5G WIRELESS: A Radiobiological Assessment

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ABSTRACT

Professor Yuri G. Grigoriev (PhD, DMedSci), was one of ORSAA's independent advisors. He had been a vocal critic of the ICNIRP approach in the setting of exposure limits for RF-EMF guidelines. Grigoriev was a giant in the science of Radiobiology in Russia, and the breadth and depth of his understanding of the interactions between biology and physics should not be ignored by governments, telecommunications engineers, or social scientists charged with responsible decision-making on this matter. Grigoriev recently published a book (titled: 5G CELLULAR STANDARDS. Total Radiobiological Assessment of the Danger of Planetary Electromagnetic Radiation Exposure to the Population).[1] He asked ORSAA to help translate this book into English.

As the book reveals, Soviet radiobiological scientists and clinicians were amongst the first to realise the therapeutic and detrimental effects of millimetre Waves (mmWaves), documented in a significant body of scientific literature spanning many decades. The findings were very clear in the 1970s that pulsed modulated low frequency signals on mmWaves, although having shallow penetration in the skin, can lead to a variety of bioeffects that over the long term, will result in health effects particularly amongst the most vulnerable, including children, the infirm and the aged.

Grigoriev noted that it is necessary to assess the degree of radiosensitivity of various organs and their interaction with the biological systems of the body. These vital organs develop over the course of our lives and should be considered when setting safety standards. Thus, it is necessary to assess potential adverse reactions in important organs such as the brain, the visual and auditory systems, the vestibular system, the thyroid gland, the sclera of the eyes, the endocrine system, the reproductive system and the immune system. The study of the effects of long-term or chronic radiation exposure, such as benign and malignant tumors, is particularly important for assessing the risk of all forms of EMF. The experiments showing sensitivities of these organs to RF exposures are given in the book. The results from these experiments point to an urgent need for specialized research that can assess the degree of harm from cellular communication to children and other vulnerable individuals. Moreover, it is important to establish a scientific basis for developing ethical radiation protection standards that are optimised with appropriate "safety factors" to address unknown and emerging factors related to health impacts, as well as possible future technological developments.

Key Words

Electromagnetic Radiation, EMR, EME, EMF, RF, Microwaves, Wi-Fi, Mobile phones, Health, Cancer, millimetre Waves (mmWaves)

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Introduction

Russian research is often portrayed by other countries as being less than rigorous when judged by western experimental standards. Furthermore, radiation accidents such as Chernobyl and the radioactive contamination of the waterways on the eastern slope of the southern Urals[2] are often alluded to by scientists as evidence of poor radiation protection practice. This gives Western scientists and decision makers ammunition to dismiss Russian research and subsequent policy. However, other countries also have had similar accidents such as 3-mile island,[3] and the military nuclear waste problems at the Hanford Site, Washington State USA.[4] In Australia Rum Jungle NT,[5] El Sharana NT,[6] and Mary Kathleen Uranium (MKU) Qld[7] uranium mining operations are also good examples of how poor practices with tailings disposal can lead to contamination of waterways. Atomic weapons testing at Maralinga SA and Montebello Islands WA[8,9] are other contaminated sites. This reminder gives us a more sober perspective and an openness to investigate the research and subsequent policies that have been established in other countries. When we do, we find a discrepancy in policy: the Russian wireless communication standard for members of the public is 100 times lower than that adopted by most other countries. The question that remains unanswered is: Why is this so?

To answer this question, we can look at the history of experimental studies conducted by both eastern and western scientists and the contribution that Prof Yuri Grigoriev[10] and his colleagues have made to the understanding of biological effects and how long-term exposure translates into health effects.

Prof Yuri Grigoriev was not only head of the Russian National Committee Burnasyan on Non-Ionizing Radiation Protection; he also worked at the State Research Centre (SRC) - Federal Medical Biophysical Centre (FMBC).[11] This Russian State Research Centre is a powerful research and clinical cluster in the system of the SRC-FMBC and is a flagship institution of Public Health of the Russian Federation in the fields of biophysics, radiation, nuclear medicine and safety. This is a research hub for innovative biomedical technologies. That is, this centre combines research and clinical practice so that the science can be informed by both. The centre also incorporates the radiation regulatory role for the setting of radiation exposure limits for wireless standards for occupational and public limits.

