5G Wireless Technology: Millimeter Wave Health Effects

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The emergence of **5G**, fifth-generation telecommunications technology, has been in the news lately because the wireless industry has been pushing controversial legislation at the state and federal level to expedite the deployment of this technology. The legislation would block the rights of local governments and their citizens to control the installation of cellular antennas in the public "right-of-way." Cell antennas may be installed on public utility poles every 10-20 houses in urban areas. According to the industry, as many as 50,000 new cell sites will be required in California alone and at 800,000 or more new cell sites nationwide.

Although many major cities and newspapers have opposed this legislation, the potential health risks from the proliferation of new cellular antenna sites have been ignored. These cell antennas will expose the population to new sources of radio frequency radiation including millimeter waves.

5G will employ low- (0.6 GHz - 3.7 GHz), mid- (3.7 – 24 GHz), and high-band frequencies (24 GHz and higher). In the U.S., the Federal Communications Commission (FCC) has allocated "low-band" spectrum at 0.6 GHz (e.g., 600 MHz), "mid-band" spectrum in the 3.5 GHz range, and 11 GHz of "high-band" frequencies including licensed spectrum from 27.5-28.35 GHz and 37-40 GHz, as well as unlicensed spectrum from 64-71 GHz which is open to all wireless equipment manufacturers.

Prior to widespread deployment, major cell phone carriers are experimenting with new technologies that employ "high-band" frequencies in communities across the country. The "high-band" frequencies largely consist of millimeter waves (MMWs), a type of electromagnetic radiation with wavelengths of one to ten millimeters and frequencies ranging from 30 to 300 GHz (or billions of cycles per second).

The characteristics of MMWs are different than the "low-band" (i.e., microwave) frequencies which are currently in use by the cellular and wireless industries. MMWs can transmit large amounts of data over short distances. The transmissions can be directed into narrow beams that travel by line-of-sight and can move data at high rates (e.g., up to 10 billion bits per second) with short lags (or latencies) between transmissions. The signals are blocked by buildings, and foliage can absorb much of their energy. Also, the waves can be reflected by metallic surfaces. Although antennas can be as small as a few millimeters, "small cell" antenna arrays may consist of dozens or even hundreds of antenna elements.

What does research tell us about the biologic and health effects of millimeter waves?

Millimeter waves (MMWs) are mostly absorbed within 1 to 2 millimeters of human skin and in the surface layers of the cornea. Thus, the skin or near-surface zones of tissues are the primary targets of the radiation. Since skin contains capillaries and nerve endings, MMW bio-effects may be transmitted through molecular mechanisms by the skin or through the nervous system.

Thermal (or heating) effects occur when the power density of the waves is above 5–10 mW/cm^2. Such high-intensity MMWs act on human skin and the cornea in a dose-dependent manner—beginning with heat sensation followed by pain and physical damage at higher exposures. Temperature elevation can impact the growth, morphology and metabolism of cells, induce production of free radicals, and damage DNA.

The maximum permissible exposure that the FCC permits for the general public is 1.0 mW/cm^2 averaged over 30 minutes for frequencies that range from 1.5 GHz to 100 GHz. This guideline was adopted in 1996 to protect humans from acute exposure to thermal levels of radiofrequency radiation. However, the guidelines were not designed to protect us from nonthermal risks that may occur with prolonged or long-term exposure to radiofrequency radiation.

With the deployment of fifth generation wireless infrastructure (aka **5G)**, much of the nation will be exposed to MMWs for the first time on a continuous basis. Due to FCC guidelines, these exposures will likely be of low intensity. Hence**, the health consequences of 5G exposure will be limited to non-thermal effects produced by prolonged exposure to MMWs in conjunction with exposure to low- and mid-band radiofrequency radiation.**

Unfortunately, few studies have examined prolonged exposure to low-intensity MMWs, and no research that I am aware of has focused on exposure to MMWs combined with other radiofrequency radiation.

Although biologic effects of low-intensity MMWs have been studied for decades, particularly in Eastern Europe, study results are often inconsistent because the effects are related to many factors including the frequency, modulation, power density, and duration of the exposures, as well as the type of tissue or cells being investigated.

Results vary across studies—MMWs have been shown to induce or inhibit cell death and enhance or suppress cell proliferation. Some studies found that the radiation inhibits cell cycle progression, and some studies reported no biologic effects (Le Drean et al., 2013)

A review of the research in 2010 noted that “A large number of cellular studies have indicated that MMW may alter structural and functional properties of membranes.” Exposure to MMWs may affect the plasma membrane either by modifying ion channel activity or by modifying the

phospholipid bilayer. Water molecules also seem to play a role in these effects. Skin nerve endings are a likely target of MMWs and the possible starting point of numerous biological effects. MMWs may activate the immune system through stimulation of the peripheral neural system (Ramundo-Orlando, 2010).

