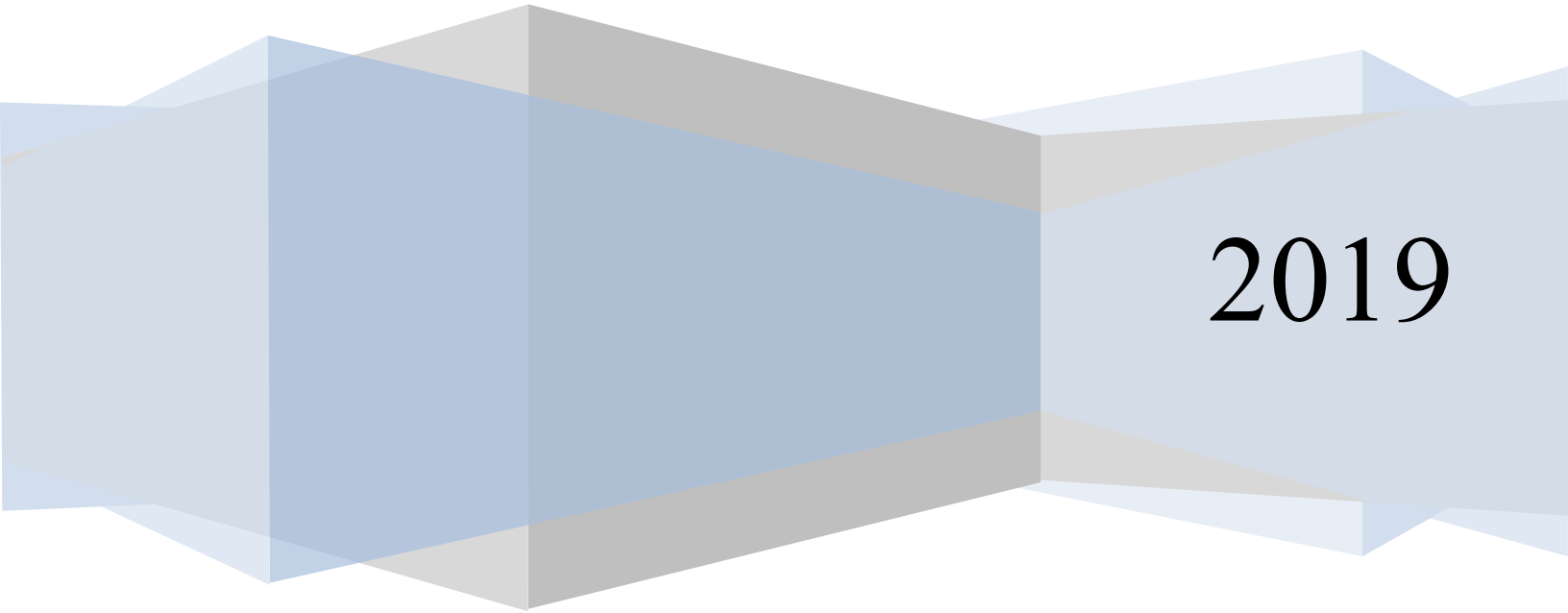
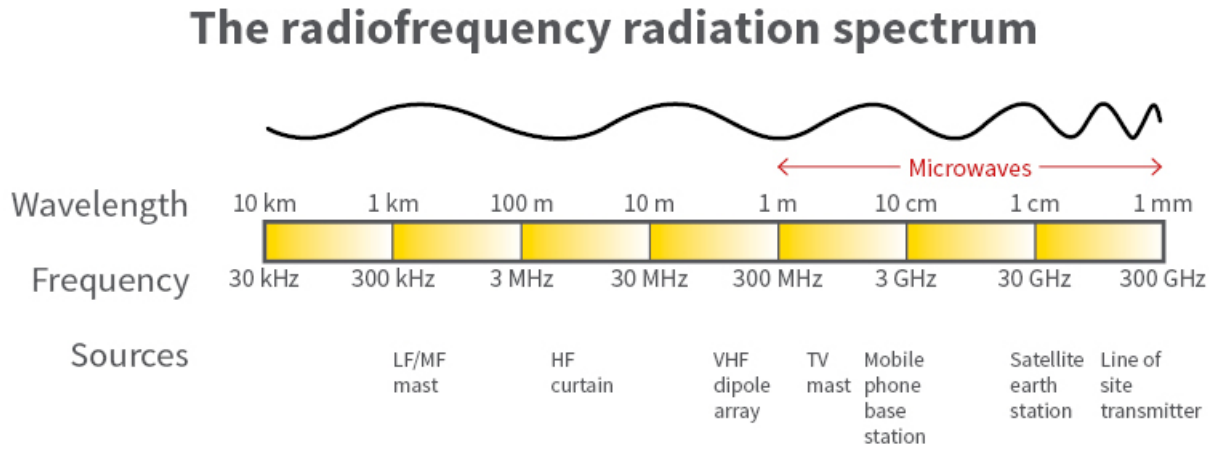