There is no equivalent centre in Australia, USA, UK or the EU countries.

Balance of Evidence

The Oceania Radiofrequency Scientific Advisory Association Inc. (ORSAA)[12] was formed as an independent organisation to review the current scientific evidence on EMF. ORSAA established a categorised Database of EMF Bioeffects (ODEB)[13] as shown in Figure 1 below. The focus of the ODEB is on non-thermal effects, which occur well below the ICNIRP thermal short-term limit. This database has undergone many revisions over the last five years.

The main biological effects discussed in the literature and collated within ODEB are as follows:

- DNA and cell damage in the brain, blood, body organs, immune and reproductive systems;
- Increased production of free radicals leading to a state of oxidative stress, resulting in accumulated damage throughout the body;
- Neurodegeneration and changes in neurotransmitter levels and signalling pathways in the brain;
- Damage to sperm and ovaries;
- Damage to cellular systems such as mitochondria, mast cells and signalling systems.

Damage to the biological processes listed above may underlie many health conditions. Figure 2 shows the biological and health categories for outcomes used by the ODEB. As shown in Figure 2, the category "DNA damage/Mutagenic/Genotoxic" has 228 experimental papers that show significant bio-effects, including as a precursor for cancer. Further, the category "Oxidative Stress / ROS/ Free Radicals" has 317 experimental papers which

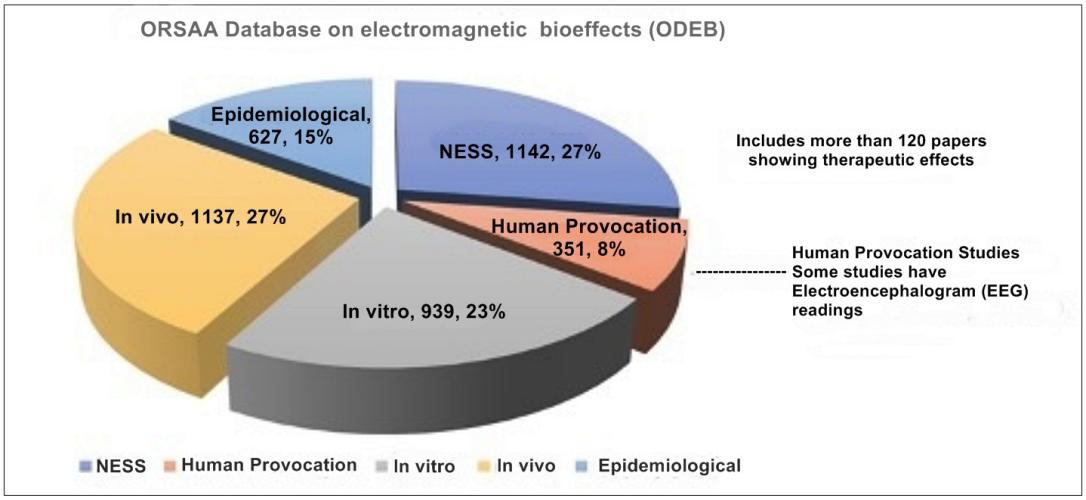

***Figure 1**. ODEB database contains both experimental studies (in vitro, in vivo, epidemiological & provocation studies) as well as Non-Experimental Scientific Studies (NESS) (reviews, reports, guidelines, measurement and dosimetry studies, etc.) for a range of frequencies from Extremely Low Frequency (ELF) (3 Hz-100 Hz) to Super High Frequency SHF (3 GHz - 60 GHz).*

show significant bio-effects, being a biomarker for inflammatory conditions associated with disease.