In 1998, five scientists employed by U.S. Army and Air Force research institutes published a seminal review of the research on MMWs. They reported:

"Increased sensitivity and even hypersensitivity of individual specimens to MMW may be real. Depending on the exposure characteristics, especially wavelength, a low-intensity MMW radiation was perceived by 30 to 80% of healthy examinees (Lebedeva, 1993, 1995). Some clinical studies reported MMW hypersensitivity, which was or was not limited to a certain wavelength (Golovacheva, 1995)."

"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, although in view of numerous bioeffects and growing usage of MMW technologies this research objective seems 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, but 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 exposures are based solely on predictions of energy deposition and MMW heating, but in view of recent studies this approach is not necessarily adequate." (Pakhomov et al., 1998)

Microbes are also affected by MMW radiation. In 2016 a review of the research on the effects of MMWs on bacteria was published (Soghomonyan et al., 2016). The authors summarized their findings as follows:

"…bacteria and other cells might communicate with each other by electromagnetic field of sub-extremely high frequency range. These MMW affected Escherichia coli and many other bacteria, mainly depressing their growth and changing properties and activity. These effects were non-thermal and depended on different factors. The significant cellular targets for MMW effects could be water, cell plasma membrane, and genome….The consequences of MMW interaction with bacteria are the changes in their sensitivity to different biologically active chemicals, including antibiotics….These effects are of significance for understanding changed metabolic pathways and distinguish role of bacteria in environment; they might be leading to antibiotic resistance in bacteria."

"Changing the sensitivity of bacteria to antibiotics by MMW irradiation can be important for the understanding of antibiotic resistance in the environment. In this respect, it is interesting that bacteria [that] survived near telecommunication-based stations like Bacillus and Clostridium spp. have been found to be multidrug resistant (Adebayo et al. 2014)." (Soghomonyan et al., 2016)

In sum, the peer-reviewed research demonstrates that short-term exposure to low-intensity millimeter wave (MMW) radiation not only affects human cells, it may result in the growth of multi-drug resistant bacteria harmful to humans. **Since little research has been conducted on the health consequences from long-term exposure to MMWs, widespread deployment of 5G or 5th generation wireless infrastructure constitutes a massive experiment that may have adverse impacts on the public's health.**

Early Russian research on millimeter radiation

Russian scientists conducted much of the early research on the effects of exposure to millimeter radiation. The U.S.Central Intelligence Agency collected and translated the published research but did not declassify it until decades later.

In 1977, N.P. Zalyubovskaya published a study, "Biological effects of millimeter waves," in a Russian-language journal, "Vracheboyne Delo." The CIA declassified this paper in 2012.

The study examined the effects of exposing mice to millimeter radiation (37-60 GHz; 1 milliwatt per square centimeter) for 15 minutes daily for 60 days. The animal results were compared to a sample of people working with millimeter generators.

Here is a brief summary of the paper:

BIOLOGICAL EFFECT OF MILLIMETER RADIOWAVES

Kiev VRACHEBNOYE DELO in Russian No 3, 1977 pp 116-119

[Article by N. P. Zalyubovskaya, Khar'kov Scientific Research Institute of Microbiology, Vaccines and Sera imeni Mechnikov]

[Text] Morphological, functional and biochemical studies conducted in humans and animals revealed that millimeter waves 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 processes of tissue respiration and nucleic metabolism. The degree of unfavorable effect of millimeter waves depended on the duration of the radiation and individual characteristics of the organism.

Excerpts:

The conducted investigations showed that the irradiation of animals by millimeter waves caused changes of the processes of oxidative phosphorylation in the liver, kidneys, heart and brain of the animals. The irradiation inhibited the oxygen consumption rate by the mitochondria of those organs in the active phosphorylating state and slowed down the rate of respiration upon exhaustion of the ATP. In the liver and kidneys of irradiated animals the intensity of phosphorylation decreased by 64%, the values of the respiratory controls decreased by 26 and 28% respectively and the changes were less expressed in the heart and brain.

The conducted experimental investigations were compared with observations of the state of health of 97 persons working with generators of the millimeter range on the basis of systematic conducting of biochemical analyses. The obtained data confirmed the existence of an influence of radiowaves on the state of metabolic processes in the organism, in particular, changes of the indicators of protein and carbohydrate metabolism were revealed and disturbances of the indicators of immuno-biological reactivity and of the blood system were established.

The paper can be downloaded from http://bit.ly/MMWstudy1977.