2019

Acronyms:
Millimeter waves (MMW), Radiofrequency (RF), electromagnetic radiation (EMR), electromagnetic field (EMF), World Health Organization (WHO), Microwave (MW), International Agency for Research on Cancer (IARC), National Toxicology Program (NTP), International Commission on Non-ionizing Radiation Protection (ICNIRP), Vitamin-D receptor (VDR), Nitric Oxide (NO), Heat Shock Protein (HSP), Tumor Necrotic Factor (TNF), Anti-mullerian Hormone (AMH), Personal Exposure Meters (PEM), Specific Absorption Rate (SAR), Continuous Wave (CW)

Terms:
Mobile phone base station (cell phone tower), uplink (cell phone uploading information to tower), downlink (cell phone downloading information from tower), Phagocytosis (the ingestion of bacteria or other cells by phagocytes and amoeboid protozoans)
Unit Conversion equation: $V/m=\sqrt{(W/m^2 x 377)}$ or volts per meter = the square root of the product of Watts per meter squared times 377.

General Information Summary:
The current FCC guidelines are twenty years old and based on heating tissues for short periods of exposure (up to six minutes). Those at higher risk are pregnant women and children because the child is more susceptible due to immature organs and bone density. The WHO (1981) stated that the prevention of potential health hazards from radiation is a more efficient and economical way of achieving control than belated efforts to reduce health effects from existing levels. Stating they agree that preemptive action has a greater beneficial effect than harm reduction efforts and the foresight for having stated this nearly forty years ago. 5G MMW are extremely high-frequency (30–300 GHz). The longer the wavelength the longer it can travel and the farther apart broadcast stations can be placed. Therefore, the 5G short higher frequency millimeter wavelengths travel shorter distances (a few hundred meters) and to achieve a seamless integrated wireless system the "small cell" antenna are proposed to be placed about every 250 m (Russell, 2018).



(Australia).

Frequency	Wavelength	Designation	Abbreviation[6]	IEEE bands[7]
3–30 Hz	10^5–10^4 km	Extremely low frequency	ELF	-
30–300 Hz	10^4–10^3 km	Super low frequency	SLF	-
300–3000 Hz	10^3–100 km	Ultra low frequency	ULF	-
3–30 kHz	100–10 km	Very low frequency	VLF	-
30–300 kHz	10–1 km	Low frequency	LF	-
300 kHz – 3 MHz	1 km – 100 m	Medium frequency	MF	-
3–30 MHz	100–10 m	High frequency	HF	HF
30–300 MHz	10–1 m	Very high frequency	VHF	VHF
300 MHz – 3 GHz	1 m – 10 cm	Ultra high frequency	UHF	UHF, L, S
3–30 GHz	10–1 cm	Super high frequency	SHF	S, C, X, Ku, K, Ka
30–300 GHz	1 cm – 1 mm	Extremely high frequency	EHF	Ka, V, W, mm
300 GHz – 3 THz	1 mm – 0.1 mm	Tremendously high frequency	THF	-

MRI RF emission (3T=128MHz)

Microwave Oven cooking - around 2.4GHz

THERMAL EFFECT

(People, 2019).