The International Agency for Research on Cancer (IARC) in May 2011 classified radiofrequency electromagnetic fields as a possibly carcinogenic to humans (Group 2B).[14] Certain brain cancers are increasing in various countries around the world,[15,16] particularly in age groups over 60 who represent the group which has been living with this technology for the longest time. However, this does not appear to be the case in Australia.[17]

Ahead of the International Agency for Research on Cancer (IARC) reclassification of radio frequency radiation[18] as a cancer-causing agent, the WHO has funded eleven review projects in different areas such as oxidative stress, human cognitive decline and effects on sperm. The task is for each team to assess the quality of the experiments cited in the literature (Table 1) with a view to forming an overall opinion on the strength of evidence. The selection of ICNIRP members in the various groups means that we are seeing already the problem that could potentially bias the outcomes. Unfortunately, bias is already showing in the preliminary scientific papers as revealed by the funder of the research[19].The rejection of peer-reviewed papers within this review must be done with care and performed in an impartial manner with no industry involvement or we run the risk of public health being compromised by the economic imperative.

Figure 2 summarises the effects of pulsed-modulated signals for current wireless technology[13] as well as proposed new signals for 4G LTE and 5G frequencies. From a position of denial, ICNIRP 2020[20] claims that these non-thermal bio-effects don't lead to health effects; however, this claim cannot be justified and is not consistent with the medical literature regarding biological effects. For example, oxidative stress is known to be a causal factor underlying heart disease, neurodegenerative diseases, depression, and auto-immune disease such as diabetes.

With such a wide range of bioeffects it must be concluded that there is a plausible risk, particularly for children, the elderly, and those who have comorbidities. The Russian health authorities subsequently advise parents on the safe use of mobile phones and devices[21]. This is in contrast with a recent study, the MobiKids project[22], which started a decade ago. The recently released findings were inconclusive, with admissions of poor experimental design[23,24]. Unfortunately, epidemiological studies may be no longer be viable given the general all-pervasive

Table 1. World Health Organisation funded reviews ahead of IARC review into category of carcinogenicity for radiofrequency radiation.

No	ORSAA Paper ID	Title	URL
1	4244	The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis.	https://pubmed.ncbi.nlm.nih.gov/34735951/
2	4243	The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies.	https://pubmed.ncbi.nlm.nih.gov/34735955/
3	4221	The effect of radiofrequency electromagnetic fields (RF-EMF) on biomarkers of oxidative stress in vivo and in vitro: A protocol for a systematic review.	https://pubmed.ncbi.nlm.nih.gov/34662800/
4	4175	The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A protocol for a systematic review on human observational studies.	https://pubmed.ncbi.nlm.nih.gov/34500362/
5	4159	The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A protocol for a systematic review of human observational studies.	https://pubmed.ncbi.nlm.nih.gov/34433115/
6	4116	The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: A protocol for a systematic review.	https://pubmed.ncbi.nlm.nih.gov/34333292/
7	4160	Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on male fertility and pregnancy and birth outcomes: Protocols for a systematic review of experimental studies in non-human mammals and in human sperm exposed in vitro.	https://pubmed.ncbi.nlm.nih.gov/34454359/
8	556	Effects of radiofrequency electromagnetic fields (RF EMF) on cancer in laboratory animal studies.	https://pubmed.ncbi.nlm.nih.gov/35091376/
9	2918	Influence of Radiofrequency Electromagnetic Fields on the Fertility System: Protocol for a Systematic Review and Meta-Analysis.	https://www.ncbi.nlm.nih.gov/pubmed/29422451
10	3795	Genotoxic and cytotoxic effects of mobile phone use on the oral epithelium: a systematic review with meta-analysis,	https://pubmed.ncbi.nlm.nih.gov/33136050/
11	4360	The effect of long-term radiofrequency exposure on cognition in human observational studies: A protocol for a systematic review.	https://pubmed.ncbi.nlm.nih.gov/34953282/

levels of electromagnetic pollution.

Russian researchers have also written a number of papers on the effects of RF on the immune system,[25,26] which have been translated into English. Soviet studies conducted between 1974 and 1980 were repeated in 1991. These repeated experimental animal studies were sponsored by the WHO under their experimental protocols. The experiments gave rats long-term exposures from pulsed-modulated signals. The results revealed risks to the human immune system, and immunological and reproductive effects. The rats in these experiments were exposed to 5,000 mW m^{-2} for 7 hours per day, 5 days per week, for 30 days. This exposure of 5,000 mW m^{-2} is half the ICNIRP “member of the public” exposure limit. The Russians in their

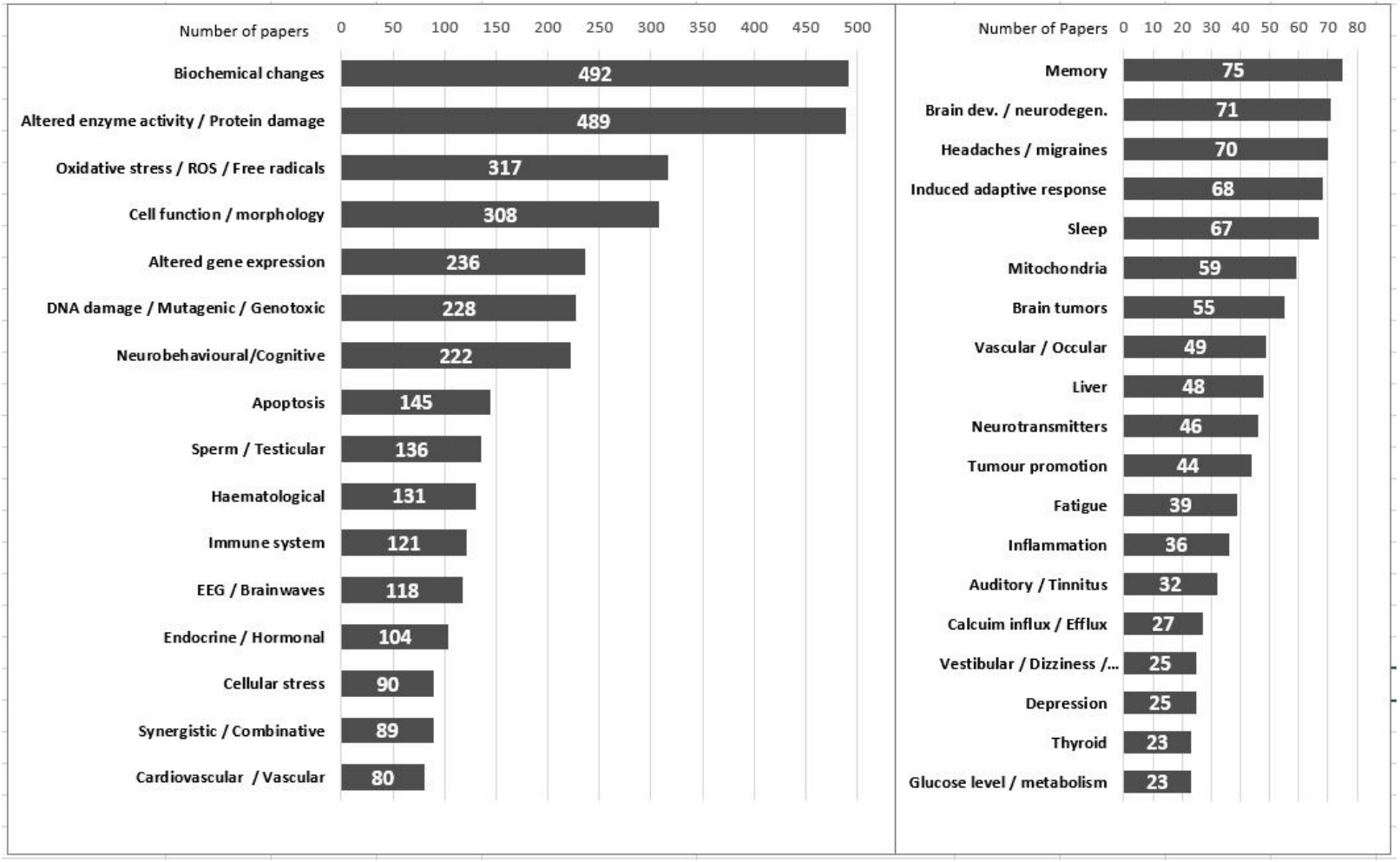

Figure 2. The number of papers in ODEB showing significant effects of radiofrequency within the prominent biological and health categories.

studies used low frequency pulsation with high frequency modulated signals which were different to the simulated signals used in the USA and European studies. The USA and European studies may or may not use 217 Hz low frequency pulsing but the high frequency carrier wave (usually in the range 0.9 to 5 GHz) is normally unmodulated, that is it carries no data. The variability in signal strength is absent. Using airport scanners as an example of safety is disingenuous[27].These non-thermal studies indicated possible side effects on autoimmune processes resulting in increased formation of antibodies in brain tissue. Some uncertainty remained as to the precise pathological mechanism but production of reactive oxygen species (ROS) and reactive nitrogen species is a plausible pathway for many of these bio-effects seen in these experiments. Further studies on pregnant rats showed adverse effects on blood serum, and foetal and offspring developmental effects.