Personal Exposure to Radio Frequency Electromagnetic Fields among Australian Adults (Topics-sources and dosage measurements)

This study aimed to measure personal RF-EMF exposure levels from a wide range of frequency bands. In recent decades the amount of exposure to man-made RF-EMF has increased drastically. These fields typically range from 0.1 to 6 GHz frequency bands and are typically classified into two categories: near-field (mobile phones, iPads, tablets, laptops etc), and far-field sources (mobile phone base stations, Wi-Fi routers, radio/TV towers, surrounding area mobile phones etc). The purposes of this study were to evaluate personal RF exposure levels without limiting to specific micro-environments and to describe the RF-EMF exposure from each frequency band over the whole measurement period. RF-EMF was recorded for 63 adults for roughly 27 hours using exposimeters that register over a large frequency band range. The RF-EMF exposure levels were recorded for each frequency band as well as from downlink (mobile phone base station), uplink (mobile phone handset), broadcast and Wi-Fi. The participants were all adults in the mid 20s to late 40s range and 2/3s of them were female almost entirely from urban areas. Nearly all households contained a Wi-Fi router (96.8%) and 61.2% contained a Wi-Fi enabled smart TV, as well as 41.3% noticed the existence of a mobile phone base station (roughly 500m from their place of residence). The median personal RF-EMF exposure was 208 mV/m. Downlink contributed 40.4% of the total RF-EMF measurement followed by broadcast (22.4%) with uplink being 17.3% and Wi-Fi being 15.9%. RF-EMF exposure levels vary throughout the week and time of day and were estimated to be higher on weekday than weekends ($p<0.05$) with downlink and broadcast being the major contributors (Berihun M. Zeleke 1 et al., 2018).

Exposure to radiation from single or combined radio frequencies provokes macrophage dysfunction in the RAW 264.7 cell line (Topics-signal mixing, cellular changes)

A study was conducted on RAW 264.7 cell line with exposure to 900 MHz and 2.45 GHz RF signals individually and simultaneously for 4, 24, 48 and 72 hours respectively in a

GTEM electromagnetic test chamber. It was determined that the combination of the two signals caused decreased phagocytic activity rate. Phagocytosis is a means of defense against microorganisms as well as a way of eliminating dead tissue. Changes to this could affect the integrity of the immune response and the biochemical processing of unwanted substances. The results show a decrease in one of the groups followed an increase after 72 hours. Other studies have shown the effects of this to last approximately one day and disappear after three days. There was significant cytoprotective, cytotoxic and anti-inflammatory actions within the cells. No changes to cell line viability, no changes in tumor growth so cells continue to replicate. NO increased when exposure went from 48 to 72 hours, HSP70 changes were not significant, the TNF-α changes were not significant aside from the inflammatory activity measured from the TNF-α expression. This was significant after 72 hours of continuous exposure to both RF signals. This could be because the macrophage inflammatory response increases with continuous and combined exposure to RF signals. This could be important to the mammalian immune system in our current RF environment. All effects appear dependent on exposure time. This study corroborates other studies for no changes to the RAW 246.7 cell lines (Lopez-Furelos, 2018).

Understanding physical mechanism of low-level microwave radiation effect (Topics: MW, study evolution, safety levels)

The conventional testing method for MW radiation is that it is deemed safe unless it causes a heating within the tissue. This has led to the production and distribution of products that according to this method have been deemed safe. Upon further research it has been discovered that this is, in fact, an inadequate form of measurement. Hinrikus conducted a review of published theoretical and experimental results of physics and biological-physiological consequences. The dipolar molecules cause polarization of dielectric medium weakening hydrogen bonds causing decreased viscosity and enhanced diffusion at constant temperature. The low-level MW radiation restructures hydrogen bonds despite the energy of MW radiation is less than the energy of bonding. The proposed model steps have no critical frequency restrictions at MW frequencies and have been confirmed with electromagnetic field theory or published results. Through testing it has been confirmed that the nature of the effect differs from the thermal effect and that MW exposure causes specific consequences in biology not characteristic of conventional heating (Hiie Hinrikus 2018).