These studies were used, in part, for developing exposure standards for the members of the public. Such standards would be in line with ionising radiation guidelines as developed by ICRP radiation protection philosophy that recognises plausible risk to health status for an uncontrolled heterogenous population.

Criminal Offence in Russia if Public Health Information withheld

Grigoriev clarified that hiding risks to health is a criminal offence in Russia:

"In Russia, the penalty for concealment of information given to teachers by educational officials about the danger to health of participants within educational systems is given in article 237 of the criminal code “Concealment of information on circumstances creating danger to life or health” where the directive is clear that:

"***Officials of educational organizations are obliged to report this threat to the public, as well as immediately take response measures to eliminate the danger to participants in the educational process.***"

Grigoriev continues: “This is the first time in the entire period of civilization, there is a massive constant electromagnetic irradiation of the brain of a child/teenager and, first of all, the nerve structures of the inner ear and vital centres of the brain. With the support of parents, the child became the owner of a mobile phone, which is an open, uncontrolled source of EMF" (Grigoriev, book translation, 2021, p.124)[28].

The book translation

The original title or Grigoriev’s book, written in Russian is: **5G CELLULAR STANDARDS. Total Radiobiological Assessment of the Danger of Planetary Electromagnetic Radiation Exposure to the Population**[1]. The cover of this book written in Russian is shown in Figure 3.

ORSAA has translated this book into English with a view to publishing an English version. Unfortunately, the author Professor Yuri Grigoriev died before it could be completed. A large part of this book was translated before his passing with his approval. Subsequently we have completed a final derivative work available to read[28].

One of the main focuses of the book was on the effects of mmWaves on the skin and the eyes (sclera) as critical organs of concern (Grigoriev, book translation, 2021, pp.26-34)[28].

This research over that last century regarding the skin and eyes can be summarised as follows:

1. The sclera: almost no research;
2. The skin: there is limited research and the current modelling treats skin as an inert substrate with no biological function[29];

   The current ICNIRP approach is to treat skins as an inert substrate or overcoat and the only criterion for limit setting is pain due to heating. This approach ignores the very important biological role that skin plays in homeostasis;

   - Skin is our largest organ and interfaces with our immune system;
   - Skin is rich in nerves and very sensitive. It connects to the brain and central nervous system and blood vessels which in turn are critically

interconnected with the other organs of the body;

- Skin has receptors that carry abundant innervation associated with both the central and autonomic nervous system. The autonomic nervous system, is a division of the peripheral nervous system that services smooth muscle and glands, and thus influences the function of internal organs;
- Skin plays a role in the regulation of immunity and wound healing. The surface of the skin is a natural environment for thousands of different microbial species;
- Skin is part of our waste removal system and discharges toxins from the body;
- Skin responds to and protects against mechanical and chemical factors, ultraviolet radiation, and the penetration of microbes and viruses into the body;
- Skin performs endocrine functions, and produces vitamin D when exposed to sunlight.

Children are at Risk

The net effect of this research is consumer advice to parents as follows[21].

- A conversation on a mobile phone should not last more than 2 minutes, and the minimum pause between calls should be at least 15 minutes. It is much safer to write messages than to hold the receiver to your ear.
- Hold the handset of the mobile phone away from the ear, by its lower part and vertically. Attenuation of radio waves occurs in proportion to the square of the distance travelled, therefore, by moving the internal antenna away from the ear by only a centimetre and thus increasing the distance to the brain by half, it is possible to reduce the power and radiation effects on the brain, four times.
- It is better to bring the receiver to your ear after answering at the other end. At the time of the call, the mobile phone operates at its maximum capacity, regardless of the communication conditions in the given place. At the same time, 10-20 seconds after the

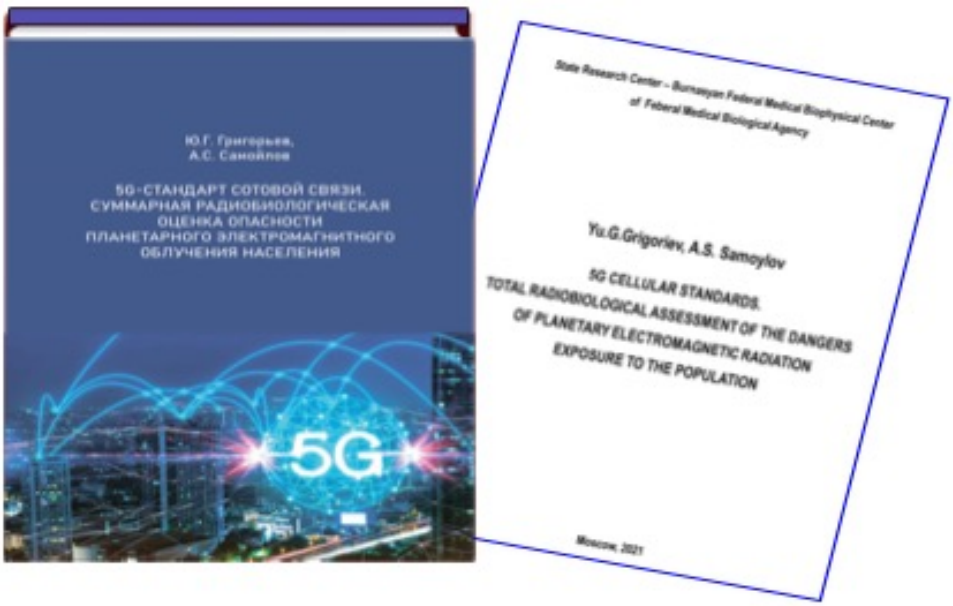

Figure 3. Book title: **5G CELLULAR STANDARDS. Total Radiobiological Assessment of the Danger of Planetary Electromagnetic Radiation Exposure to the Population**[1].

start of the call, the radiated power decreases to the minimum allowable level. It is also pointless to put the phone to your ear immediately because the first long beep does not appear immediately.

- Many children often send SMS messages or are overly addicted to games built into cell phones. Such regular and prolonged stress on the growing hand and fingers can cause various disorders of the bones and joints. In addition, while playing, the child is forced to look at a small image, looking at the backlit screens for a long period, which is always at the same distance from the eves. This is a serious strain on the eyes and can have a very negative effect on vision.
- It is recommended to take off glasses with metal frames when talking. The presence of such frames may lead to an increase in the intensity of the electromagnetic field affecting the user.
- It is not recommended to put mobile phones next to you while sleeping.
- Do not keep your mobile phone with you at all times, for example, in your pants pocket.
- Contact with a mobile phone should be limited, especially if there is no need for it.
- It is better to carry a mobile phone in a bag. You should not keep a mobile phone on your chest, belt or in your breast pocket for a long period.

The distribution of absorbed RF dose in the brain is entirely dependent on the age of the user[29] as shown in Figure 4.

The absorbed dose of RF-EMFs in the brain of children aged 5-10 years is up to two times greater than in adults. This fact gives weighty credence to our judgement that the brain and the nerve structures are critically vulnerable. Moreover, it indicates that when assessing the risk of mobile phones for the population, there must be a tailored approach to protecting children, since their exposure, and the consequent **risk** from exposure to mobile phones is greater.

In addition to the brain, the mobile phone also directly irradiates the auditory and vestibular systems of the inner ear, including the otolith organs and associated sensory pathway[30].In the inner ear, the cochlea system is dedicated to the sense of hearing, while the vestibular system is responsible for maintaining a sense of balance and spatial orientation.

Optimisation and Justification behind RF-EMF wireless limits

After reading through this book, the reader can no longer ignore the extensive literature and associated warnings coming from various countries around the world, and the potential harm that RF exposures present to the current generation.