Continuous 900-megahertz electromagnetic field applied in middle and late-adolescence causes qualitative and quantitative changes in the ovarian morphology, tissue and blood biochemistry of the rat (Topics: rat sex cells, CW)

The purpose of this study was to observe histological and biochemical changes within rat ovarian cells exposed to 900 MHz EMF at continuous power levels of 300mW of CW in middle and late adolescence. The histopathological review revealed a thinning of the zona granulose and theca layers, shrinking of the granulose cells, reduced mitotic activity and reduced leukocyte permeation in the follides and stroma. The primary morphological changes to granulose cells included retraction of granulose cells, loss of microvilli and condensation or loss of mitochondrial cristae. The authors suggested that the oocyte

changes indicated cytotoxic effect and that the changes are indicative of apoptosis within the cells. Secondary follicle numbers were reduced significantly in the EMF group and that EMF exposure may interfere with the normal folliculogenesis process. In terms of biochemistry the EMF and sham groups experienced an increase in superoxide dismutase, catalase and anti-Mullerian hormone levels as well as 8-hydroxy-deoxiguanosine. The EMF group increased significantly in 3-nitrotyrosine, total oxidant status and oxidative stress index values compared to the control. In this study there was no significant difference at the primordial and preantral follicle level or in the serum AMH levels although tissue levels were increased. Therefore, 900 MHz EMF may have a morphology and biochemical affect on mid to late stage adolescence rat ovarian tissue (Derya €Ozt€urk Okatana, 2018).

Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context (Topics: RF, EMF, international everyday exposure levels)

RF EMF micro-environmental measurements have several advantages such as environmental sources can be measured and quantified which is not possible in simulations. Also the measurement by a skilled technician allows for strict adherence to measurement protocol and measured uptake fields can be attributed to other people's mobile phones. Finally, larger geographical areas can be covered than with spot measurements while still maintaining high reproducibility such as the utilization of the same device throughout the study. The study can ensure that the meters themselves do not have issues with sensitivity range, out-of-band response and body shielding. The purpose of this study was to quantify RF EMF personal exposure levels using a tested protocol in microenvironments in an international setting. Using portable measurement devices in 94 outdoor environments and 18 public transport vehicles the RF EMF was measured either walking with a backpack for the device or driving with it on the roof of the car. The mean total outdoor exposure varied between 0.23 V/m (140.318 $\mu W/m^2$) (non-central residential area in Switzerland) and 1.85 V/m (9,078.249 $\mu W/m^2$) (university area in Australia) and across modes of public transport from 0.32 V/m (271.618 $\mu W/m^2$) (bus in rural Switzerland) and 0.86 V/m (1,961.804 $\mu W/m^2$) (Auto rickshaw in urban area Nepal). For most outdoor areas the majority of RF EMF exposure was from mobile phone base stations, otherwise broadcasting was dominant. Uplink from mobile phones was generally small aside from in Switzerland public transport. This study demonstrates high variability across microenvironments from all over the world and exposure levels tend to increase with urbanity and in most environments the downlink from mobile phone base towers was the most pertinent contributor (Sanjay Sagara et al., 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 (Topics: rat cells, cancer rates, gender effects)

In 2011, the WHO classified RF radiation at 30 kHz-300 GHz frequency range as Group 2B after a carcinogenic study in animals was posted in 1982. During the handheld mobile and wireless use the brain is the main target for RF radiation. An increased risk of developing a glioma or acoustic neuroma has been found in epidemiological studies. An

NTP study found an increased incidence of glioma in the brain and malignant schwannoma in the heart was found in rats. The aim of this review was to compare earlier epidemiological studies with the NTP with a short review of animal studies. The concluded findings of this study were that there is an increased incidence and risk of RF radiation as a human carcinogen, causing glioma, vestibular schwannoma (acoustic neuroma) and of developing thyroid cancer. There is also clear evidence that RF radiation is a multi-site carcinogen. The WHO International EMF Project founder appears to be using the non-governmental organization studies by ICNIRP, many members of who have been shown to have ties to the industry and therefore a conflict of interest. The current ICNIRP guidelines were established in 1998 based on 2-10 W/m^2 ($2e^6$-$1e^7$ $\mu W/m^2$) for RF radiation depending on frequencies. However, these guidelines do not cover cancer and other long-term non-thermal effects. The scientific benchmark for possible health risks was set at 30-60 $\mu W/m^2$ based on the BioInitiative Reports from 2007 and 2012. However, the Bioinitiative Group proposed a cautionary target level of 3-6 $\mu W/m^2$ using a safety factor of 10. Based on this, the IARC Monographs should classify RF radiation as a Group 1, carcinogenic to humans (CARLBERG, 2019).

The effect of antenna polarization and body morphology on the measurement uncertainty of a wearable multi-band distributed exposure meter (Topics: cellular effects, electric fields, antenna polarization)

Elucidation of exposure to wireless technology radiation has been classified as an important issue by WHO. Measurement of this is typically completed with PEMs which are portable devices worn to constantly quantify the incident electric fields at their location. These devices are calibrated in free space but worn on the body. Therefore, it is of concern as to the accuracy of their measurements of the incident body EMF measurements. Previous studies have shown variability of measurements due to the presence of a body due to the body shielding part of the EMFs known as body shadowing. In order to address this on-body the use of on-body calibration of PEMs has been suggested. This study is on the effects of antenna polarization on measurement uncertainty of a multi-band body-worn distributed exposure meter ((BWDM). The device assesses electromagnetic fields in real environments. It consists of 8 nodes and is calibrated on the body for simultaneous measurements of the incident power density in four frequency bands each node containing one antenna with two potential polarizations. The BWDM was calibrated on four subjects in an anechoic chamber to determine its measurement uncertainty to the 68% confidence interval (CI_{68}) of the body antenna aperture. This showed that using fixed antenna polarization on body can lead to a different CI_{68} up to 4.9 dB when worn by another person, which is still 9.6dB lower than the measurement uncertainty of commercial exposure meters (Reza Aminzadeh et al., 2019).

5 G wireless telecommunications expansion: Public health and environmental implications

The premise of the literature review conducted by Dr. Russell is a study on the emerging health effect of 1-4G with speculation on the possible health effects of 5G. The review contains arguments for the radio frequency controversies and the current technical policies in place. The IARC has categorized non-ionizing radio frequency radiation as

from cell phones and wireless signals in Group 2B (possibly carcinogenic). The current safety models are based on heating effects, although the effects displayed are well below that of the heat threshold. In order for 5G to be an effective form of data transmission it is a high frequency and a wider spectral bandwidth of 6-100 GHz. The shorter frequencies transmit over short distances so there needs to be a dense network of antennas. There is growing evidence within scientific literature of nonthermal cellular damage from non-ionizing wireless radiation from telecommunication devices. There is evidence linking RF EMR to an array of adverse effects on gene expression, DNA integrity, protein synthesis, cellular membranes, the blood brain barrier, melatonin production, neuronal function, and immune dysfunction and sperm damage. There have been human studies linking these effects specifically to neurodegenerative changes, brain cancer and infertility. In addition to these effects, electrosensitivity to electrical and wireless devices is being recognized by a growing number of physicians and scientists. A biologically based standard with a scientific benchmark of 0.003 $\mu W/cm^2$ (30 $\mu W/m^2$) has been recommended to a 'lowest observable effect' for RF EMR. There is also growing evidence of harm to biosystems such as trees and other wildlife. MMW are absorbed by water in living plants, animals, bacteria and human skin with variable effects. The penetration effect in human skin tissue is absorbed up to 90% in the epidermal layer, because the depth is so superficial higher heating occurs with less dissipation. Systemic signaling within the skin can results in physiological effects within the nervous system, heart and immune system mediated through neuroendocrine mechanisms. Currently, MMW is used in some high speed wireless systems and radar sensor navigation. With imminent growth and continuous exposure of MMW there is a need to fully understand the health effects of these frequencies (Russell, 2018).