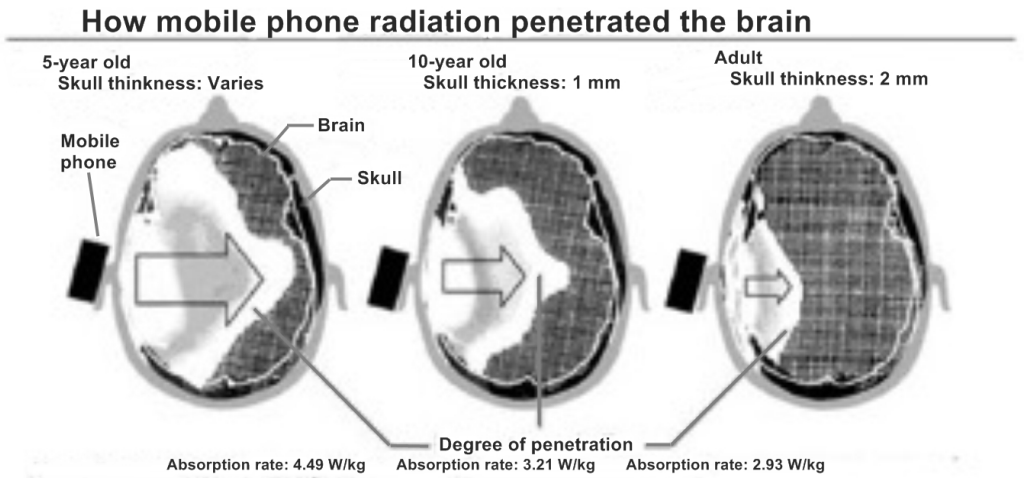

Figure 4. Distribution of absorbed dose in the brain in children aged 5 and 10 years and in adult mobile phone users (Gandhi et al., 1996)[30].

Like Grigoriev, ORSAA is highly critical of the ICNIRP philosophical approach to setting these limits and believes ICNIRP's approach represents a move away from the ICRP ethical approach. Our criticisms are summarized below:

1. Where is the radiation protection justification and optimization behind the increase in 5G RF limits and beyond? As radiation protection practitioners we look for this justification as developed over 100 years by ICRP. There is no equivalent framework for man-made wireless devices.
2. ICNRP is the wrong organisation as it is an unbalanced committee and rejects scientists who are critical of their current guidelines[32].
3. There exists a blurring between medical application (therapy) and consumer applications in the current ICNIRP guidelines.
4. Regulations based on thermal effects alone mean that optimisation is not practiced, as the current limit will be unlikely to be exceeded. This thinking also impairs environmental measurement. The reason being this is low in comparison to the limit. Perception changes when the invisible becomes visible[33].
5. We now have mass exposure of populations exposed without consent, so the concept of As Low As Reasonably Achievable (ALARA) is absent.
6. The ICNIRP guidelines are written with industry interests prioritised over and above human health and well-being. The support for consumer applications like the Internet of Things (IoT) and the Internet of Bodies (IoB) is clearly evident[34].

The Internet of Bodies has valid medical applications as well as consumer applications; however, the current guidelines do not rule out cosmetic implants which opens the area of Transhumanism and Body-hacking[35].

Conclusion

The overview of the last half a century of research from various countries presented in Grigoriev's book is timely. It is an appeal to decision makers to pause and reconsider before launching blindly into the 5G Internet of Things revolution. Currently, we have no safety net to protect us and no set of principles to guide us on the journey ahead. Those tasked with this responsibility have failed the general public with a veneer of expertise only, and industry interests as their true purpose. It is time for those of us who know radiation protection philosophy and process to amend the situation. What is needed is a review of the current Guidelines for RF wireless radiation to include a truthful account of the current knowledge of bio-effects. These bio-effects cannot preclude long-term health effects such as cancer, depression and autoimmune diseases. New risk assessments, polices and guidelines need to be created for industry, government institutions, public spaces and home environments. The scientific radiation protection community together with the public needs to be made aware of these risks and although industry must have a say in the setting of limits, a balanced approach needs to be taken.

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