Electrosmog and autoimmune disease

A study on murine immunosuppression found that a similar immune suppression response occurred with low-level non-ionizing electromagnetic radiation as with the NSAID diclofenac. It also noted a suppression of inflammation in lizards with exposure to pulsed DECT radiation similar to cordless phones radiation. Also found the hydrogen bond exchange within the VDR displayed structural resonances at frequencies usually found in typical modern Electrosmog. Typical Electrosmog consists of radio waves (from broadcasting towers) and microwaves (from Wi-Fi, cell phones and cell towers). The force exerted by an electromagnetic wave on a moving charge is dependant on the charge's velocity and the wave's amplitude and frequency. In Electrosmog the amplitude is an uncontrolled variable and can exceed -16 dBm^3 (25.12 $\mu W/m^2$). A case study using shielding caps of microwave shielding fabric on the groups' olmesartan cohort and discovered through patient reported outcomes that there was a definite effect in up to 90% of the patients. Although the response could be either positive or negative there is heavy support that autoimmune patients are predisposed to hypersensitivity to Electrosmog levels in the current home and work environments. This factor may be affecting their therapeutic response. It has been suggested that the research literature is criticized because it was not sufficiently authoritative under the current paradigm of placebo control and simplistic analysis of results ($p=0.05$). That research in this area can only move forward if qualitative study outcomes are observed. The ethical and practical

regions of this area of study are difficult to control in our current environment (Marshall, 2017).

Nationl Technical Report of TOXICOLOGY AND CARCINOGENESIS STUDIES IN B6C3F1/N MICE EXPOSED TO WHOLE-BODY RADIO FREQUENCY RADIATION AT A FREQUENCY (1,900 MHz) AND MODULATIONS (GSM AND CDMA) USED BY CELL PHONES

The predominant exposure source to humans of RF radiation (RFR) is cell phones as cell phones utilize RFR to transmit and receive data. The FDA authorized cell phone RFR emission for testing in toxicology and carcinogenicity testing in 1999. At the time the use of B6C3F1/N mice were deemed crucial for meaningful studies as human testing is unethical. Since their development of the original analog (1G) technology to the digital (2G) or second generation and subsequent 3G and 4G technologies there have been increasing levels of RFR. Today's phones are so complex they actually contain multiple antennas for Wi-Fi, GPS, 2G/3G/4G bands etc. The levels of previous studies remain relevant however the power levels of exposures are much higher than typical patterns for human use. This study exposed 90 male and 90 female mice to 2.5, 5 and 10 W/kg RFR that was regulated to signals similar to that of cell phones and Wi-Fi communication devices. Other mice housed in similar enclosures were used as the controls. Exposure levels were 9hrs/day, 7 days/week for 2 years and the tissue samples were taken from over 40 sites on every animal. The survival rate was higher in males at the 2.5 and 5 W/kg exposure level. Body weights remained unvaried compared to controls. For both GSM and CDMA there was a higher incidence of malignant lymphoma in females compared to controls however this was within the range of other NTP studies. There were higher incidence of skin and lung tumors in males for GSM RFR at 5 and 10 W/kg and liver tumors for CDMA mid-dose (5 W/kg) RFR. Thus it has been determined that GSM-modulated RFR may have caused skin and lung tumors in males and malignant lymphomas in female mice and that CDMA RFR may have caused liver tumors in male mice and malignant lymphomas in female mice (Health et al., 2018).

Final Summary:

The cited papers were chosen based on their recent publication (post January 2018), topic relevance and diversity of subject matter as well as the credibility of the sources. The subject matter is widely published and summarizing only ten papers is a minimal representation of subject matter. The overall study conclusion consists of the current need for better regulation of RFR and EMF as well as industry acknowledgement of possible health effects. Future studies should consist of more long term health effects of low power high frequency RFR and EMF in rats as well as observational studies in humans. The values in the National Toxicology Report uses SAR which is wattage per weight (W/Kg) versus all the other papers are measuring in $\mu W/m^2$ with ranging scales. The need for standardized unit measurements across the field would not only be beneficial but is required to advance the field in research. It should also be noted that typical GPS (is a receiver) does not produce enough signal power to register on any current market meter. The need for industry regulated meters is paramount for future measurements and studies. It can be noted that there is no industry standard for RF meters and very few are lab

calibrated. There are meters that have been calibrated and the urge for standard implementation is underway.

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